FY 2012 Annual Report
National Program 211 - Water Availability and Watershed Management

Introduction

There is no substitute for fresh water nor are there replacements for its essential role in maintaining human health, agriculture, industry, and ecosystem integrity. Throughout history, a key measure of civilization's success has been the degree to which human ingenuity has harnessed freshwater resources for the public good.

As the Nation was established and expanded, it flourished in part because of its abundant and readily available water and other natural resources. With expansion to the arid west, investments in the use of limited water resources became critical to economic growth and prosperity. In the 19th century, water supplies for new cities were secured by building reservoirs and water distribution systems. The 20th century was characterized by pivotal accomplishments in U.S. water resource development and engineering. Investments in dams, water infrastructure, irrigation, and water treatment provided safe, abundant, and inexpensive sources of water, aided flood management and soil conservation, and dramatically improved hygiene, health, and economic prosperity. The U.S. water resources and technologies were the envy of the world.

In the 21st century, the situation is much different for the U.S., and indeed for the world. Depleted ground water reserves, degraded water quality, and adverse climate conditions are reducing the amount of available freshwater. At the same time, allocations of our freshwater resources are shifting among different users and different needs (e.g., from agricultural to urban uses; from storing water supplies in reservoirs to maintaining in-stream flows to support healthy aquatic ecosystems; from industrial and energy production to recreation). Our shared freshwater supply has been significantly reduced and is becoming more variable, unreliable, and inadequate to meet the needs and demands of an expanding population.

Water-related science and technology have served our Nation well. We have built infrastructure that provides safe drinking water to our cities, irrigation water to grow a large portion of our Nation's food supply, water for industry, and the means to keep waterways navigable. Through improved waste treatment technologies, we have made great strides in improving water quality, and have protected and enhanced our waterways to provide habitat for aquatic organisms and recreational opportunities for the public.

Today, the agricultural and energy sectors are the two largest users of water in the U.S. Some of the water use is consumptive—water is lost through crop water use or evaporation from cooling. When fresh and saline water withdrawals for thermoelectric use are combined with those for hydropower, the energy sector has the largest water use. When only freshwater withdrawals are considered, agriculture is clearly the largest user of water and the least understood in terms of opportunities for conserving water supplies and improving water quality for drinking, swimming, and fishing.

In the 21st century, agriculture faces new challenges—the increasing demand for water by our cities, farms, and aquatic ecosystems; the increasing reliance on irrigated agriculture for crop and animal production and farm income; and changing water supplies due to groundwater depletion in some areas, climate variability, and global change. These challenges are not insurmountable. Science can provide the tools needed by water planners and managers to accurately predict the outcomes of proposed water management decisions, and new technologies can widen the range of options for future water management. The factual basis for decision-making includes an understanding of effectiveness, potential unintended consequences, and a plan for getting water users and agencies to adopt the most effective technologies. The Nation has the opportunity to use science and technology to build a strong economy and to improve human and ecological health.

The approach for this National Program is to address the highest priorities for agricultural water management (effective water management, erosion, sedimentation, and water quality protection, improving conservation effectiveness in agricultural watersheds, and improving watershed management and ecosystem services in agricultural landscapes). Research will also be conducted to determine the transport and fate of potential contaminants (sediments, nutrients, pesticides, pathogens, pharmaceutically active and other organic chemicals, and salts and trace elements) as well as to assess our capabilities to conserve and reuse waters in both urban and agricultural landscapes and watersheds.

Specific topics to be studied include: irrigation scheduling technologies for water use efficiency; drainage water management and control; field scale processes controlling contaminant fate and transport; improving our understanding of the aggregate effects of conservation practices at the watershed scale; improving conservation practices to better protect water resources; maintaining the effectiveness of conservation practices under changing climate and land use; developing tools to improve hydrologic assessment and watershed management; and improving watershed management and ecosystem services through long-term observation and characterization of agricultural watersheds and landscapes. The overall goal is to provide solutions to problems in the utilization of the Nation's water resources.

