Summary of Findings

Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Arkansas-White-Red River Basin

United States Department of Agriculture
Natural Resources Conservation Service
Conservation Effects Assessment Project

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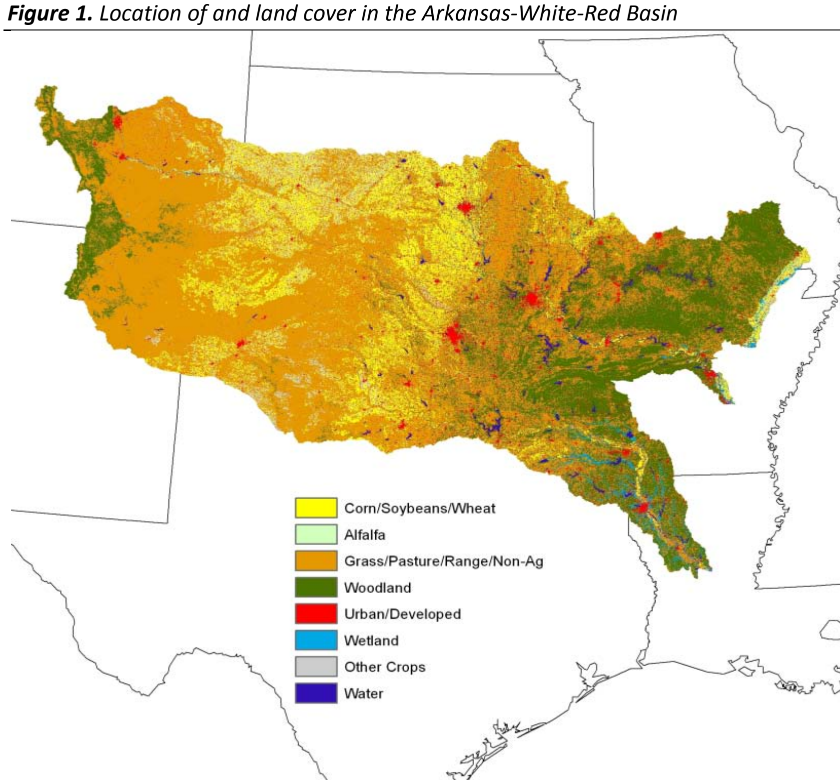
The U.S. Department of Agriculture's Conservation Effects Assessment Project (CEAP) has undertaken a series of studies designed to quantify the effects of conservation practices on cultivated cropland in the conterminous 48 States. The sixth study in this series is on the Arkansas-White-Red Basin. The basin covers about 248,000 square miles and extends from the Continental Divide through the Great Plains to the Lower Mississippi River Basin in Arkansas and Louisiana. It includes all of Oklahoma and parts of Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, and Texas (fig. 1).

Twenty-two percent of the region is cultivated cropland, including land enrolled in the General Signup of the Conservation Reserve Program. The region has 10 percent of all farms and 13 percent of all land in farms in the United States. The basin is similar to the Missouri River Basin, to the north, in the diversity of climate and agriculture across the region. Continuous wheat and rotations that include wheat dominate cropping systems. Irrigation is more common on cropland in the western part of the region.

The most pervasive conservation concern in the region is excessive rates of wind erosion during dry periods, including windborne losses of nitrogen and phosphorus. Wind erosion and windborne sediment degrade the soil, water, and air quality, and can cause human health issues.

Figure 1. *Location of and land cover in the Arkansas-White-Red Basin*



SOURCE: TEXAS AGRILIFE RESEARCH, TEXAS A&M UNIVERSITY (USDA-NASS DATA)

Study Methodology

The assessment uses a statistical sampling and modeling approach to estimate the effects of conservation practices. The National Resources Inventory (NRI), a statistical survey of conditions and trends in soil, water, and related resources on U.S. non-Federal land conducted by USDA's Natural Resources Conservation Service, provides the statistical framework for the study. Physical process simulation models were used to estimate the effects of conservation practices that were in use during the period 2003 to 2006. Information on farming activities and conservation practices was obtained primarily from a farmer survey conducted as part of the study. The assessment includes not only practices associated with Federal conservation programs but also the conservation efforts of States, independent organizations, and individual landowners and farm operators. The analysis assumes that structural practices (such as buffers, terraces, and grassed waterways) reported in the farmer survey or obtained from other data sources were appropriately designed, installed, and maintained.

Difference between these two scenarios represents the benefits of the accumulation of conservation practices currently in place on the landscape.

The national sample for the farmer survey consists of 18,700 sample points with 1,280 of these sample points located in the Arkansas-White-Red Basin. This sample size is sufficient for reliable and defensible reporting at the regional scale and for large watersheds within the region, but is generally insufficient for assessments of smaller areas.

The modeling strategy for estimating the effects of conservation practices consists of two model scenarios that are produced for each sample point.

1. A baseline scenario, the "baseline conservation condition" scenario, provides model simulations that account for cropping patterns, farming activities, and conservation practices as reported in the NRI-CEAP Cropland Survey (2003–06) and other sources.

2. An alternative scenario, the "no-practice" scenario, simulates model results as if no conservation practices were in use but holds all other model inputs and parameters the same as in the baseline conservation condition scenario.

