Agricultural Systems for Environmental Quality
ASEQ

An Integrated Systems Approach to Watershed Management and Water Quality

Missouri ASEQ Research and Extension Outreach Project

Authors

Myra B. Smith,
Tony A. Prato
and
Paul E. Blanchard
Missouri MSEA/ASEQ Project
University of Missouri-Columbia

Newell R. Kitchen,
Robert N. Lerch,
Allen T. Hjelmfelt
and
E. Eugene Alberts
Missouri MSEA/ASEQ Project
USDA/Agricultural Research Service,
Cropping Systems and Water Quality
Research Unit

Funding

Funding for this publication was provided by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under special project number 98-EWQI-1-0332.

Production

Pam Roe, editor and designer;
Garry Brix, illustrator
University of Missouri-Columbia

Cover Photo

Mark Twain Lake
by Don Schuster

Printed with soy ink

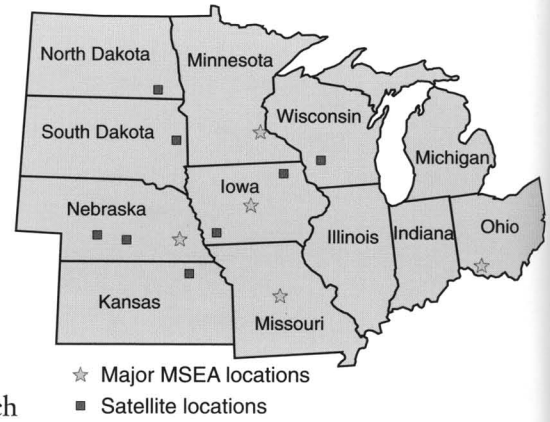
Protecting our resources

Water is one of the most abundant resources in Missouri. About 3.2 million Missouri citizens obtain their drinking water directly from the Missouri and Mississippi Rivers. More than 80 percent of rural Missourians obtain their drinking water from reservoirs and lakes. Both Missourians and non-Missourians alike enjoy the abundant recreational activities associated with these water resources. It is vitally important that the quality of Missouri's water resources be maintained and improved.

The Missouri MSEA/ASEQ Projects

A model for protecting water quality through successful integration of research and education.

The U.S. Department of Agriculture (USDA) initiated five comprehensive projects in 1990 to evaluate and develop profitable cropping systems that safeguard water resources. Known as the Management Systems Evaluation Areas (MSEA), main study sites were established in Iowa, Minnesota, Missouri, Nebraska, and Ohio.



Missouri was also selected to participate in a multistate research and education program called the Agricultural Systems for Environmental Quality (ASEQ) program. It was initiated in 1996 to address water quality and other related environmental issues. The cornerstone of the MSEA and ASEQ programs is the close integration of research, teaching, and extension activities. This integration exists not only within each project, but also among the states coordinating project efforts. Ongoing discovery, learning, and engagement programs among the projects continue to provide useful information to varied audiences, both inside and outside the agricultural community.

Missouri's ASEQ research and extension outreach project promotes an integrated systems approach to watershed management and water quality. The Missouri ASEQ project represents a collaborative effort between:

USDA/Agricultural Research Service
Cropping Systems and Water Quality Research Unit

College of Agriculture, Food and Natural Resources
University of Missouri

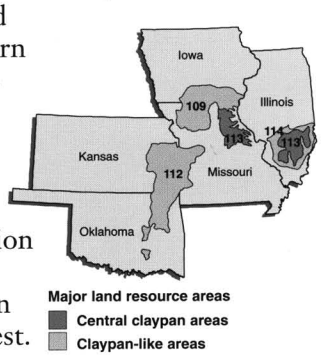
University Outreach and Extension
University of Missouri and Lincoln University

This brochure highlights some of the findings and ongoing research and extension outreach efforts of the Missouri ASEQ project.

