FY 2010 Annual Report
National Program 211 - Water Availability and Watershed Management

Introduction

Water is fundamental to life and a basic requirement for virtually all of our agricultural, industrial, urban, and recreational activities, as well as for the sustained health of our natural ecosystems.

Since 2009, global concerns about climate change have come to the forefront and National priorities have increased to meet the need for renewable biofuel feedstocks. In 2010, Secretary Vilsack formally announced the establishment of five regional USDA Biomass Research Centers to help ensure the availability of dependable supplies of the feedstocks needed for the production of advanced biofuels to meet legislated goals and market demand, and enable as many rural areas across the country as possible to participate and benefit economically. Both issues have significant consequences for water availability and quality. At the global scale, food security is strongly associated with the availability of fresh water. During the last century, Earth's human population tripled, but the global demand for Earth's finite supply of available fresh water increased six-fold. Currently, the United Nations estimates that more than a billion people live without access to clean water, while more than 2.4 billion people lack the basic sanitation needed for human health. In December 2010, Secretary Vilsack approved the USDA Global Food Security Action Plan, subsequently endorsed by US-AID and the State Department (Visit the *Feed the Future* website at http://www.feedthefuture.gov). In advanced economies, clean water availability has become increasingly threatened due to contamination from agriculture (crop fertilization and animal manure), urban sources (storm runoff, pharmaceuticals, disinfection byproducts) and industry. Against these serious and growing problems, the importance of conserving water resources has never been greater.

The goal of the 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. To achieve this goal requires 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) the 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 research on the processes that control water availability and quality for the health and economic growth of U.S. citizens; and apply this new knowledge (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.

Both within USDA and across the Federal government, ARS leverages agency resources by coordinating its activities with other government agencies through active participation in a variety of intergovernmental committees including: (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); (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; (4) the Advisory Committee on Water Information (ACWI) Subcommittee on Sedimentation; (5) the USDA Drought Team and the USDA Working Group on Water Resources; (6) the Conservation Effects Assessment Project Steering Committee; (7) various working groups of the US Climate Change Science Program; and (8) the USDA Water Team.

Problem Area 1—Effectiveness of Conservation Practices.

Improved conservation practices reduce sediment and nutrient losses from agriculture. Ideal practices will reduce the cost of inputs for the producer, improve the sustainability of land resources, and minimize the impacts of agriculture on water quality. Assessments of the impact of conservation practices across large, complex watersheds depends on the development of reliable assessment criteria, an understanding of the physical processes that occur within the field and watershed, and the integration of this knowledge into improved, validated models and tools to evaluate and predict the impact and result of management options.

Selected Accomplishments

Sediment and nutrient benefits of Conservation Reserve Program land use conversion quantified. Through the Conservation Reserve Program (CRP), approximately 1.7 billion dollars are spent each year to remove cultivated lands from production for conservation purposes, but specific environmental benefits of the CRP have rarely been directly quantified. ARS scientists in Oxford, MS showed that in the Mississippi Delta, converting 280 ha of cropland to trees reduced sediment concentrations and nutrient loads in runoff by an order of magnitude relative to adjacent sites with similar topography and soils that were under reduced tillage crop production, with associated positive impacts (e.g., reduced nutrient concentrations and sediment loads; improved water clarity and fisheries) on the water quality of the receiving water body, Beasley Lake. These findings support continued federal investment in the CRP.

Geospatial tools improve conservation effects assessment in the Chesapeake Bay region. Conservation practices such as winter cover crops have significant potential to reduce nitrogen and phosphorus pollution from agricultural fields to the Chesapeake Bay, but verifying and quantifying these potential benefits over large areas can be difficult. In collaboration with the U.S. Geologic Survey (USGS) and the MD Department of Agriculture (MDA), the Choptank River Conservation Effects Assessment Project (CEAP) Watershed completed five years of research to support the development and implementation of geospatial tools to aid in cover crop management. Field-specific data on conservation program enrollment were combined with satellite imagery analysis to rapidly verify, quantify, and certify cover crop performance. Following successful development of these methodologies, MD has begun ‘beta-testing’ technology transfer of the geospatial cover crop management toolkits at the Talbot County, MD Soil Conservation District. Part of the strategy is to automate the aggregation of site-specific data on conservation program performance to match watershed and county boundaries, providing useful, rapid appraisal of cover crop success in protecting water quality, while maintaining farm data privacy as required in Section 1619 of the Farm Bill. Continuing this collaboration among the MDA, USDA, USGS, the US Fish and Wildlife Service, and other partners, should substantially improve the contribution of winter cover crops in preventing nutrient release from agricultural fields to the Chesapeake Bay.