This National Program is organized into four problem areas:
- Effective Water Management in Agriculture
- Erosion, Sedimentation, and Water Quality Protection
- Improving Conservation Effectiveness
- Improving Watershed Management and Ecosystem Services in Agricultural Landscapes

EFFECTIVE WATER MANAGEMENT IN AGRICULTURE

Human civilization learned millennia ago that supplying adequate food and fiber in many regions requires artificial manipulation of the natural hydrology through irrigation and drainage. In the U.S., irrigated agriculture produces 49% of crop market value on 18% of cropped lands. Irrigation is essential to the most highly productive, intensely managed, and internationally competitive sectors of our agricultural economy, which play a key role in meeting growing global food, fiber, and energy needs. Equally important to production agriculture are surface and subsurface drainage. On approximately 120 million acres throughout the nation, removing excess water has resulted in reliable crop production. Yet agriculture is subject to growing competition for water resources, and irrigation and drainage systems must be improved to deal with adverse environmental effects and inevitable reductions in water resources available for irrigated agriculture in some areas.

Selected Accomplishments

WinSRFR 4.1 released to the public and Natural Resources Conservation Service (NRCS). The water-use efficiency of gravity (surface) irrigation, the prevalent method of on-farm water application in the United States and worldwide, is typically low, but can be substantially improved if systems are designed and/or operated based on hydraulic engineering principles to maximize water distribution. ARS researchers in Maricopa, Arizona, released Version 4.1 of WinSRFR, a surface-irrigation software program that can be used to analyze field evaluation data, estimate field infiltration properties, analyze design alternatives, optimize operations, and conduct simulation studies. The new software features an updated simulation engine that was reprogrammed using a design layout that includes a modern graphical diagnostic and debugging tool. New functionalities include improved simulation capabilities and irrigation modeling. Intended users include university extension agents, farm advisors, irrigation consultants, and NRCS irrigation specialists. (NP 211, Component 1, Problem Statement A; Performance Measure 6.1.1, Project No. 5347-13660-007-00D)

Canopy temperature as a guide for irrigation scheduling. Canopy temperature has been successfully used for irrigation scheduling in arid environments, but in humid regions the technique is limited by high humidity and intermittent cloud cover. Infrared thermometers are a convenient, non-contact way of measuring crop canopy temperatures that are not affected by high humidity or cloud cover. With colleagues from the University of Missouri, ARS scientists in Columbia, Missouri, evaluated an alternate irrigation scheduling method for humid environments using canopy temperatures measured by infrared thermometers. Although soybean and cotton yields were not significantly different across a range of irrigation treatments, use of the infrared technique improved irrigation water use efficiency—crop yield per unit of irrigation water—for corn and cotton. Irrigation is already increasing in humid areas. Many climate change models predict more frequent droughts in these regions in the future, that will likely lead to further increases in irrigation. As demand for water in humid environments increases, for both irrigation and other purposes, the infrared method shows potential to aid in irrigation scheduling to optimize water management and protect water supplies. (NP 211, Component 1, Problem Statement A; Performance Measure 6.1.1, Project No. 3622-13610-002-00D)

> Bockhold, D.L., Thompson, A.L., Sudduth, K.A., and Henggeler, J.C. 2011. Irrigation scheduling based on crop canopy temperature for humid environments. Transactions of the ASABE 54(6):2021-2028.

New soil water sensor improves the water use efficiency of irrigation. Knowledge of soil water content is a key parameter for irrigation scheduling and farm management, the development of new drought-tolerant and water-efficient crop varieties and hybrids, and for watershed and environmental management. In cooperation with a private firm, ARS scientists at Bushland, Texas, in the Texas High Plains, invented a new, accurate, automatic system for simultaneously measuring soil water content and bulk electrical conductivity, and applied for a patent for this new system. The system can be installed to depths greater than 10 feet, in 8-inch sensor segments, to cover only as much of the crop root zone as needed for irrigation management, or to measure the complete soil profile from the surface to well below the root zone. The additional ability to measure soil bulk electrical conductivity enables better management of salt-affected soils and monitoring of environmental contamination. (NP 211, Component 1, Problem Statement A; Performance Measure 6.1.1, Project No. 6209-13000-014-00D)

Evett, S.R., Schwartz, R.C., Casanova, J.J., and Heng, L.K. 2012. Soil water sensing for water balance, ET, and WUE. Agricultural Water Management 104:1-9.