Missouri ASEQ: Focus, scale, partners and goals

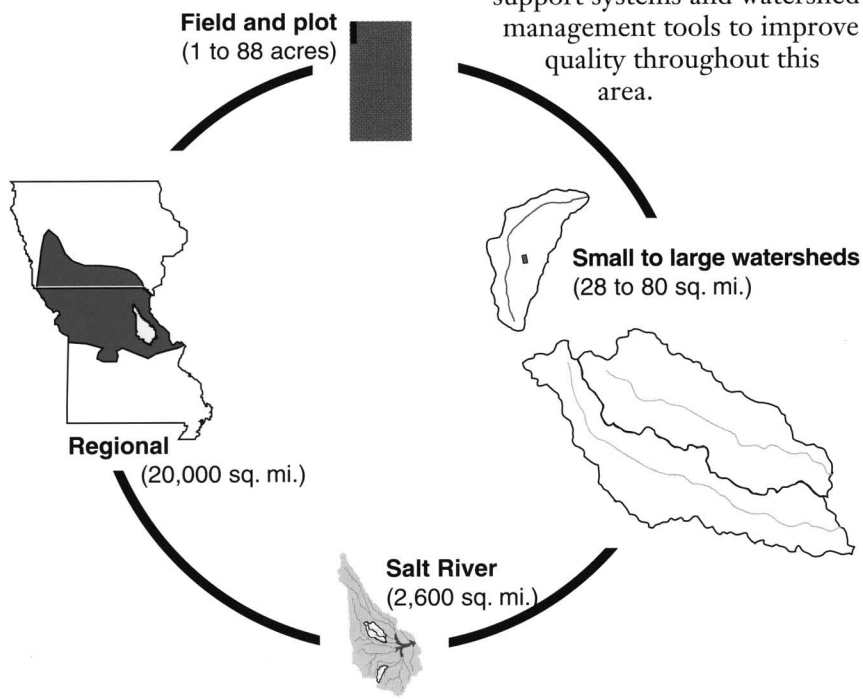
Project focus

Research focuses on the claypan soil region (MLRA 113) in the north central and northeastern part of the state, representative of more than seven million acres of cropland in the Midwest. Research may also be applicable to other areas of the Midwest with climatic conditions, land use, and soils with moderately high to high runoff potential similar to those of northern Missouri. Claypan-like soils (Major land resource areas 109, 112, and 114) are also runoff prone, primarily because they have high clay content subsoils (argillic horizons). There are more than 32 million acres of claypan-like soils in the Midwest.



Project scale

Research is being conducted on a variety of scales including large plots and fields, individual watersheds ranging from 28 sq. mi. to 80 sq. mi., a major river system, and the major river basins throughout northern Missouri and southern Iowa. Multiple scale research will facilitate the development of support systems and watershed management tools to improve water quality throughout this area.



Missouri ASEQ Partners

The ASEQ project works directly with commodity groups, dealers, farmers, Certified Crop Advisors (CCAs) and community watershed alliances. An interdisciplinary, collaborative approach has been the hallmark of the Missouri ASEQ project. Our partners include a large number of other University programs, Water Quality projects, and state and federal agencies, including:

MU Water Quality Program
MU Integrated Pest Management Program
Missouri Precision Agriculture Center (MPAc)
MU Agroforestry Center
MU Commercial Agriculture Program
Center for Agricultural Resource and Environmental Systems (CARES)
Missouri Watershed Information Network (MOWIN)
Mark Twain Water Quality Initiative (MTWQI)
Missouri Watershed Initiative
Natural Resources Conservation Service
Missouri Department of Agriculture
Missouri Department of Natural Resources
U.S. Geological Survey
Environmental Protection Agency

Goals

The Missouri ASEQ project has five major goals:

- **Improve surface water quality**
- **Improve ground water quality**
- **Improve soil quality**
- **Develop and refine decision support aids**
- **Improve information transfer**

This brochure highlights some of the ongoing research and extension outreach efforts focused towards achieving these goals.

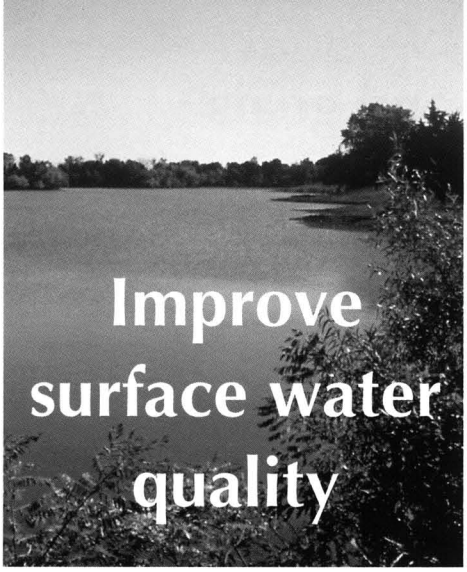


photo by Don Schuster

The most important water quality problem in the Midwest is contamination of streams. The restrictive layer in claypan soil causes nearly 30 percent of the total annual precipitation to be lost as runoff. Dissolved herbicide discharges in surface runoff are generally less than five percent of that applied, but losses as high as 19 percent can occur when intense rainfall follows application.