Object Modeling System Version 3.0 (OMS3) released. In 2010, ARS scientists and their collaborators at Fort Collins, CO, released OMS3—a new framework for computer model development and broad application. OMS3 provides an open-source approach for object- and component-based modeling, and contains multi-threading capability for high performance computing on multi-CPU desktops (particularly for complex, spatially distributed models). OMS3

also supports Natural Resources Conservation Service (NRCS) infrastructure for information technology and the use of existing model code. Researchers have implemented on-demand documentation of simulation projects, including model variables and parameter sets, to produce indexed PDF technical documents. ARS, NRCS, the U.S. Geological Survey, and their university partners are currently implementing simulation projects in OMS3 that will significantly reduce the costs of model development, deployment, maintenance, and ongoing application.

Model that simulates water quality in large river basins improved. The U.S. Environmental Protection Agency (EPA) and state environmental agencies have identified approximately 15,000 impaired water bodies in the U.S., with agricultural production frequently identified as a major contributor of nonpoint sources of water contamination. At the same time, USDA's mission mandates that it: 1) thoroughly analyze the risks and benefits of USDA conservation programs to human health, safety, and the environment; 2) determine alternative ways of reducing risk; and 3) conduct cost-benefit assessments. In response to this mandate, ARS scientists at Temple, TX, developed new algorithms for the river basin scale model, SWAT (Soil and Water Assessment Tool), to simulate landscape routing, septic tanks, and urban runoff and management practices, and are currently testing these routines at watersheds across the U.S. To assess the environmental impact of USDA conservation programs, SWAT was applied in and validated for the Upper Mississippi River Basin (490,000 km^2), with scenario runs used to identify locations where conservation practices such as conservation tillage, terraces, and the CRP, would be most efficient and provide the greatest benefit, thus helping to guide USDA conservation policy. In addition, EPA is using the model in more than 30 states to aid in the selection of land management alternatives to resolve water quality concerns.

Assessment of conservation practices in the Little River Experimental Watershed (LREW), GA, identifies riparian forest buffers as the most comprehensive approach to reducing sediment, nitrogen, and phosphorus pollution. OMB has tasked USDA with quantifying the effectiveness of federally funded conservation programs. ARS scientists at Tifton, GA, used the Soil Water Assessment Tool (SWAT) to simulate the water quality effects of upland conservation practices (CPs) commonly adopted in the LREW for erosion or nutrient control, comparing these results to the simulated impact of existing riparian forest buffers. Erosion CPs produced the greatest reductions in sediment and phosphorus while nutrient reduction practices were most effective in reducing total stream nitrogen. ARS scientists also evaluated three different prioritization scenarios for implementation. Prioritizing based on nonpoint source pollutant load yielded more efficient water quality improvements than the other implementation schemes. Riparian forest buffers offered the most comprehensive reduction of all three pollutants. Simulation results indicate that current levels of riparian forest cover may be the single largest contributor to reducing nonpoint source pollution in the LREW.

Planning tool allows watershed managers to simultaneously evaluate cost and effectiveness of sediment/contaminant Best Management Practices (BMPs). Tools to design and evaluate BMPs are essential for the effective management of agricultural watersheds. ARS scientists at Oxford, MS developed a BMP planning tool by coupling the ARS watershed model, AnnAGNPS, with a channel routing model developed by the National Center for Computational Hydroscience and Engineering at the University of Mississippi. The tool allows users to work at different scales to minimize sediment and nutrient loadings to the streams and rivers of an agricultural watershed, while keeping costs at a minimum. The BMP Planning Tool gives watershed managers the ability to evaluate the effectiveness and cost of a wide range of BMP scenarios for controlling the delivery of sediment and the associated contaminants to the streams and rivers of a watershed simultaneously.