The effects of conservation practices are obtained by taking the difference in model results between the two scenarios. The need for additional conservation treatment was evaluated using a common set of criteria and protocols applied to all regions in the country to provide a systematic, consistent, and comparable assessment at the national level.

Study Findings

These findings represent the baseline conservation condition, using conservation practices reported in the 2003–06 NRI-CEAP Cropland Survey. *Wind erosion is the most pervasive conservation concern in the western part of the region, and nitrogen loss though leaching is the most pervasive concern in the eastern part.*

Voluntary, Incentives-Based Conservation Approaches Are Achieving Results

Farmers have reduced sediment, nutrient, and pesticide losses from farm fields through conservation practice adoption throughout the Arkansas-White-Red Basin, compared to losses that would be expected if no conservation practices were in use. Structural practices for controlling water erosion are in place on 46 percent of all cropped acres in the region, and structural practices for controlling wind erosion are in place on 7 percent. Forty-four percent of cropped acres meet criteria for mulch till. However, only 14 percent meet criteria for no-till, which is much lower than the other regions in the Mississippi River Basin. Thirty-four percent of cropped acres are conventionally tilled. Still, 87 percent of cropped acres have structural or management practices, or both. Farmers meet criteria for high levels of nitrogen management on more than 34 percent of the cropped acres and high levels of phosphorus management on 50 percent. About 31 percent of cropped acres are gaining soil organic carbon—29 percent in the eastern part of the region and 32 percent in the western part. Application of these practices has reduced sediment and nutrient losses from cultivated cropland (table 1).

Table 1. Reductions in edge-of-field losses of sediment and nutrients from cultivated cropland through conservation treatment in place during 2003–06, in percent, Arkansas-White-Red Basin

Location	Sediment		Nitrogen			Phosphorus *	
	Windborne	With runoff	Windborne	With runoff	Through leaching	Windborne	With runoff
	- - - - - - - - - - - - - - - - *Percent reduction* - - - - - - - - - - - - - - - -						
Eastern part of region	**21**	**51**	**22**	**42**	**60**	**33**	**54**
Western part of region	**33**	**76**	**28**	**65**	**54**	**42**	**64**
Entire region	**31**	**61**	**27**	**51**	**57**	**40**	**57**

*** Phosphorus lost to surface water includes sediment-attached and soluble phosphorus. Soluble phosphorus includes not only phosphorus in runoff but also leaching to loss pathways such as tile drains and natural seeps, that eventually return to surface water.**

Opportunities Exist to Further Reduce Soil Erosion and Nutrient Losses from Cultivated Cropland

The need for additional conservation treatment in the region was determined by imbalances between the level of conservation practice use and the level of inherent vulnerability. Areas of sloping soils are more vulnerable to surface runoff and consequently to loss of sediment and nutrients with overland flow of water; areas of level, permeable soils are generally not vulnerable to sediment loss or nutrient loss through overland flow but are more prone to soluble nitrogen and soluble phosphorus losses through subsurface pathways. Three levels of treatment need were estimated:

- **A high level of need** for conservation treatment exists where the loss of sediment and/or nutrients is greatest and where additional conservation treatment can provide the greatest reduction in agricultural pollutant loadings. *Some 1.3 million acres—4 percent of the cultivated cropland in the region—have a high level of need for additional conservation treatment.*
- **A moderate level of need** for conservation treatment exists where the loss of sediment and/or nutrients is not as great and where additional conservation treatment has less potential for reducing agricultural pollutant loadings. *Approximately 9.1 million acres—30 percent of the cultivated cropland in the region—have a moderate level of need for additional conservation treatment.*
- **A low level of need** for conservation treatment exists where the existing level of conservation treatment is adequate compared to the level of inherent vulnerability. Additional conservation treatment on these acres would

provide little additional reduction in sediment and/or nutrient loss. *Approximately 20.1 million acres—66 percent of the cultivated cropland in the region—have a low level of need for additional conservation treatment.*

A total of 10.4 million acres have a high or moderate level of need for additional treatment. Potential reductions from existing levels could be achieved through implementation of suites of conservation practices on cropped acres having high or moderate levels of treatment need. Table 2 shows potential for further reductions (beyond 2003–06 baseline levels) in edge-of-field sediment, nitrogen, and phosphorus losses.

Table 2. Potential for further reductions in edge-of-field losses of sediment and nutrients from cultivated cropland through comprehensive conservation treatment of high- and moderate-treatment-need cropland, Arkansas-White-Red Basin