Regional ASEQ monitoring program

Water quality monitoring throughout northern Missouri showed herbicide losses are strongly correlated to soil type. Soils are categorized into four main hydrologic groups (A, B, C, D) based on estimated water infiltration rates under field conditions. Group D soils have the slowest infiltration rates when wet and the highest runoff potential, and are therefore the most susceptible to herbicide loss in runoff. Figure 1 shows the prevalence and distribution of soils with moderately high to high runoff potential in Missouri, USDA-NRCS data, 1994.

Although maximum herbicide concentrations vary year-to-year because of total streamflow, the same general pattern of herbicide loss occurs each year. Highest atrazine concentrations are in areas with C and D group soils, rather than those areas with the greatest number of corn and sorghum acres. (Figure 2. Maximum atrazine concentrations (ppb) for northern Missouri and southern Iowa rivers, May - June 1997, Missouri ASEQ Project. Figure 3. Percent corn and sorghum acres in Missouri and southern Iowa in 1997, 1998 Missouri Farm Facts and 1998 Iowa Ag Statistics.)

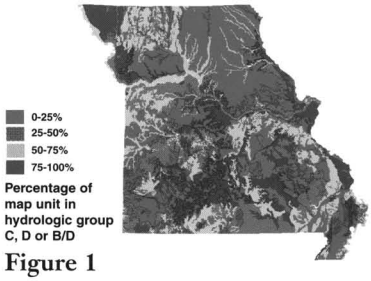


Figure 1

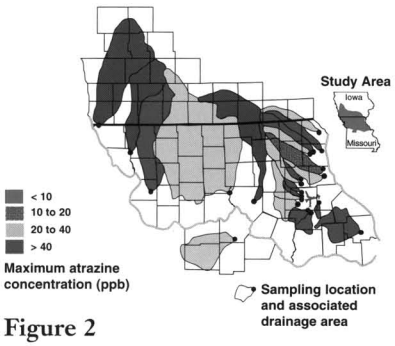


Figure 2

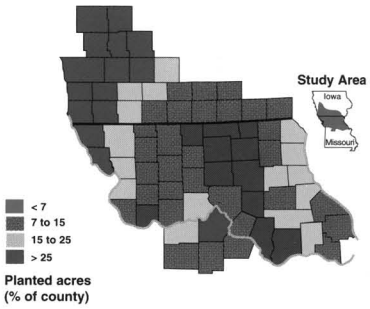


Figure 3

Large plots and fields

This level of research will develop and evaluate the impact of specific best management practices (BMPs) on water quality. Current research is expanding to include total losses of nutrients and sediment.

Watershed projects

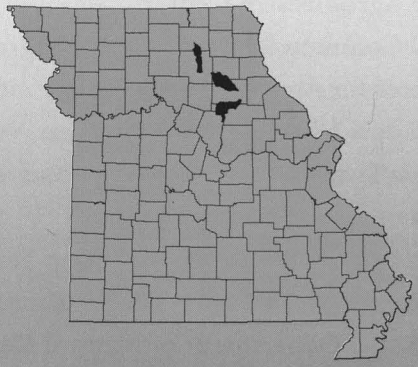
These efforts will demonstrate the efficacy, cost-effectiveness and water quality benefits of BMPs on a watershed scale. They are also aimed at accelerating and documenting the adoption of viable BMPs, and the resulting changes on overall water quality in these watersheds. This effort involves grower surveys; year-round detailed monitoring for herbicides, total nutrients and sediment; and numerous demonstration projects.

TMDL development

Missouri submitted its list to EPA identifying waters that exhibit impairment of designated use and thus require additional pollution controls (1998 303(d) list). Total maximum daily loads (TMDLs) will be established for each contaminant identified on this list. The ASEQ project is working with the Missouri Department of Natural Resources to assist in the development of TMDLs that meet agronomic and economic goals, while protecting our water resources.

Correlation of chemical and biological monitoring

will be done in collaboration with the Agroforestry Center. Biological monitoring and stream restoration sites are planned in each of the targeted watersheds.



Targeted watersheds are located in northeast Missouri.