Knowledge of soil moisture availability improves fertilizer nitrogen use by corn in mid-Atlantic landscapes. The sloping landscapes of the mid-Atlantic region have a distinct hydrology that can result in substantial differences in soil moisture availability during the growing season. ARS scientists at University Park, PA, demonstrated that improving nitrogen use efficiency by corn requires a better agronomic understanding of the interaction between soil moisture and

nitrogen availability at a particular landscape position in the field. When soil moisture availability during the growing season is adequate, corn grain yield is directly related to nitrogen availability, but when soil moisture availability is low, nitrogen fertilizer has little effect on grain yield. Results support the ongoing improvement of precision nitrogen recommendations in sloping, mid-Atlantic landscapes, to minimize nitrogen loss to aquatic ecosystems that eventually drain into Chesapeake Bay.

Problem Area 2—Irrigation Water Management.

Agricultural producers depend on the availability of surface and groundwater to supply irrigation needs and mitigate drought, and while just 17 percent of all harvested cropland in the U.S. is irrigated, these areas contribute over 40 percent of our food supply including the predominance of fruits, nuts and vegetables with high market value. Improving the efficiency of irrigation practices can increase the availability of water for other uses (urban, industrial, ecosystem, recreation and the environment). Irrigated areas of the United States have grown from 7.8 million acres in 1900 to 56.6 million acres in 2007. About 42 million acres of irrigated land are in the 17 western States. The remaining 14 million acres of irrigated land are in the humid East. The East is experiencing faster growth than any other region, gaining almost 190,000 acres annually from 1997 to 2007. As demand for biofuel feedstock increase there is increasing pressure to produce more food on less land using irrigation technologies. The increased demand for water from all sectors leads to an emphasis to produce more crop per drop and to increase the efficiency of irrigation practices. Climate change induced variations in precipitation and snowmelt also place a greater need for efficient methods to trap, store, and deliver water needed for irrigation.

Selected Accomplishments

Water network updates regional water use projections in northern Texas for next 50 years. In the northern Texas High Plains, where irrigation accounts for 90% of all water use, accurate and representative water use estimates are necessary to sustain agricultural production. ARS and Texas AgriLife Research updated and improved data on plant and evaporative water loss (i.e., evapotranspiration (ET)) from the Texas High Plains ET Network (TXHPET), using them to estimate water use and irrigation water demand for all crops grown in the Texas Panhandle. The ET data are used with Farm Service Agency crop acreage data and precipitation on a county basis to run the Texas A&M–Amarillo (TAMA) irrigation demand model, modified to include new crop categories and yearly and forecasted ET data inputs. These new estimates reflect both regional production potential as well as actual reductions in water use by producers using new and improved irrigation management techniques, and are being used by regional water planners for water demand planning purposes, by water conservation districts for establishing groundwater pumping regulations, and for regional socio-economic and sustainability analyses.

Guidelines and protocols developed for regional-scale salinity assessment in the Red River Valley. Land managers and policy makers across the globe need a regional-scale tool for measuring and inventorying soil salinity in agricultural fields where salt buildup can lower crop yields. A scientific team led by an ARS scientist at Riverside, CA, used Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery to assess and map soil salinity in 300,000 hectares of North Dakota's and Minnesota's Red River Valley (RRV). Rising salinity levels in RRV soils have been linked to increasing in precipitation and rising water tables resulting from climate change. The team found that 53 percent of the variability in soil salinity measured *in situ* was correlated with a vegetation (crop) index derived from MODIS satellite imagery averaged over 7 years of data collection, and whether the land was eligible for inclusion in the Conservation Reserve Program (a federal program that sets aside marginally productive land for conservation purposes). The observed relationship between soil salinity measured in the field and the satellite-derived vegetation (crop) index provides NRCS with protocols and guidelines for mapping soil salinity over hundreds of thousands of hectares in the RRV, with applicability in many other regions of the world as well.