Generalized hydraulic guidelines and tools developed for roller compacted concrete (RCC) spillways. Inadequate spillway capacity is a common deficiency in aging embankment dams; RCC stepped spillways might be the solution. ARS researchers in Stillwater, Oklahoma, are continually developing and enhancing generalized design criteria for RCC stepped spillways, to protect dams from overtopping and to increase spillway capacity, to aid in the rehabilitation of aging embankment dams. Flow depth, energy dissipation, air concentrations, and air entrainment relationships were developed from two height (H):volume (V) (4(H):1(V) and 3(H):1(V)) sloped RCC stepped spillway physical models, data were collected from a 2(H):1(V) slope stepped spillway, and preliminary data analysis is underway. Data will enhance generalized design relationships for inception point, flow, depth, energy dissipation, and air concentrations. Relationships developed will provide quantifiable design guidance for engineers to use in designing RCC stepped spillways, as well as economic justification for selecting particular design parameters (e.g., step height), while also keeping in mind the safety of the general public. Approximately 1100 embankment dams constructed under the Small Watershed Program administered through Natural Resources Conservation Service (NRCS) are expected to utilize this technology. Increased knowledge of air entrainment properties within stepped spillways has great potential to extend the design life of thousands of embankment dams worldwide. (NP 211, Component 1, Problem Statement B; Performance Measure 6.1.1, Project No. 6217-13000-009-00D)

Hunt, S.L., Temple, D.M., Abt, S.R., Kadavy, K.C., and Hanson, G. J. 2012. Converging stepped spillways: Simplified momentum analysis approach. Journal of Hydraulic Engineering 138(9):796-802.

Water quality criteria for irrigation. Using accurate water quality criteria optimizes the range of water sources that can be used for irrigation sing marginal waters and treated wastewaters. ARS scientists in Riverside, California, used results from new field and laboratory experiments to revise earlier water quality criteria that now relate infiltration hazard to pH as well as SAR (sodium adsorption ratio) and salinity. These new criteria replace earlier Food and Agricultural Organization (FAO) criteria that did not consider pH, and that underestimated the adverse impacts of low SAR on water infiltration. New guidelines are also included for assessing infiltration hazard in environments where rainfall contributes to the water budget. Results from this work provide water quality specialists, water planners, regulatory agencies, and producers with the improved ability to evaluate the infiltration hazards associated with the application of irrigation waters, based on their chemical composition. These improved guidelines ensure safer use of saline waters for irrigation, and thus extend the supply of water resources available for agriculture. (NP 211, Component 1, Problem Statement F; Performance Measure 6.1.1, Project No. 5310-61000-013-00D)

Suarez, D.L. 2012. Irrigation water quality assessments. In: Wallender, W.W. and Tanji, K.K. (eds.).

ASCE Manual and Reports on Engineering Practice No. 71 Agricultural Salinity Assessment and Management (2nd Edition). ASCE, Reston, VA. Chapter 11, pp. 343-370.

EROSION, SEDIMENTATION, AND WATER QUALITY PROTECTION

Surface and/or subsurface hydrologic transport of nutrients, pesticides, pathogens, and emerging pollutants can contaminate water resources and harm aquatic ecosystems. Interactions of land resource management practices with climate, soil, and landscape properties control the processes of sediment detachment, the fate and transformation of contaminants transported in both dissolved and sediment-associated states, and the impacts of these materials on aquatic ecosystems.

Selected Accomplishments

Contaminant transport in karst recharge areas. Karst hydrology, characterized by caves, fissures, and underground streams through limestone, is the most vulnerable groundwater setting for contamination by surface land use activities. Agricultural Research Service scientists in Columbia, Missouri, characterized flow and contaminant transport in two karst recharge area cave systems over a 3-year period. Despite similarities in land use, geology, and weather, water quality in the two cave streams (Devils Icebox and Hunters Cave) was very different. The Devils Icebox recharge area had significantly greater concentrations and total loads of nutrients, sediment, and herbicides than the Hunters Cave recharge area. In the Devils Icebox recharge area, 94 percent of the row crops occurred on high runoff potential soils, as compared to only 57 percent for the Hunters Cave recharge area. Previous research had already demonstrated that these high runoff potential claypan soils are especially prone to the surface transport of contaminants. These new findings led to the development of a stakeholder-led watershed plan for the Bonne Femme watershed that includes the two cave watersheds, with the primary goal of improving water quality by implementing management practices to protect karst recharge areas. (NP 211, Component 2, Problem Statement A; Performance Measure 6.1.1, Project No.3622-12310-004-00D).

Lerch, R.N. 2011. Contaminant transport in two central Missouri karst recharge areas. Journal of Cave and Karst Studies 73:99-113. DOI: 10.4311/jcks2010es0163.