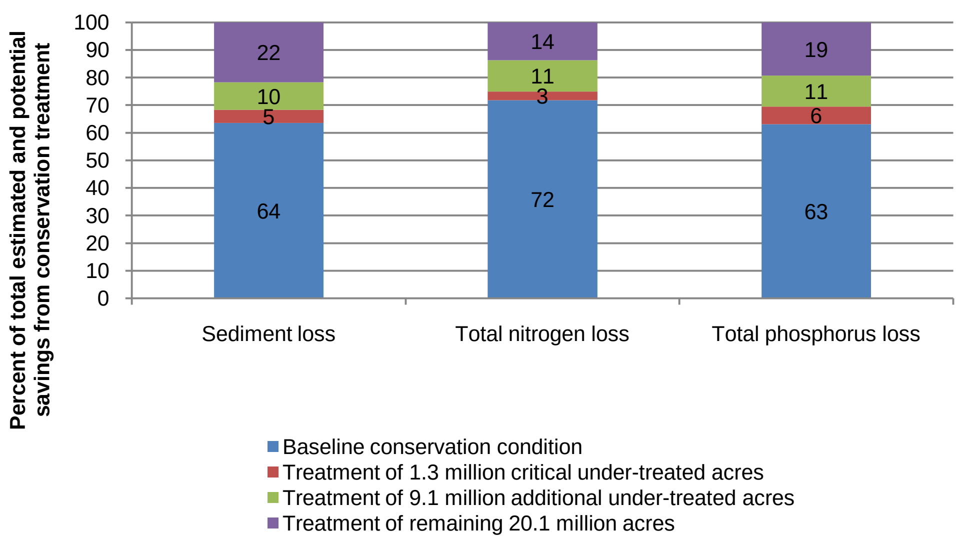
Location	Sediment		Nitrogen loss—		Phosphorus *
	Windborne	With runoff	With runoff	Through leaching	
	Percent reduction				
Entire region	**26**	**36**	**21**	**21**	**21**

*** Phosphorus lost to surface water includes sediment-attached and soluble phosphorus. Soluble phosphorus includes not only phosphorus in runoff but also leaching to loss pathways such as tile drains and natural seeps, that eventually return to surface water.**

Targeting Enhances Effectiveness and Efficiency

The practices in use during the period 2003 to 2006 achieved about 64 percent of potential reductions in sediment loss, 72 percent of potential reductions in nitrogen loss, and 63 percent of potential reductions in phosphorus loss (fig. 2). Significant per-acre reductions in sediment and nutrient losses could be achieved by focusing on the 10.4 million high- and moderate-treatment-need cropland acres. Targeting critical acres significantly improves the effectiveness of conservation practice implementation. Use of additional conservation practices on acres that have a high need for additional treatment—acres most prone to runoff or leaching and with low levels of conservation practice use—can reduce most edge-of-field losses by about twice as much or more compared to treatment of acres with a moderate level of need. Even greater efficiencies can be achieved when comparing treatment of high- or moderate-need acres to low-treatment need acres.

Figure 2. *Comparison of estimated sediment, nitrogen, and phosphorus savings (field-level) due to practices in use in the baseline conservation condition and potential savings with additional water erosion control and nutrient management treatment of cropped acres in the Arkansas-White-Red Basin*



Conservation Practice Effects on Water Quality

Reductions in field-level losses due to conservation practices, including land in long-term conserving cover, are expected to improve water quality in streams and rivers in the region. Figures 3, 4, and 5 summarize the extent to which conservation practices on cultivated cropland acres have reduced, and can further reduce, sediment, nitrogen, and phosphorus loads in the Missouri River Basin, on the basis of the model simulations. In each figure, the top map shows delivery from cultivated cropland to rivers and streams within the region and the bottom map shows delivery from all sources to the Mississippi River after accounting for losses and gains through instream processes. On all three figures—

- "no-practice scenario" refers to conditions that would be expected if no conservation practices were in use;
- "baseline conservation condition" refers to estimates of conditions based on farming and conservation practices in use during the period 2003–06;
- "critical under-treated acres" refers to land with a high level of conservation treatment need, as defined on page 3;
- "all under-treated acres" refers to land with high and moderate levels of conservation treatment need, as defined on page 3; and
- "background" refers to expected levels of sediment and nutrient loadings if no acres were cultivated in the region. Estimates of background loadings simulate a grass and tree mix cover without any tillage or addition of nutrients or pesticides for all cultivated cropland acres in the watershed. Background loads also include loads from all other land uses—hayland, pastureland, rangeland, horticultural land, forest land, and urban land—and point sources.

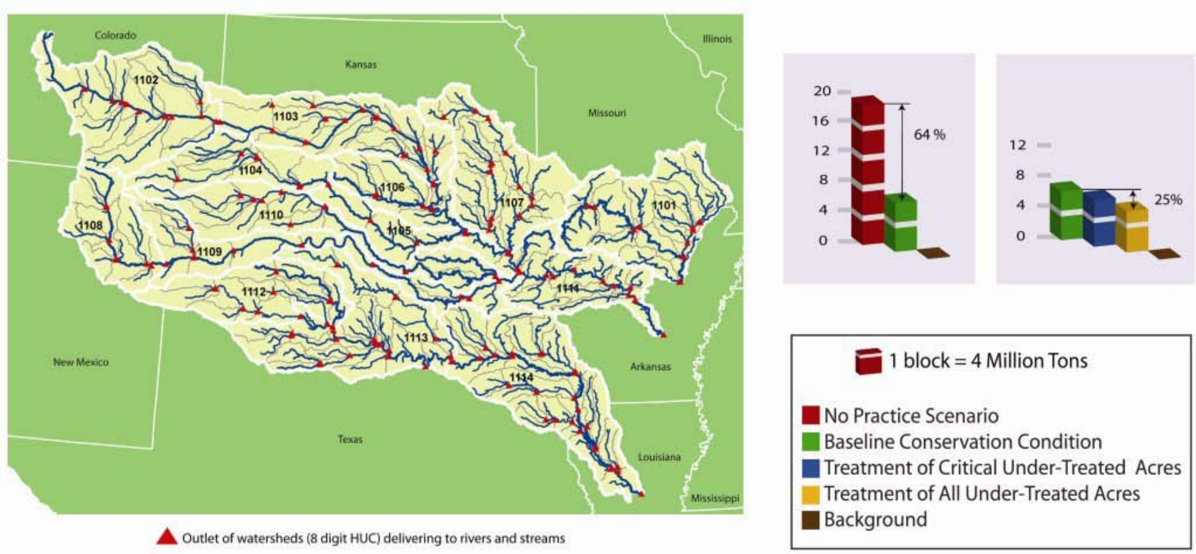
The effects of practices in use during the period 2003 to 2006 are determined by contrasting loads for the baseline conservation condition to loads for the no-practice scenario. The effects of additional conservation treatment on loads are determined by contrasting the loads for the baseline condition to either loads for treatment of cropped acres with a *high* level of treatment need (1.3 million acres), or loads for treatment of cropped acres with a *high* or *moderate* level of treatment need (10.4 million acres).