New FAO guidelines developed for water quality criteria for irrigation. Increased use of marginal waters and treated wastewaters for irrigation increases the need for accurate water quality criteria degrading pH, sodium absorption ratio (SAR), and salinity. ARS scientists in Riverside, CA used new field and laboratory experiments to refine earlier water quality criteria relating infiltration hazard to pH, SAR, and salinity. These guidelines replace earlier FAO criteria that did not consider pH and underestimated the adverse impact of even slight increases in SAR on water infiltration. Results from this work provide water quality specialists, water planners, regulatory agencies, and producers with an improved ability to evaluate the infiltration hazards associated with application of a specific irrigation water composition. The improved guidelines ensure safer use of saline waters for irrigation and thus extend the supply of fresh water resources.

Improvements made in remote sensing for water use efficiency. The estimation of evaporation of water from plants (ET) with satellite and airborne remote sensing has great promise for increasing crop water use efficiency in irrigated lands because spatial water use patterns are readily distinguishable. Thermal infrared remote sensing in particular can be especially helpful for detecting crop water stress. However, implementing remote sensing image data into farm-scale routines has been very difficult because of cloudy skies, infrequent images, or coarse resolution. ARS scientists in Maricopa, AZ demonstrated that these problems can be reduced by combining spatially-oriented remote sensing data with time-oriented land surface temperature data from fixed ground-based sites. This combined data approach can reasonably forecast crop ET up to 10 days without additional remote sensing data. This information will be valuable for scientists and engineers involved in developing decision support tools for irrigation.

Conservation tillage increases cotton yield under drought conditions. Current climate models predict that as greenhouse gasses continue to accumulate in the atmosphere, periods of drought in the southeastern US will increase. For southeastern agriculture to adapt to these predicted changes requires production practices that maintain productivity during extended rain-free periods. In collaboration with Clemson University, ARS scientists at Florence, SC, found that compared to conventional tillage, conservation tillage resulted in a 25% increase in cotton yield in drought years. Researchers and extension personnel can use these results to develop improved cotton production practices to ensure sustainable cotton production in a changing climate.

Problem Area 3—Drainage Water Management Systems.

Specific guidelines and tools are needed for nutrient and pesticide management in both surface and subsurface drainage water management systems. Automation of these systems, including the integration of weather forecasts, could enhance water conservation benefits during short-term drought periods in humid areas. Long-term soil quality improvement, increased water availability (quantity and quality), and wildlife benefits are all possible with improvements in wetland management practices. Improved drainage water management can also improve water use efficiency in irrigated agriculture while reducing the long-term effects of salinity and trace elements under different cropping systems. The combined effects of improved subsurface drainage water management practices and alternative cropping systems for irrigated agriculture need to be incorporated into an environmental and economic decision support system that fully evaluates the cost-effectiveness of these systems.

Selected Accomplishments

Potential of drainage water management to improve water quality in the Midwestern US quantified. Drainage water management (DWM) is a promising technology for reducing nitrate losses from artificially drained (or “tiled”) fields, but while there is an extensive history for the practice in North Carolina, little is known about the efficacy or cost effectiveness of the practice under Midwest conditions where artificial drainage is widely used. ARS scientists at Ames, IA used soil and land cover databases combined with modeling to estimate that 4.8 million ha of

land currently used to grow corn in the Midwest would be suitable for DWM, with the potential to reduce nitrate loss by approximately 83,000 metric tons (91,300 tons) per year. Considering the cost of control structures, redesign of new drainage systems, and payments to farmers to adjust the control structures to reduce nitrate losses, the cost per kg of nitrate removed from drainage water by DWM was estimated at $2.71 ($1.23/lb). While this is more than the current cost of nitrogen fertilizer, it represents a competitively priced alternative method for removing nitrate from agricultural drainage waters that does not involve taking arable land out of production. Both farmers and state and federal action agencies can use this information to set priorities for the expenditure of conservation funds to improve surface water quality.

Closing the curtain on phosphorus losses from agricultural fields to drainage ditches. The loss of phosphorus in shallow groundwater leaving fields of the Delmarva Peninsula can account for more than 90% of the phosphorus exported by drainage ditches to tributaries of the Chesapeake Bay. ARS scientists at University Park, PA installed a curtain of gypsum (calcium sulfate) along the border of a field from which high loads of phosphorus had previously been recorded in groundwater. During the first rainstorms after installation, the new curtain (or permeable reactive barrier) removed 38-59% of the dissolved phosphorus in groundwater. Efforts are underway to expand the testing of this practice for enhancing water quality to other areas in the region.