Improved prediction of lateral channel migration. Laterally migrating, meandering streams erode large quantities of fine-grained bank soils, adversely affecting downstream aquatic resources. Previously, tools used to predict future migration patterns have relied on migrations observed in historical aerial images, an approach that introduces great uncertainty. With collaborators at the Universities of Illinois and Pittsburgh, ARS scientists in Oxford, Mississippi, co-developed a new computer model that uses the resistance-to-erosion properties of floodplain soils, in combination with a meandering channel flow model, to predict channel migration rates. This new technology not only improves predicted migration rates but also the predicted patterns of meandering streams. The U.S. Army Corps of Engineers and natural resource agencies in various states have adopted the model to design, locate, and prioritize bank protection and stream restoration works. (NP 211, Component 2, Problem Statement A; Performance Measure 6.1.1, Project No. 6408-13000-023-00D).

Improved estimates of nitrogen availability in years after a dairy manure application. To maximize nutrient use by crops and minimize nitrogen losses to the environment, farmers need to understand how soil nitrogen changes in the years following manure application. Agricultural Research Service scientists at Kimberly, Idaho, measured nitrogen mineralization in the top 2 feet of soil, in soils where manure had been applied one to five years earlier. The fraction of the total applied nitrogen that was available for crop use decreased each year at a different rate depending on the manure application rate. These findings will allow growers in semi-arid, irrigated regions to more efficiently utilize nitrogen from dairy manure to support crop growth. (NP 211, Component 2, Problem Statement A; Performance Measure 6.1.1, Project No. 5368-13000-008-00D)

Lentz, R.D., and Lehrsch, G.A. 2012. Net nitrogen mineralization from past year's manure and fertilizer applications. Soil Science Society of America Journal. DOI:10.2136/sssaj2011.0282.

Drainage ditches document the history of pesticide transport. Drainage ditches surrounding agricultural fields are conduits for stormwater and irrigation runoff, linking production landscapes to aquatic systems such as rivers, lakes, and other water bodies. In collaboration with scientists from Mississippi State University, an ARS scientist at Oxford, Mississippi, analyzed seasonal sediment and water samples from eight ditches throughout the Lower Mississippi Alluvial Valley. Pesticide concentrations in ditch sediments were an order of magnitude higher (150-300 μg kg-1) than those in water samples (6-14 μg L-1). Additionally, out of all collected samples, approximately 87% were below detection limits for the 17 current and past-use pesticides examined. This lack of pesticide prevalence highlights the improved conditions in aquatic systems adjacent to agricultural fields, as well as a potential decrease in pesticide toxicity in the agricultural landscapes of the Lower Mississippi Alluvial Valley. (NP 211, Component 2, Problem Statement A; Performance Measure 6.1.1, Project No. 6408-13660-006-00D).

Kroger, R., Moore, M.T., and Brandt, J.R. 2012. Current- and past-use pesticide prevalence in drainage ditches in the Lower Mississippi Alluvial Valley. Pest Management Science 68:303-312.

New irrigation practices reduce sediment, nitrogen, and phosphorous losses. To meet the needs of a growing global population and improve human nutrition, agricultural production must continue to increase. At the same time, it is necessary to decrease losses of sediment, nitrogen, and phosphorus. ARS scientists in St. Paul, Minnesota, showed that in the U.S. Corn Belt, these goals can be met simultaneously by combining increased landscape water storage with supplemental irrigation. This combination reduces flooding and associated nutrient losses while stabilizing yields and permitting the adoption of alternative cropping practices, like cover crops and living mulches that provide environmental benefits but increase the risk of soil moisture depletion. Annual precipitation and stream flow have increased substantially over the past 50 years, so there is water available to supply supplemental irrigation if it can be stored during periods of excess. Restoration of wetlands and construction of ponds could provide that storage, with the added benefits of creating new wildlife habitat, serving as buffers to reduce downstream losses of sediment and nutrients, and providing additional crop biomass for forages or renewable fuels. Producers would benefit from the additional productivity as well as the reduced financial risk associated with irrigation-stabilized yields, while the broader public would enjoy the environmental benefits. (NP 211, Component 2, Problem Statement D; Performance Measure 6.1.1, Project No. 3640-12130-005-00D)

Baker, J.M., Griffis, T.J., and Ochsner, T.E. 2012. Coupling landscape water storage and supplemental irrigation to increase productivity and improve environmental stewardship in the

US Midwest. Water Resources Research (available at: http://www.agu.org/journals/wr/wr1205/2011WR011780/).