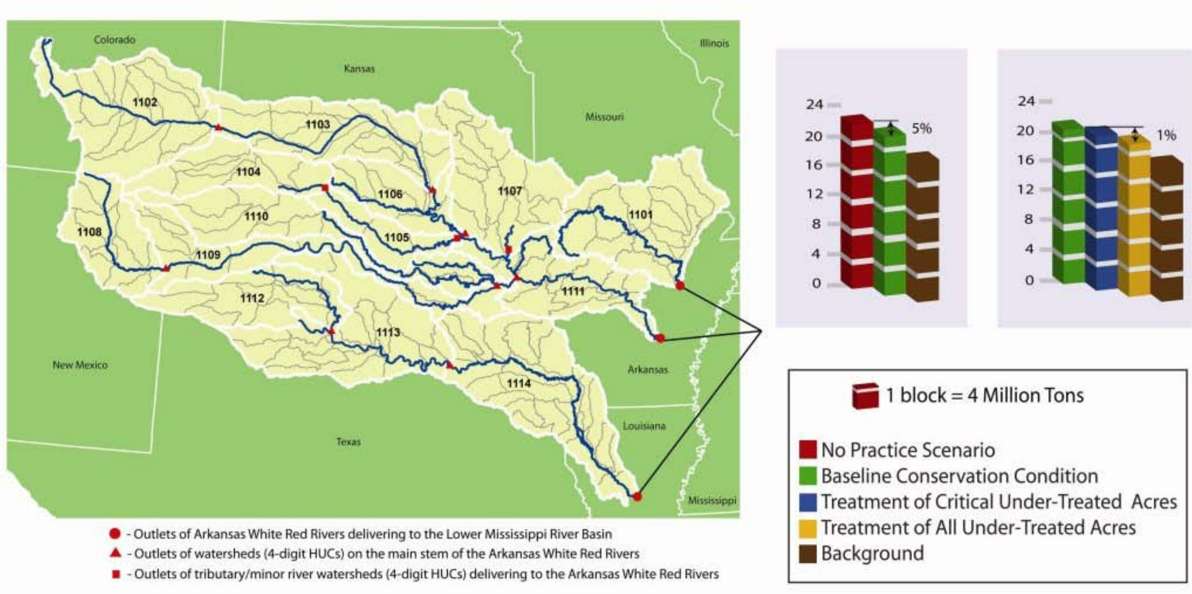
Sediment Loss

In figure 3, the top map shows that the use of conservation practices has reduced ***sediment loads delivered from cropland to rivers and streams*** in the region by 64 percent from conditions that would be expected without conservation practices. Application of additional conservation practices on the high- and moderate-treatment-need acres would further reduce sediment loads to rivers and streams by 25 percent.

The bottom map shows that the use of conservation practices on cropland has reduced ***sediment loads delivered to the Mississippi River from all sources*** by 5 percent from conditions that would be expected without conservation practices. Application of additional conservation practices on the high- and moderate-treatment-need acres would further reduce sediment loads to the Mississippi River by 1 percent. The Arkansas-White-Red Basin contains several reservoirs that significantly affect the delivery of sediment. Much of the sediment load from the western and central portions of the basin is intercepted and trapped in reservoirs on the Arkansas, Canadian, and Red Rivers. These intercepted loads are not delivered to the Mississippi River.