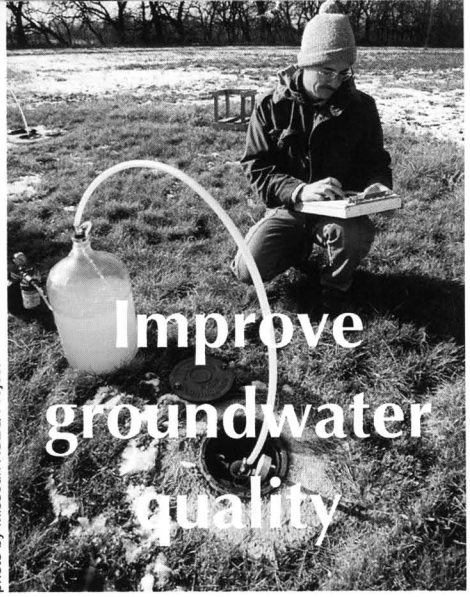
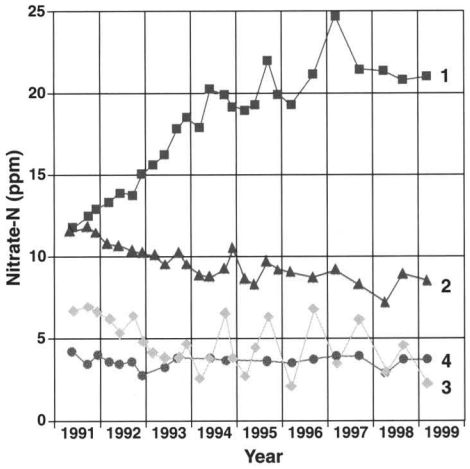


photo by Missouri ASEQ Project

Research has shown that groundwater contamination from pesticides is mainly a problem in localized areas where soil conditions allow rapid transport to shallow groundwater (Midwest Studies Provide Some Answers, 1999 MSEA Regional Publication). Nitrogen (N) leaching into groundwater is a more widespread water quality concern.

Nitrate leaching

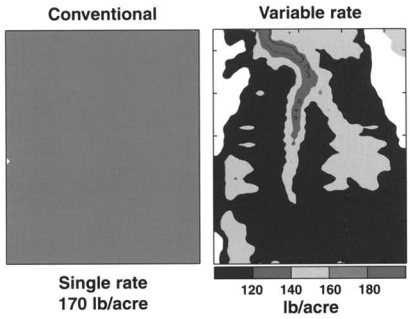
This is the most serious agriculture-related groundwater contamination problem in the Midwest. For glacial drift aquifers underlying claypan soils, nitrate leaching occurs primarily during the fall and winter. Nitrate-N contamination of the glacial drift aquifer is widespread throughout the Goodwater Creek watershed, with 25 percent of wells exceeding 10 ppm. Monitoring results from wells located in fields within the Goodwater Creek watershed over an eight-year period show that nitrate concentrations are slowly decreasing in some wells, but are increasing at alarming rates (1 to 2 ppm per year) in other wells.



Nitrate-N concentrations in four wells located within Goodwater Creek watershed.

Nitrogen loss

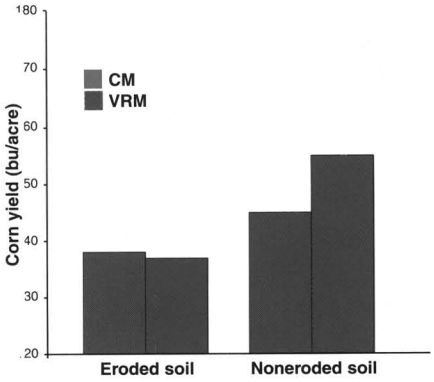
Reducing nitrogen loss to groundwater and streams may be achieved by varying the rate of N fertilizer application with topsoil depth as measured by soil electrical conductivity (EC). Results indicate that the amount of N fertilizer applied to a typical field can be reduced by 10 to 20 percent using variable rate application technology.



Conventional vs. variable rate nitrogen fertilizer application.