IMPROVING CONSERVATION EFFECTIVENESS

The magnitude of annual Federal expenditures for conservation programs (at least $4B per year) necessitates that the cost of conservation practices implemented through those programs be evaluated in comparison with the environmental benefits they provide. While examining the effects of existing practices can provide a retrospective analysis of prior expenditures, researchable questions remain as to how new practices can be developed, and existing and new practices implemented, to improve the benefits achieved with available funds. The demands for information from ongoing research projects like the Conservation Effects Assessment Project (CEAP), and regional initiatives such as in the Mississippi River Basin (MRBI) and the Chesapeake Bay (CBI), demonstrate the continuing need to assess and improve the benefits of conservation practices.

Selected Accomplishments

Fall-planted cover crops improve water quality in the Upper Mississippi River basin. Fall-planted cover crops are a management practice with benefits that include reducing nitrate losses from artificially drained fields. The practice is widely used in the southern and eastern United States, but little is known about its efficacy in the upper Midwest, characterized by long, cold winters and extensive artificial subsurface drainage systems. Agricultural Research Service scientists in Ames, Iowa, used the Root Zone Water Quality Model to predict the impact of a cereal rye cover crop on reducing nitrate losses from drained fields across five Midwestern states. The model estimated that across this region, winter cover crops, planted at main crop maturity in a corn–soybean rotation, could reduce nitrogen losses in tile flow by an average of more than 40 percent. The model also indicated that if winter cover crops were planted on the area of the five states draining to the Mississippi River, the potential reduction in nitrate-nitrogen losses from drained fields would be about 20 percent of the total nitrate-nitrogen load in the Mississippi River. Additionally, the model estimated that the cost of nitrate-nitrogen removed by cover crops would be from $2.08 to $4.13 per kilogram. This estimated cost is competitive with other management practices that reduce nitrate losses to surface waters. These results are of interest to a broad spectrum of stakeholders seeking viable ways to reduce hypoxia in the Gulf of Mexico. (NP 211, Component 3, Problem Statement A; Performance Measure 6.1.1, Project No. 3625-13000-009-00D)

Qi, Z., Helmers, M., Malone, R.W., and Thorp, K.R. 2011. Simulating long-term impacts of winter rye cover crop on hydrologic cycling and nitrogen dynamics for a corn-soybean crop system. Transactions of the ASABE 54:1575-1588.

Reducing atrazine losses in agricultural landscapes. Atrazine is a popular and economical corn herbicide that occurs in concentrations in drinking water that exceed water quality standards in many supply reservoirs of the upper Midwest. However, the watershed scale impacts of conservation practices aimed at reducing atrazine use have not been quantified, particularly in channelized agricultural headwater streams in central Ohio. Agricultural Research Service scientists in Columbus, Ohio, quantified the conservation practice adoption threshold needed to reduce atrazine concentrations at the watershed scale, and then demonstrated the effectiveness of a USDA National Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) special incentive addressing atrazine in a drinking water supply reservoir. These analyses indicate that the implementation of conservation practices in 30 percent or less of a channelized agricultural headwater stream's watershed is not likely to be effective in reducing atrazine concentrations in these streams. Thus, to achieve watershed-scale reductions in atrazine concentrations a participation in conservation practices greater than 30 percent will be required. Understanding the effects of reducing atrazine usage to achieve watershed scale reductions in atrazine concentrations will help in developing management guidelines for agricultural watersheds in the midwestern United States. In a subsequent investigation in a drinking water supply reservoir, NRCS's EQIP program was used to incentivize operators to adopt one of four practices aimed at reducing atrazine concentrations. Agricultural Research Service research demonstrated that the combined effect of adopting these practices was a significant reduction of atrazine in the reservoir. Most importantly, every dollar spent in EQIP practice incentives resulted in a $2.04 savings for the city of Columbus's downstream water treatment facility, confirming the economic viability of this program. (NP 211, Component 3, Problem Statement A; Performance Measure 6.1.1, Project No. 3604-13000-009-00D)

King, K.W., Fausey, N.R., Dunn, R., Smiley, P.C., Jr., and Sohngen, B.L. 2012. Response of reservoir atrazine concentrations following regulatory and management changes. Journal of Soil and Water Conservation 67(5):416-424.

Smiley, P. C., King, K. W., Gillespie, R. B., and Fausey, N. R. 2012. Watershed scale influence of pesticide reduction practices on pesticides and fishes within channelized agricultural headwater streams. Journal of Sustainable Watershed Science & Management 1:61-75.