Problem Area 4—Integrated Soil Erosion and Sedimentation Technologies.

Soil erosion, sediment movement, and deposition processes involve the interactions of land management practices with climate, soil, and landscape properties. Because erosion affects soil properties progressively over time and generally results in decreased soil quality and reduced resistance of agricultural systems to stresses, soil erosion control is essential for sustainable agricultural production systems. Sediment generated by soil erosion has costly, negative off-site impacts on downstream channel evolution, flooding, and water and air quality. Better erosion control technologies and improved decision support systems for planning and assessment are needed. In both cases, local effects on a field, farm, or channel, and off-site impacts at the larger watershed scale are necessary.

Selected Accomplishments

Updated Water Erosion Prediction Product (WEPP) (version 2010.1) released. The updated Water Erosion Prediction Product (WEPP) model (version 2010.1), released in January 2010, contains significant improvements in the prediction of soil freezing and thawing, snow accumulation, and runoff resulting from snowmelt. Cooperative work between ARS-NSERL, ARS-Pullman, and Washington State University resulted in this updated version. In validation studies using data from Pullman, Washington, and Morris, Minnesota, the new model performed significantly better than the previous version. The updated WEPP model will impact thousands of users throughout the U.S. and the world, providing better predictions of runoff, soil loss, and sediment yield from hillslopes and small field-scale watersheds. Users in areas experiencing substantial erosion from snowmelt on thawing soils should notice particularly better performance.

Improved technology to measure sediment improves ability to assess conservation practices for erosion. Measurements of the concentration of sediment in the streams of agricultural watersheds are difficult and expensive to collect. Yet streams are responsible for moving the majority of sediment eroded from the land. In collaboration with National Center for Physical Acoustics, ARS scientists at Oxford, MS developed a new technology using acoustic attenuation that contributes to the measurement of fine suspended sediments in streams. Results showed that this new acoustic technology could be used to measure a useful concentration range of fine sediment (<0.062 mm) in water. The technology is amenable to remote, autonomous deployment, is relatively inexpensive, and gives much more detailed information than traditional manual sampling techniques.

Sedimentation rates in Mississippi Delta lakes impacted by watershed management practices. Measuring the performance of costly watershed management practices is a problem with far-reaching impacts. Civilization and intensive agriculture have caused erosion rates many times higher than that of undisturbed land, but since the effects of erosion control measures are not often measured, the return on the investment of funds used to control erosion is largely unknown. Sediments stored in lakes are a valuable archive for recovering information on the erosion history of the surrounding watersheds. ARS scientists at Oxford, MS, examined sediments from five natural oxbow cutoffs in the Mississippi River alluvial floodplain, using ^{210}Pb decay rates and bomb-pulse derived ^{137}Cs to date episodes of sediment deposition and develop trends in sedimentation rates associated with management practices. Radioisotope dating methods worked best when used in concert with known dates for implementation of management practices. Using these methods, changes in sedimentation rates over intervals as short as 15 years were detectable.

A beta version of a predictive overtopping breach erosion model completed. Present and future USDA Small Watershed Dams will require assessments to determine hazard classification, population at risk, and emergency action plans, and for prioritizing rehabilitation of aging infrastructure. A physically based dam embankment failure predictive model is essential for conducting these in-depth assessments. A cooperative effort between the ARS Hydraulic Engineering Research Laboratory, NRCS, and Kansas State University, has resulted in the development of a computer engineering application tool WinDAM B (Beta version). The application software allows engineers to evaluate embankment overtopping erosion, breach timing, breach location, breach failure, and flood discharge, for flood overtopping of homogeneous earthen embankments. This computer tool will be important in evaluating existing structures, with potential for determining hazard classification, developing emergency action plans, and reducing costs associated with rehabilitation.

Problem Area 5—Watershed Management, Water Availability, and Ecosystem Restoration.