Figure 3. *Summary of the effects of conservation practices on sediment loads delivered to rivers and streams in the Arkansas-White-Red Basin (top) and to the Lower Mississippi River Basin (bottom)*



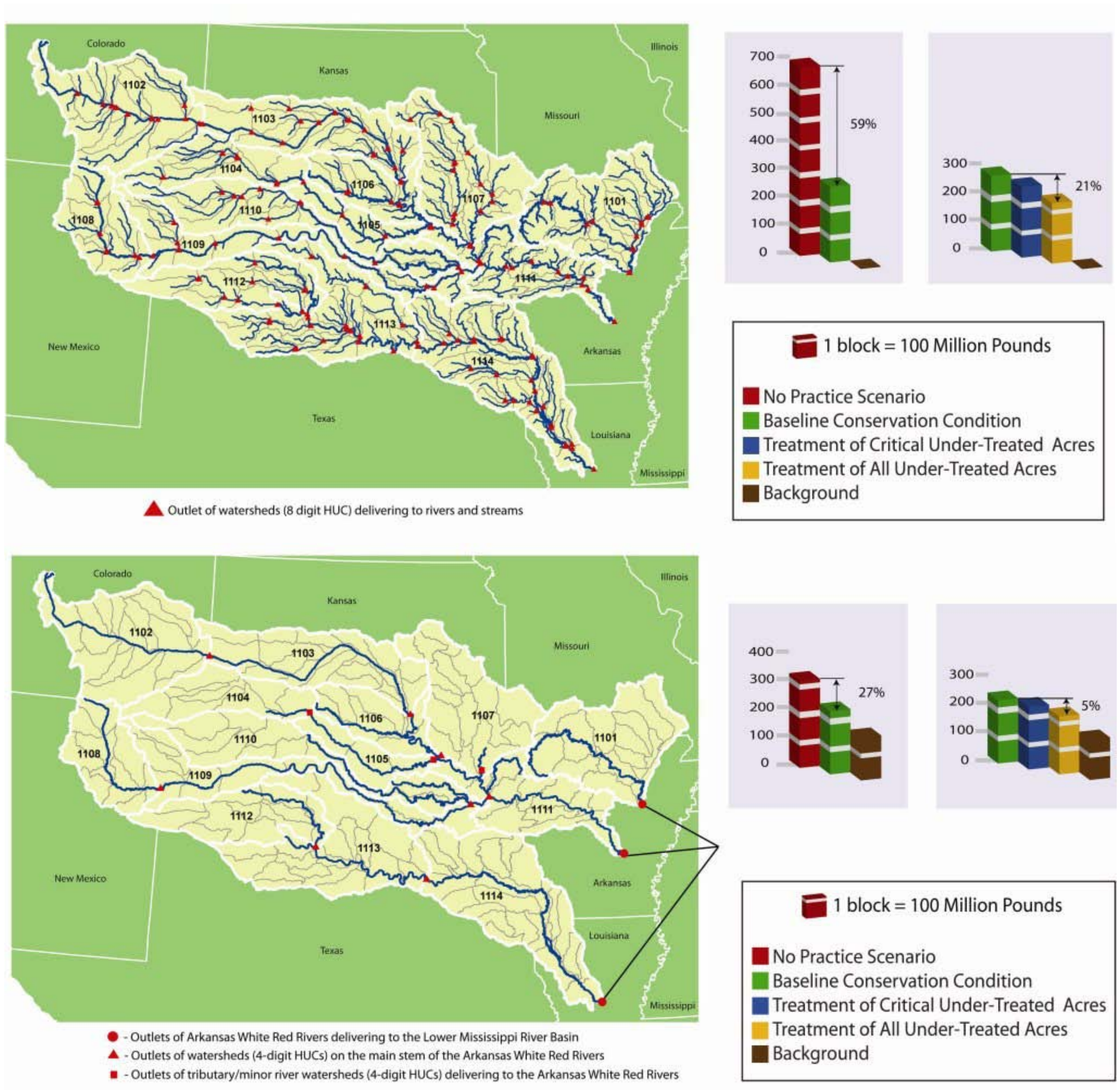


Nitrogen Loss

In figure 4, the top map shows that the use of conservation practices has reduced ***total nitrogen loads delivered from cropland to rivers and streams*** in the region by 59 percent from conditions that would be expected without conservation practices. Application of additional conservation practices on the high- and moderate-treatment-need acres would further reduce nitrogen loads to rivers and streams by 21 percent.

The bottom map shows that the use of conservation practices on cropland has reduced ***total nitrogen loads delivered to the Mississippi River from all sources*** by 27 percent from conditions that would be expected without conservation practices. Application of additional conservation practices on the high- and moderate-treatment-need acres would further reduce nitrogen loads to the Mississippi River by 5 percent. The Arkansas-White-Red Basin contains several reservoirs that significantly affect the delivery of nutrients. Much of the nutrient load from the western and central portions of the basin is intercepted and trapped in reservoirs on the Arkansas, Canadian, and Red Rivers. These intercepted loads are not delivered to the Mississippi River.

Figure 4. *Summary of the effects of conservation practices on nitrogen loads delivered to rivers and streams in the Missouri River Basin(top) and to the Mississippi River (bottom)*