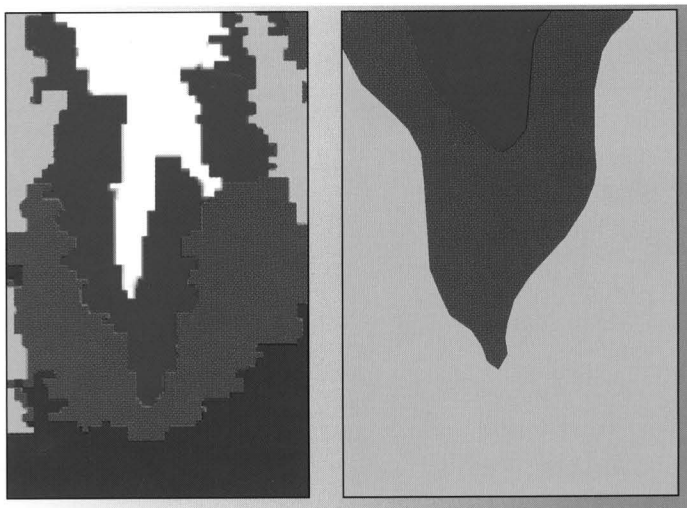
Fertilizer nitrogen-use efficiency

Fertilizer N-use efficiency was increased on test fields using EC-based variable rate management (VRM) vs conventional, one-rate management (CM). Yield between VRM and CM has been similar on eroded soil, but is often higher with VRM on noneroded soil. Post-harvest soil nitrate concentrations varied little between VRM and CM. Results indicate likely within-season leaching losses of fertilizer N for CM. An evaluation of the economic differences between VRM and CM fertilizer applications on claypan soil fields is being conducted using a GIS-based program.



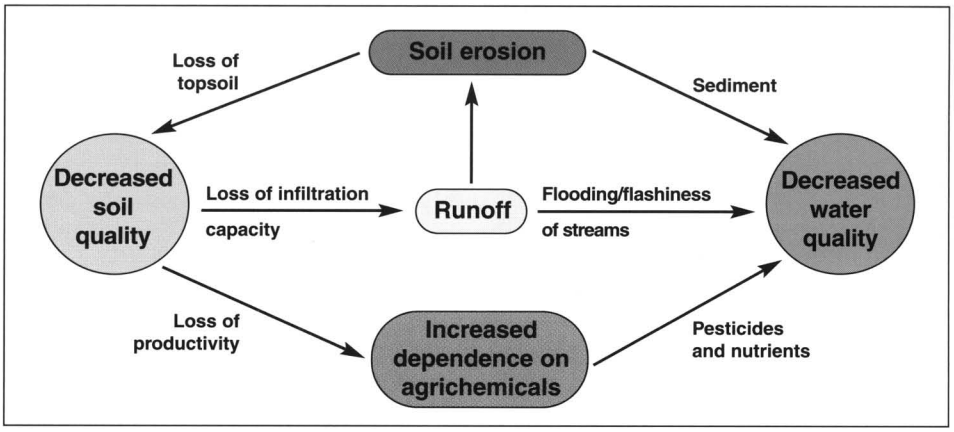
Management zones

Site-specific yield and soil data have been used to develop and evaluate various methods for subdividing fields and mapping unique management zones. A new approach employing GIS tools has been especially helpful in developing potential management zones. These maps have been compared to conventional soil maps and found to be equal or better in explaining the effects of within-field variation on crop production.



Management zones developed using GIS tools (left) vs. conventional soil map (right).

photo by Kim McGinty



Critical linkages between water and soil quality for claypan soils.

Soil quality degradation has led to excessive surface runoff and decreased farmer profitability. Water quality and soil quality are inextricably linked.

Erosion

Erosion has caused significant losses of topsoil leading to reduced infiltration of water because of the low permeability of the claypan subsoil. Reduced infiltration has resulted in increased surface runoff. Increasing the quality of the soil overlying the claypan will not have a measurable impact on increasing infiltration because the hydraulic conductivity of the claypan is so low. Instead, it is the quality of the restrictive horizon that must be improved.

Stiff-stem hedges

These are narrow, parallel strips of stiff, erect, dense, native warm-season grasses planted close to the contour. Their deep roots may open channels to and through the underlying claypan subsoil improving overall infiltration. Studies have also shown potential for reductions in total runoff, sediment, and gully development with the use of grass hedges.

Compatibility with current systems

Compatibility issues include management of hedge residue, spacing between hedges, herbicide resistance, establishment and maintenance challenges, and economic feasibility. Ongoing and new research and demonstration efforts will provide results on how best to use grass hedges in erosion control.

photo by Jingcai Zhu

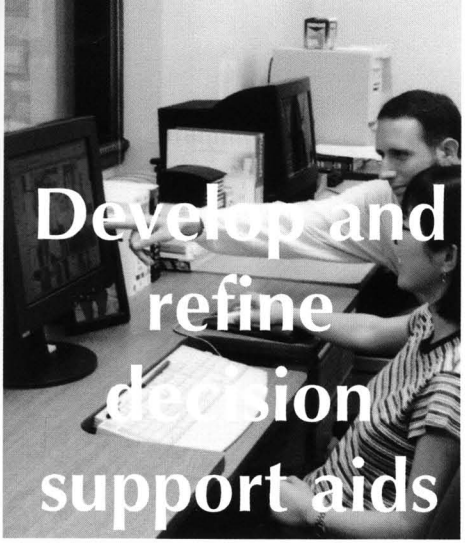
The hedge traps sediment from the field, protecting an intermittent stream.