Model development to support national conservation assessment. The U.S. Environmental Protection Agency and state environmental agencies have identified approximately 15,000 water quality-impaired water bodies in the U.S. At the same time, it has been mandated that USDA: 1) conduct a thorough analysis of the risks and benefits of USDA conservation programs to human health, safety, and environment; 2) determine alternative ways of reducing risk; and 3) conduct cost-benefit assessments for these practices. Agricultural Research Service scientists at Temple, Texas, El Reno, Oklahoma, and Tifton, Georgia, developed new algorithms for the river basin scale model SWAT (the Soil and Water Assessment Tool) to simulate real time irrigation management, fate and transport of hormones and antibiotics, and the reduction in glacier volumes. As part of the Conservation Effects Assessment Project (CEAP) National Cropland Assessment, the team validated SWAT at more than 40 U. S. Geological Survey (USGS) stream gauges across the U.S. to assure realistic simulation of streamflow, sediment, nutrient, and atrazine loads. The team also completed final SWAT validation and scenario analyses for the Missouri River basin, the Arkansas-Red River basin, and the Texas Gulf basin. Scenario runs from this model identified the optimum placement of conservation practices in the Mississippi River Basin to minimize the flux of nitrogen and phosphorus into the Gulf of Mexico, thus limiting the extent of the hypoxic zone. As part of the CEAP National Rangeland Assessment, plant parameters for western range species were developed, and the team tested the ALMANAC model against biomass production estimates from Natural Resources Conservation Service (NRCS) Ecological Site Descriptions. (NP 211, Component 3, Problem Statement A; Performance Measure 6.1.1, Project No. 6206-13610-006-00D).

Moriasi, D.N., Arnold, J.G., Vazquez-Amabile, G.G., and Engel, B.A. 2011. Shallow water table depth algorithm in SWAT: Recent developments. Transactions of the ASABE 54(5):1705-

1711.

Zhang, X., Srinivasan, R., Arnold, J.G., Izaurralde, R.C., and Bosch, D.D. 2011. Simultaneous calibration of surface flow and baseflow simulations: A revisit of the SWAT model calibration framework. Hydrological Processes 25(14):2313-2320.

Development of a new conservation practice standard. In the young glacial till landscapes of the upper Midwestern United States, closed depressions – known locally as potholes – are widely pervasive. Water from surface drainage collects at the lowest spot in the pothole, keeping the area too wet for farming, even when using standard subsurface tile drains in the field. Most farmed potholes are drained using subsurface tiles, but some also have supplemental drainage from a tile riser (a pipe with holes drilled in its sides) that extends vertically above the soil surface. Agricultural Research Service scientists in West Lafayette, Indiana, found that the extent of potholes within a watershed was directly related to concentrations or loads of nutrients lost from that watershed. Research showed that an alternate practice, called a blind inlet, provided greater filtration of surface water from potholes. As compared to a tile riser, when drained with a blind inlet, watershed-scale phosphorus losses decreased by approximately 78 percent, and nitrogen losses decreased by more than 50 percent. Decreased nutrient losses in runoff waters improve water quality, but also save farmers money, increasing their bottom line. In 2012, ARS scientists in West Lafayette worked with the USDA Natural Resources Conservation Service (NRCS) to develop a conservation practice standard. The NRCS in Indiana now offers blind inlets as a cost-sharable practice through their Environmental Quality Incentives Program (EQIP). (NP 211, Component 3, Problem Statement C; Performance Measure 6.1.1, Project No. 3602-12130-001-00D)

Using weather forecasts to help fertilizer wash into, rather than run off the soil. In partnership with Penn State University colleagues, ARS scientists at University Park, Pennsylvania, unveiled a new statistical technique to predict the likelihood that rainfall will either infiltrate or runoff agricultural soils. Their research, published in the Journal of Soil and Water Conservation, describes the development of empirical models from historical runoff monitoring studies and the application of these models to predicting runoff potential from other areas. This approach is one of several under evaluation as part of the development of the Fertilizer Forecaster, a short-term decision support tool for farmers applying fertilizers and manures, recently funded by USDA's Agriculture and Food Research Initiative (AFRI). (NP 211, Component 3, Problem Statement C; Performance Measure 6.1.1, Project No. 1902-13000-011-00D)

Buda, A.R., P.J.A. Kleinman, G.W. Feyereisen, D.A. Miller, P.G. Knight, P.J. Drohan, and R.B Bryant. 2013. Forecasting runoff from Pennsylvania landscapes. Journal of Soil and Water Conservation (*in press*).