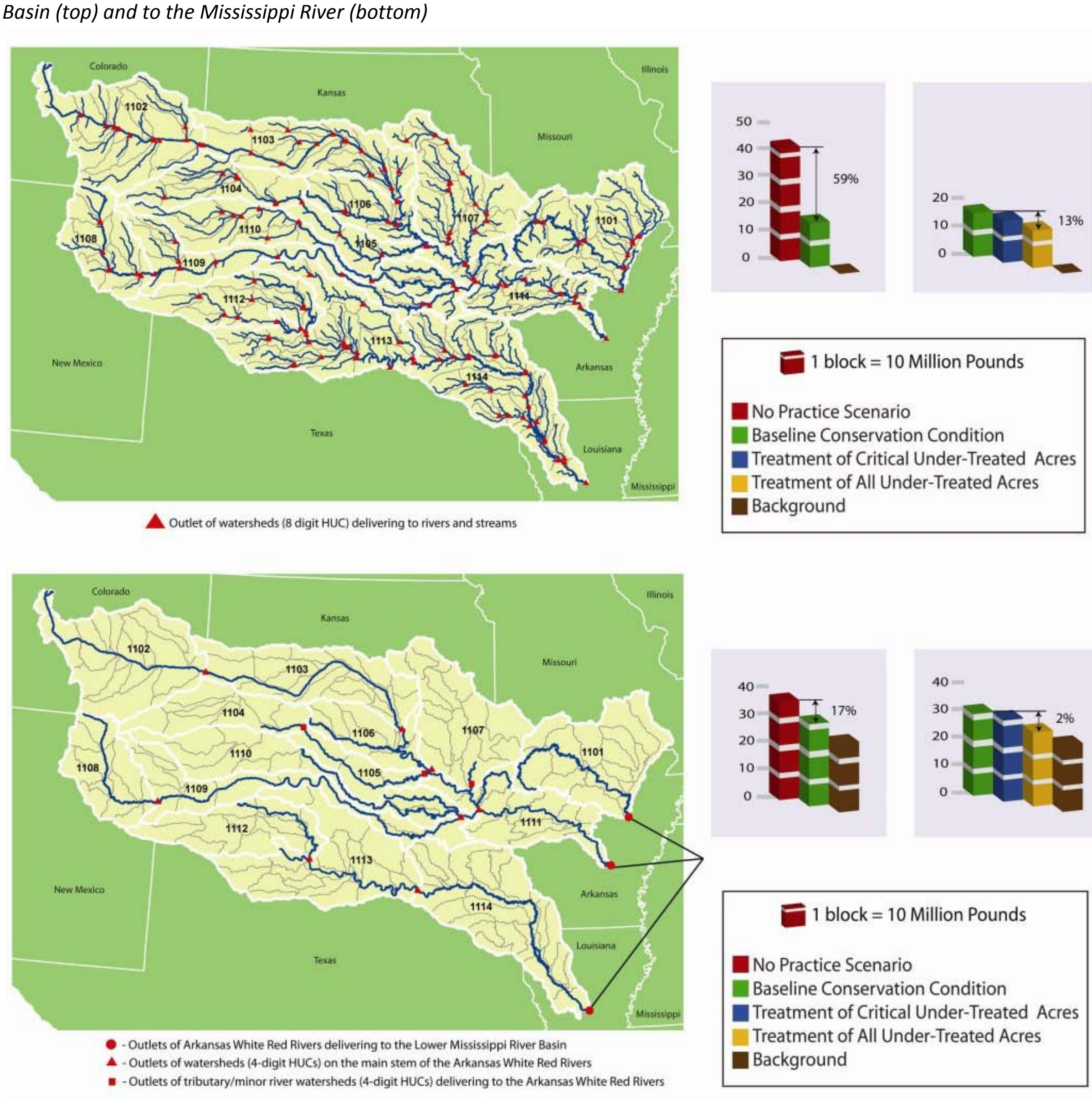


Phosphorus Loss

In figure 5, the top map shows that the use of conservation practices has reduced ***total phosphorus loads delivered from cropland to rivers and streams*** in the region by 59 percent from conditions that would be expected without conservation practices. Application of additional conservation practices on the high- and moderate-treatment-need acres would further reduce phosphorus loads to rivers and streams by 13 percent.

The bottom map shows that the use of conservation practices on cropland has reduced ***total phosphorus loads delivered to the Mississippi River from all sources*** by 17 percent from conditions that would be expected without conservation practices. Application of additional conservation practices on the high- and moderate-treatment-need acres would further reduce phosphorus loads to the Mississippi River by 2 percent. The Arkansas-White-Red Basin contains several reservoirs that significantly affect the delivery of nutrients. Much of the nutrient load from the western and central portions of the basin is intercepted and trapped in reservoirs on the Arkansas, Canadian, and Red Rivers. These intercepted loads are not delivered to the Mississippi River.

Figure 5. *Summary of the effects of conservation practices on phosphorus loads delivered to rivers and streams in the Missouri River Basin (top) and to the Mississippi River (bottom)*



Regional Comparisons:
Arkansas-White-Red, Missouri,
Upper Mississippi, and Ohio-Tennessee Basins

The Upper Mississippi, Ohio-Tennessee, Missouri, and Arkansas-White-Red Basins make up all but the southernmost part of the Mississippi River drainage area. Average annual precipitation in the Arkansas-White-Red Basin is similar to that in the Missouri Basin, but is 7 inches per year less than in the Upper Mississippi basin and about 15 inches per year less than in the Ohio-Tennessee basin. Because of the low precipitation, soils in the Arkansas-White-Red Basin are much more prone to wind erosion, especially in the western part of the region.