photo by Jingcai Zhu

Sediment accumulates on the upstream side of the grass hedge.

photo by George Smith

Implementing solutions to water and soil quality problems requires clear two-way communication between researchers and end users. While greater awareness regarding water and soil quality issues exists



Develop and refine decision support aids

Inadequate water and soil quality decision support systems and management tools for land-use planning are a problem in the Midwest.

Watershed-scale management tools

A watershed is made up of many fields. It also includes farmsteads, riparian zones, and the road network that all influence the delivery of surface runoff, sediment, and agricultural chemicals to the watershed outlet. Coupled with this are economic, soil, and water quality risks associated with landscape features, natural conditions, and uncertain weather conditions. Watershed-scale management tools integrate information, knowledge, and technology from different disciplines and support stakeholders' decisions for selecting farming systems to reduce water contamination.

Geographic information systems

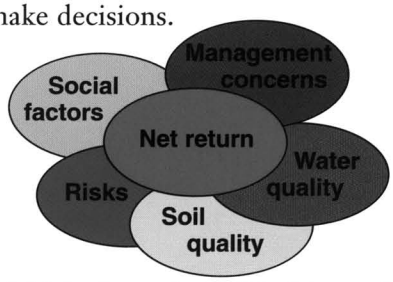
GIS makes it easy to access and manipulate spatial data including soils, land-use, and topography and nonspatial data. It also enables the data to be integrated with economic and simulation models to evaluate and solve soil and water quality problems in a watershed. A GIS also serves as a platform to develop work station and web-based data management and decision support tools.

Biophysical simulations

These mathematical models and decision aids are tools to predict water and soil quality impacts of conventional and best management practices at field and watershed levels.

Multiple criteria decision analysis

This type of analysis helps stakeholders evaluate the tradeoffs among social, economic, soil, and water quality objectives and the associated economic, soil and water quality risks, and to select best management practices. GIS-based decision support tools are accessed by a graphic user interface that makes it easier to access data and make decisions.



Multiple dimensions of decision making.

today than a few years ago, adoption lags behind knowledge and technology. Constraints that prevent the adoption of existing management tools need to be clearly identified and challenged with aggressive extension and outreach demonstration and education efforts.

Partnerships

These are critical to the success of any water quality project. Involving stakeholders in an advisory capacity enhances outreach efforts by creating ownership through participation.

photo by Wanda Eubank

photo by Dan Downing

Educational programs

Programs to disseminate project information and increase understanding and adoption of cropping practices that maintain, protect, and improve our water resources include workshops, meetings, exhibits, extension publications, and the Web. Primary efforts are targeted at groups and individuals with the potential to influence larger audiences. However, project information is also taken directly to small groups of stakeholders.

Field demonstrations

Field demonstrations bring information about the efficacy, practicality, and cost effectiveness of alternative farming systems and site specific management directly to local stakeholders.

For further information contact:

Myra Smith
267 Ag Engr. Bldg.
Columbia, MO 65211
573-882-1112
SmithMy@missouri.edu

Tony Prato
203 Mumford Hall
Columbia, MO 65211
573-882-0147
PratoA@missouri.edu

College of Agriculture, Food, and Natural Resources and University of Missouri Extension, University of Missouri-Columbia

Newell Kitchen
240 Ag. Engr. Bldg.
Columbia, MO 65211
KitchenN@missouri.edu

Robert Lerch
265 Ag. Engr. Bldg.
Columbia, MO 65211
LerchR@missouri.edu

USDA - Agricultural Research Service
Cropping Systems and Water Quality Research Unit

For copies of this special report contact:

Extension Publications
University of Missouri-Columbia
2800 Maguire
Columbia, MO 65211-0001
Phone: 1-800-292-0969
E-Mail: extpubs@missouri.edu

Full text of this manual is available on the Web at
http://www.fse.missouri.edu/ars/cswq.htm

OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211. ■ University Outreach and Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs. ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (573) 882-7216. Reasonable efforts will be made to accommodate your special needs.

Special Report 525

New 5/99/10M