IMPROVING WATERSHED MANAGEMENT AND ECOSYSTEM SERVICES IN AGRICULTURAL LANDSCAPES

Society relies on adequate freshwater resources to support households, agriculture, industry, wildlife habitat, aquatic ecosystems, and a healthy environment. Eighty-seven percent of the nation's drinking water flows over or through agricultural lands. Agricultural watersheds, including crop, pasture, and range lands, cover over 70% of the continental U.S. In the 21st century, unprecedented demands for freshwater, rapidly changing land use, recurring droughts, regional climatic variations, and new demands for energy production on working lands mean that the Nation's freshwater resources are at risk now more than ever before. A primary concern of ARS customers, stakeholders, and partners is the accurate quantification and management of our water resources to support people, agriculture, and the environment. Increasingly, this is done across heterogeneous agricultural and urban landscapes. Integrated watershed and landscape management, based on multiple objectives that include the provision of ecosystem services such as a clean and abundant water supply, agricultural (food, fiber, and fuel) production, improved wildlife habitat, greenhouse gas reduction, soil stabilization, recreational opportunities, reduced energy consumption, and reduction of urban wastes, is a complex task necessary not only to support the goals of legislation such as the Clean Water and Endangered Species Acts, but also to address the concerns of watershed coalitions, policy makers, and the public.

Selected Accomplishments

New downscaling methodology enables generating daily precipitation for climate change scenarios. Climate change scenarios produced by the National Oceanic and Atmospheric Administration are at a spatial and temporal scale that is too large for direct application for investigations of soil, water, and agricultural production issues. This significantly limits our ability to model the impacts of various climate change scenarios in agricultural landscapes and watersheds. Needed is a methodology to bridge the gap between the time and space scales at which climate change scenarios are developed, and the daily weather data needed for farm or watershed scale applications. ARS scientists at El Reno, Oklahoma developed and published such a methodology, subsequently verified with precipitation data from various continents that included climatic zones ranging from polar to tropical. Scientists from China, Canada, and the US have evaluated and are now using this downscaling methodology to study the potential impacts of climate change on natural resources at farm or station scales. (NP 211, Component 4, Problem Statements A and D; Performance Measure 6.1.1, Project No. 6218-11130-005-00D)

> Garbrecht, J.D. 2012. Random, but Uniform Please: Requirements for Synthetic Precipitation Generation for Computer Simulation in Agriculture. Applied Engineering in Agriculture 28(2):207-217.
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> Garbrecht, J.D., and Zhang, X.J. 2013. Generating synthetic daily precipitation realizations for seasonal precipitation forecasts. Journal of Hydrologic Engineering (*in press*).
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> Zhang, X.J. 2011. Cropping and tillage systems effects on soil erosion under climate change in Oklahoma. Soil Science Society of America Journal 76(5):1789-1797.
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> Zhang, X.J., Chen, J., Garbrecht, J.D., and Brissette, F.P. 2011. Evaluation of a weather generator-based method for statistical downscaling non-stationary climate scenarios for impact assessment at a point scale. Transactions of the ASABE 55(5):1745-1756.

Predicted reductions in cool-season precipitation and increasing temperatures may facilitate the further spread of invasive South African grasses in semi-desert southwestern U. S. grasslands. Previous research has suggested that the success of introduced South African grasses invading southwestern U.S. desert grasslands is due to their potential utilization of cool-season rains. Native perennial grasses are not thought to use cool-season rains extensively.

Contrary to this expectation, ARS scientists in Tucson, Arizona, demonstrated that some native grasses are better able to sustain higher levels of whole plant carbon uptake, and have higher water use efficiencies, during the exceptionally wet winter/spring conditions associated with a Southern Oscillation/El Nino event than a highly successful South African invasive grass. These findings suggest that the invasive success of this grass due to its more effective use of winter rain. Predicted reductions in cool-season precipitation and increasing temperatures may facilitate the further spread and continued dominance of South African grasses across southwestern U. S. semi-desert grasslands. (NP 211, Component 4, Problem Statement B; Performance Measure 6.1.1, Project No. 5342-13610-010-00D)

Hamerlynck, E.P., Scott, R.L., Barron-Gafford, B., Cavanaugh, M.L., Moran, M.S., and Huxman, T. 2012. Cool-season whole-plant gas exchange of exotic and native desert semiarid bunchgrasses. Plant Ecology 213:1229–1239. DOI 10.1007/s11258-012-0081-x