Agricultural lands, including crop, pasture, and range lands, constitute over 70% of the continental U.S. and play a dominant role in the management of the Nation's watersheds and the water resources needed for human consumption, recreation, agriculture, industry, wildlife habitat, aquatic ecosystems and a healthy environment. The confluence of unprecedented demands for freshwater, rapidly changing land use to accommodate rural and urban growth and biofuel production, recurring droughts, and regional climatic variations means that the Nation’s freshwater resources, agricultural production, and ecosystems are under more pressure and at greater risk than ever before. Thus, there is a need to accurately quantify and manage our water resources to support these many uses across heterogeneous agricultural and urban landscapes. Watershed management based on multiple objectives that include water supply, water pollution, urban development, climate variability, recreation, ecosystem protection and habitat restoration is a complex task necessary not only to support the goals of the Clean Water Act and the Endangered Species Act, but also to address concerns of watershed coalitions, policy makers and the public.

Selected Accomplishments

Information derived from satellites—a more efficient way of predicting drought? Compared to traditional networks monitoring precipitation and other weather-related information, satellites have the potential to more readily and accurately assess and predict drought. ARS scientists at Beltsville, MD used thermal infrared (TIR) imagery from the Geostationary Operational Environmental Satellite (GOES) satellite to model hourly plant and evaporative water loss (ET) for a 10-km grid covering the entire contiguous United States, and then used this information to develop an Evaporative Stress (i.e., Drought) Index. Compared to standard drought indices, this satellite-derived index captured spatial and temporal variations in rainfall patterns without the need for expensive precipitation monitoring. Such an index would be particularly useful in parts

of the globe where current monitoring networks are inadequate, but where accurate drought prediction could help to improve food and water security. The model developed by ARS has been revised to use standard National Oceanic and Atmospheric Administration (NOAA) satellite and meteorological data, and is being incorporated into the NOAA Climate Prediction Center's North American Drought Briefing, as well as evaluated by the National Drought Mitigation Center.

Climate change affects intermountain hydrology. A variety of studies have found links between increasing temperatures, declining snowpacks, and earlier streamflow in snow fed streams in the Western U.S., but in all of these studies, the linkages are based on observations collected from multiple locations, and are thus somewhat indirect. ARS scientists at the Northwest Watershed Research Center in Boise, ID analyzed 45 years of air temperature, snow, precipitation, and streamflow data measured at the same location, the Reynolds Creek Experimental Watershed. Over the period of record, average air temperature has increased about 2 degrees C, snow disappears more than a month earlier at lower elevations, and while total annual precipitation has remained constant, the onset of streamflow now occurs earlier in the season. In the intermountain west where the vast majority of agriculture is irrigated, water allocations are based in part on water discharge in early spring following snowmelt, with the snowpack functioning as a reservoir to retain water in the upper portions of the watershed. Without building additional reservoirs, the earlier snowmelt and onset of streamflow will mean that less water will be available during the growing season to support irrigated agriculture.

Aerial photography used for mapping giant reed infestations along the Texas-Mexico portion of the Rio Grande. Giant reed is an invasive weed throughout the southern half of the United States, with the densest stands growing along the coastal rivers of southern California and the Rio Grande in Texas. ARS scientists at Weslaco, TX, used aerial photography to map giant reed infestations and estimate infested areas along the Texas-Mexico portion of the Rio Grande. Based on the aerial photographs and ground surveys, the 898 km portion of the river from San Ygnacio to Lajitas was found to be infested with giant reed, with the densest populations located between Laredo and Del Rio. Between Lajitas and San Ygnacio, the total area infested was estimated at 5985 ha, with 3670 ha or 61% on the U.S. side and 2315 or 39% on the Mexican side. In addition to the methods for quantifying giant reed, this study provides the first accurate estimates of giant reed infestations along the Texas-Mexico portion of the Rio Grande. The study will help to estimate water use by giant reed, and will also help both land owners and government agencies manage and control of giant reed infestations.

Soil moisture active passive *In Situ* Sensor Testbed (ISST) successfully installed. As part of the Soil Moisture Active Passive (SMAP) satellite validation program, an *in situ* test bed for soil moisture sensors was developed and installed in Marena, OK. The test bed includes all of the major soil moisture technologies currently used by national and international soil moisture networks, as well as new and emerging technologies like the Cosmic Ray Soil Moisture Observing System and the Global Positioning System Reflectometry project, which will be deploying large-scale networks in the near future. In addition to *in situ* instrumentation, the study will include regular gravimetric sampling and vegetation sampling, which are critical to satellite validation. This test bed will be ongoing through the launch of the SMAP satellite and will be a part of the validation program. This test bed has international cooperation with scientists from Japan and The Netherlands participating in sensor deployment and analysis.