Table 3 compares several factors across the four regions. *The major difference in findings is that the most widespread agricultural conservation concern is the loss of nitrogen through leaching in the Upper Mississippi, the loss of soluble phosphorus in surface runoff in the Ohio-Tennessee, and control of wind erosion in the Missouri and Arkansas-White-Red.*

Conservation practice use is extensive in all four basins. Structural or management practices for erosion control are in use on 96 to 98 percent of cropped acres in three of the basins and on 87 percent in the Arkansas-White-Red Basin. Nutrient management practices are more prevalent in the Arkansas-White-Red and Missouri Basins than in either the Upper Mississippi or Ohio-Tennessee Basins; more than 60 percent of the cropped acres meet criteria for high or moderately high nitrogen or phosphorus management.

Farmers' use of structural and tillage practices has reduced sediment and nutrient losses in all four regions. Few farmers, however, are using complete and consistent nutrient application *rate, form, timing,* and *method* on all crops in all years, although many farmers are successfully meeting one or more of these criteria on some crops in the rotation.

Conservation treatment needs in the Arkansas-White-Red Basin are proportionately lower than those in the Upper Mississippi or Ohio-Tennessee Basins because of lower precipitation, lower edge-of-field losses (other than to wind erosion), and higher level of conservation practice use. Only 4 percent of cultivated cropland in the region has a high need for additional conservation treatment, and only 30 percent has moderate need for additional conservation treatment. These percentages are much lower than in the Upper Mississippi (15 percent high, 45 percent moderate) and Ohio-Tennessee (24 percent high, 46 moderate) Basins (fig. 6), but greater than in the Missouri Basin (1 percent high; 17 percent moderate).

Figure 6. *Percentage (left) and acreage (right) of high- and moderate-treatment-need cropland in the Upper Mississippi River Basin (UMRB), Ohio-Tennessee River Basin (OH-TN), Missouri River Basin (MO), and Arkansas-White-Red Basin*

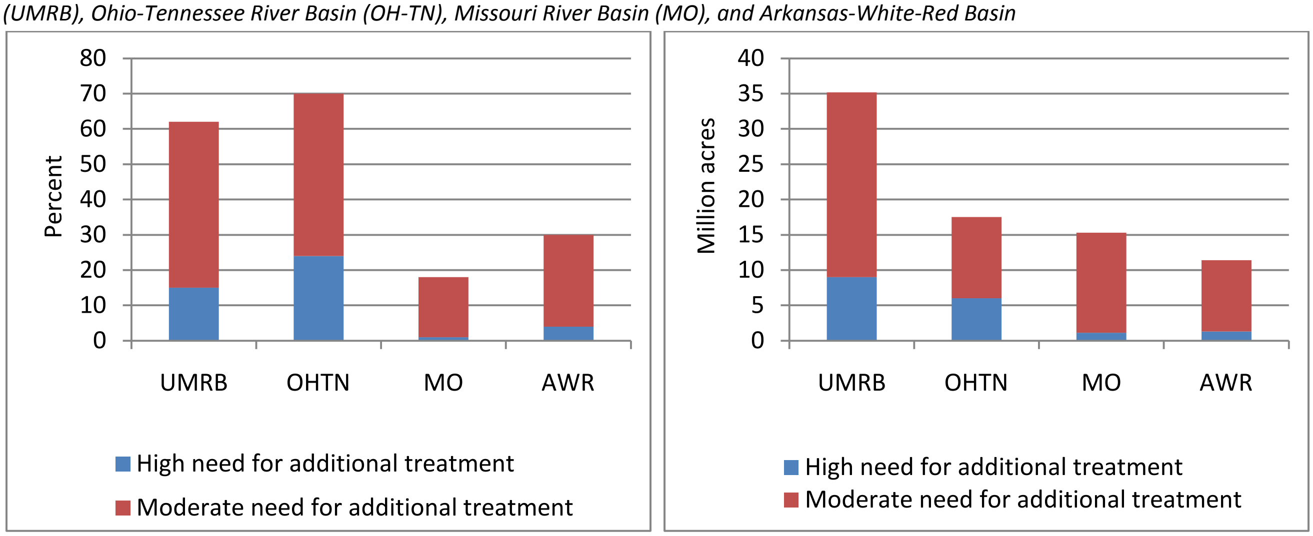


Table 3. Comparison of conservation factors in the Upper Mississippi, Ohio-Tennessee, Missouri, and Arkansas-White-Red Basins