AgroEcoSystem-Watershed (AgES-W) model provides a tool for improved watershed modeling. New watershed models are needed that can assess the outcome of implementing conservation practices at multiple locations of differing scales within a watershed, and that can also be customized to regional concerns. In collaboration with Colorado State University and German researchers, ARS scientists in Fort Collins, Colorado developed the component-based spatially distributed AgroEcoSystem-Watershed (AgES-W) model (containing 80+ verified modular components for snow processes, water balance, infiltration, groundwater recharge, nitrogen cycling, soil erosion, and plant growth). The AgES-W model contains a unique routing scheme that simulates lateral water movement and chemical transport processes, and interactions between stream flow and groundwater. The AgES-W model has undergone initial evaluation using data from the Cedar Creek Watershed in Indiana (an ARS Conservation Effects Assessment Project watershed) for runoff and nitrogen dynamics between land units. Due to its fully distributed simulation capability, the model has the potential to better quantify conservation impacts on water quality at field to watershed scales. (NP 211, Component 4, Problem Statement C; Performance Measure 6.1.1, Project No. 5402-13660-007-00D)

Ascough II, J.C., David, O., Krause, P., Heathman, G.C., Kralisch, S., Larose, M., Ahuja, L.R., and Kipka, H. 2012. Development and application of a modular watershed-scale hydrologic model using the object modeling system: runoff response evaluation. Transactions of the ASABE 55(1):117-135.

Improving global agricultural drought monitoring. Monitoring global agricultural drought requires the accurate estimation of root-zone soil moisture availability in agricultural areas. Such estimates are commonly obtained through water balance modeling from ground-based observations of meteorological variables (e.g., rainfall and air temperature), but these meteorological observations are not available over large portions of the globe, and thus international soil moisture predictions for those areas are highly inaccurate. To solve this problem, ARS scientists in Beltsville, Maryland, are exploring a number of different strategies to improve model predictions for these areas, including integrating soil moisture retrievals from satellites into existing models and/or the application of new, more complex models. Recent research uses a novel strategy for model evaluation—assessing the quality of root-zone soil moisture retrievals obtained from global water balance models and evaluating the impact of both increased model complexity and the assimilation of satellite-based soil moisture retrievals. Results clearly show that the assimilation of satellite-based soil moisture retrievals is a much more effective strategy for enhancing the quality of model-based soil moisture estimates, thereby improving the accuracy of drought detection and monitoring over large geographic areas, particularly where ground-based observations are not available. These findings are highly relevant to a number of Federal agencies (e.g., the National Oceanic and Atmospheric Administration, the U.S. Agency for International Development, and the USDA Foreign Agricultural Service) that are investing significant resources to improve their capability to monitor agricultural drought at the global scale. (NP 211, Component 4, Problem Statement D; Performance Measure 6.1.1, Project No. 1245-13610-028-00D)

Crow, W.T., Van Den Berg, M.J., Huffman, G.J., and Pellarin, T. 2011. Correcting rainfall using satellite-based surface soil moisture retrievals: The soil moisture analysis rainfall tool (SMART). Water Resources Research 47:W08521. DOI: 10.1029/2011WR010576.

Crow, W.T., Berg, A., Cosh, M.H., Loew, A., Mohanty, B., Panciera, R., De Rosnay, P., Ryu, D., and Walker, J. 2012. Upscaling sparse ground-based soil moisture observations for the validation of satellite surface soil moisture products. Review of Geophysics DOI: 10.1029/2011RG000372.

Estimation of biofuel feedstock production potentials from non-forested riparian zones and grass waterways. The USDA's *Regional Roadmap to Meeting the Biofuels Goals of the Renewable Fuels Standard by 2022* targets the southeastern United States for the delivery of half of the feedstock contributions needed to meet the advanced biofuels goal of 21 billion gallons per year. Using corporate estimates that 34,990 acres must be dedicated to feedstock production within 25 miles of a 36 million gallon per year biofuel conversion facility converting perennial grass feedstocks via cellulosic ethanol production, ARS scientists in Tifton, Georgia, used field trial data to estimate that from 6 to 38 percent of the needed acreage could be gained from riparian buffers and grassed waterways. If taken from agricultural land in the 25-mile radius, the remaining acreage would represent from 3 to 18 percent of current agricultural lands. The analysis suggests the potential to produce nearly 530 million gallons of ethanol per year from riparian zones alone around 11 case study cities in the Coastal Plain of southern Georgia, with another 215 million gallons per year coming from nonprime agricultural lands. (NP 211, Component 4, Problem Statement E; Performance Measure 6.1.1, Project No. 6602-13000-023-00D).