Drought affects water and carbon cycling in a desert grassland invaded by mesquite. One of the most widespread changes currently occurring in the southwestern US is the encroachment of woody plants (shrubs and trees) into grasslands, which affects water and nutrient cycling in these ecosystems. ARS scientists at Tucson, AZ measured water and carbon dioxide exchange between a grassland experiencing woody plant encroachment by mesquite and the atmosphere over a four-year period, determining how precipitation influenced these exchanges. Seasonal drought strongly influenced both water and carbon dioxide exchange. In contrast to current thinking, that woody plant encroachment might increase carbon sequestration, this particular grassland functioned as a net source of carbon to the atmosphere, the magnitude of which

increased with increasing drought severity. Results highlight a complex relationship between vegetation change and climatic variation in precipitation that influences carbon sequestration in these water-limited ecosystems.

Problem Area 6—Water Quality Protection Systems.

Nutrients and pesticides (insecticides, herbicides, fungicides) applied to agricultural fields, and pharmaceuticals (antibiotics and hormones) used in livestock production, can move from their point of use into surface and ground waters, where their presence raises concerns about their impact on aquatic and terrestrial ecosystems and human health. To evaluate fully the risks of using these chemicals and compounds in agriculture, there is a need to know their sources, transport behavior, fate, and biological impact at different concentrations and in different combinations in the environment. ARS conducts research to better understand and predict the source, fate, transport and environmental effects of nutrients, emerging contaminants and inorganic ions. This work provides the basis for the development of best management practices across a range of climates, soils, and agricultural and urban settings. To better design and refine existing practices, new scientific information needs to be developed that clearly delineates how agricultural contaminants move and are transformed within the environment.

Selected Accomplishments

Design and management criteria to support fish, amphibian, and reptile populations in wetlands created to treat agricultural runoff. The ability of created wetlands to reduce nutrient, pesticide, and sediment loadings in agricultural runoff can be optimized by design and management, but addressing these priorities may result in wetlands that are less beneficial as habitats for aquatic vertebrates (e.g., fishes, amphibians, reptiles) exhibiting worldwide population declines. ARS scientists in Columbus, OH documented differences in fishes, amphibians, and reptiles in two wetland types created by the wetland-reservoir-subirrigation system (WRSIS), and used this information to develop design and management criteria to increase the ecological benefits of these agricultural water-recycling systems. Differences in amphibian abundance and species composition between WRSIS wetlands and reservoirs suggest their potential to provide habitats for different communities, with wetlands favoring amphibian populations and reservoirs favoring fishes. However, this was not the case for ‘pond-type’ wetlands that, similar to reservoirs, favored fishes. To alleviate this problem, design and management criteria were developed to enable WRSIS wetlands to be managed as amphibian habitat, and reservoirs to be managed as fish habitat. These criteria can be used by federal, state, and private agencies creating agricultural wetlands, to assist them meeting their conservation and restoration goals.

Denitrifying bioreactors reduce nitrate loads in stream waters. Farmers need low-cost and simple technologies to help reduce the export of excess nitrogen in subsurface drainage waters to sensitive aquatic ecosystems. Denitrifying bioreactors introduce solid carbon substrates into the flow path of contaminated water. ARS scientists at Ames, IA summarized bioreactor design alternatives, effectiveness, and the factors limiting their performance. Two common designs successfully removed nitrate in the field at rates of up to 22.0 g N per cubic meter per day. Removal rates varied with the design, the rate of water flow, and incoming nitrate concentrations. These bioreactors may also reduce the transport of veterinary antibiotics (sulfamethazine, enrofloxacin) present in manure, and the herbicide atrazine, commonly applied to corn, without affecting denitrification rates. Denitrifying bioreactors are cost effective and complementary to other practices that can decrease nitrate loads to surface waters. This information will be of use to farmers and state and federal action agencies in setting priorities for the expenditure of conservation funds to improve surface waters affected by excess nitrate.