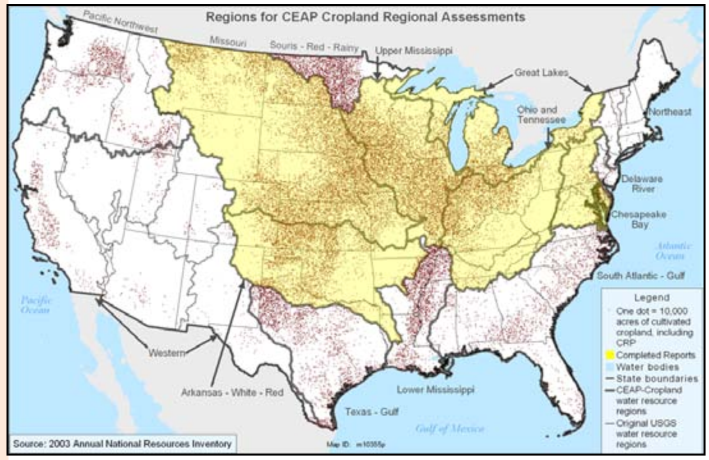
Factor	Upper Mississippi River Basin*	Ohio-Tennessee River Basin	Missouri River Basin	Arkansas-White-Red Basin
Basin Overview				
Total acres (million acres excluding water)	118.2	128.5	322.2	156.5
Acres of cultivated cropland (million acres)	62.9	26.8	95.1	35.3
Percent cultivated cropland (excluding water)	53	21	30	23
Percent urban land (excluding water)	8	9	3	5
Vulnerability Factors				
Average annual precipitation (inches)	34	42	23	27
Slopes >2% (% of cropped acres)	42	33	48	15
Highly erodible cropland (% of cropped acres)	18	27	40	32
Prone to wind erosion (% of cropped acres)	1	0	28	14
Prone to surface water runoff (% of cropped acres)	13	9	12	<1
Prone to leaching (% of cropped acres)	10	8	11	13
Conservation Practice Use (2003–06)				
Mulch till or no-till (% cropped acres)	91	93	93	58
Structural practices for water erosion control:				
Percent of all cropped acres	45	40	41	46
Percent of HEL cropland	72	59	49	47
Reduced tillage or structural practices (% cropped acres)	96	98	98	87
High or moderately high nitrogen management (% cropped acres)	41	42	65	63
High or moderately high phosphorus management (% cropped acres)	54	43	63	62
Land in long-term conserving cover (% of cropped acres)	5	4	12	17
Sediment and nutrient losses, baseline (average annual)**				
Wind erosion (tons/acre)	0.23	0.02	1.13	2.17
Waterborne sediment (tons/acre)	0.9	1.6	0.3	0.3
Windborne nitrogen (pounds/acre)	2.1	0.2	5.8	6.5
Waterborne nitrogen (surface) (pounds/acre)	8.8	13.2	2.6	2.5
Waterborne nitrogen (subsurface) (pounds/acre)	18.7	19.2	6.9	11.3
Windborne phosphorus (pounds/acre)	0.4	0.0	1.0	1.5
Phosphorus lost to surface water (pounds/acre)	2.7	4.5	0.7	0.8
Edge-of-Field Reductions Due to Conservation Practice Use (2003-06)				
Wind erosion (% reduction)	64	60	58	31
Sediment (% reduction)	61	52	73	61
Windborne nitrogen (% reduction)	37	47	46	27
Waterborne nitrogen (surface) (% reduction)	45	35	58	51
Waterborne nitrogen (subsurface) (% reduction)	9	11	45	57
Windborne phosphorus (% reduction)	55	63	58	40
Phosphorus lost to surface water (% reduction)	42	33	59	57
Conservation treatment needs				
Treatment need for one or more resource concerns:				
Cropland with high need (% of cropped acres)	15	24	1	4
Cropland with moderate need (% of cropped acres)	45	46	17	30
High or moderate need (% of cropped acres)	60	70	18	34
High or moderate need by resource concern:				
Wind erosion (% of cropped acres)	0	0	12	23
Sediment loss due to water erosion (% of cropped acres)	10	25	3	3
Nitrogen loss with surface water (% of cropped acres)	24	29	4	0
Nitrogen loss in subsurface flows (% of cropped acres)	47	17	2	9
Phosphorus loss (% of cropped acres)	22	63	1	2
Most extensive need:	Subsurface nitrogen loss	Phosphorus loss	Wind erosion control	Wind erosion control

*Findings from the Upper Mississippi River Basin study were revised in December 2010 (revision published August 2012).

**"Baseline" refers to estimates of conditions based on farming and conservation practices in use during the period 2003–06.

River Basin Cropland Modeling Study Reports The U.S. Department of Agriculture initiated the Conservation Effects Assessment Project (CEAP) in 2003 to determine the effects and effectiveness of soil and water conservation practices on agricultural lands. The CEAP report *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Arkansas-White-Red River Basin* is the sixth in a series of studies covering the major river basins and water resource regions of the conterminous 48 United States. It was designed to quantify the effects of conservation practices commonly used on cultivated cropland in the Arkansas-White-Red Basin, evaluate the need for additional conservation treatment in the region, and estimate the potential gains that could be attained with additional conservation treatment. This series is a cooperative effort among USDA's Natural Resources Conservation Service and Agricultural Research Service, Texas AgriLife Research of Texas A&M University, and the University of Massachusetts.

- *Upper Mississippi River Basin (draft released June 2010, revision completed July 2012)*
- *Chesapeake Bay Region (released March 2011)*
- *Great Lakes Region (released September 2011)*
- *Ohio-Tennessee River Basin (released February 2012)*
- *Missouri River Basin (released August 2012)*
- *Arkansas-White-Red River Basin (April 2013)*
- Lower Mississippi River Basin
- Texas Gulf Water Resource Region
- South Atlantic-Gulf Region
- Pacific Northwest and Water Resource Region
- Souris-Red-Rainy Water Resource Region
- Delaware River Watershed



The Northeast and Western Water Resource Regions cannot be completed because there are too few National Resources Inventory sample points for reliable statistical estimation.

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