United States Department of Agriculture
Natural Resources Conservation Service

Conservation Effects Assessment Project

August 2012

Summary of Findings

Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Upper Mississippi River Basin

CONTENTS

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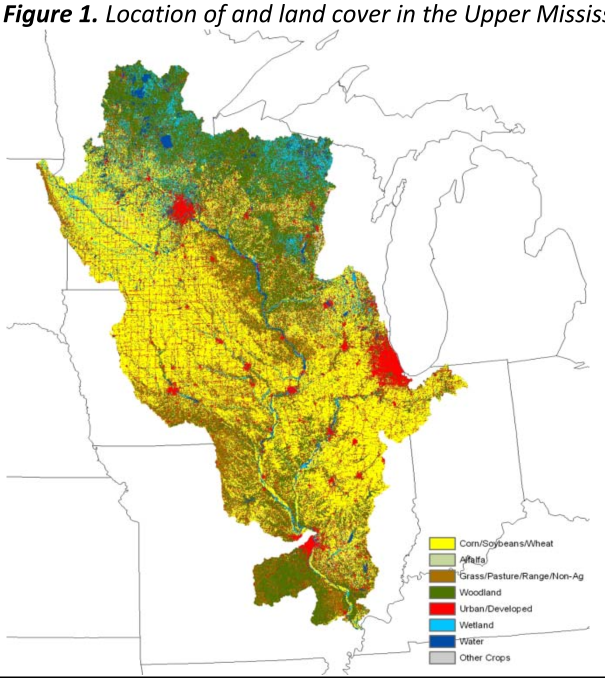
The U.S. Department of Agriculture's Conservation Effects Assessment Project (CEAP) has undertaken a series of studies designed to quantify the effects of conservation practices on cultivated cropland in the conterminous 48 States. The first study in this series was on the Upper Mississippi River Basin (UMRB), the northernmost of the water resource regions that make up the Mississippi River drainage (fig. 1). USDA released a draft report on the UMRB in June 2010, then revised the draft and released the final report in August 2012 to reflect changes in modeling protocols and the inclusion of an additional subregion in the analysis.

The UMRB covers some 190,000 square miles—121.5 million acres—between Lake Itaska in northern Minnesota and the confluence of the Mississippi and Ohio Rivers. The basin includes large parts of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, and small areas in Indiana, Michigan, and South Dakota. Urban areas make up about 8 percent of the basin. The major metropolitan areas are Chicago, IL; Minneapolis-St. Paul, MN; St. Louis, MO; Des Moines, IA; and the Quad Cities area of Illinois and Iowa.

About half the area of the UMRB is in crops; in 2007, UMRB cropland accounted for 19 percent of all harvested cropland and 17 percent of crop sales in the United States. Most of the cropland is in corn (32 million acres) or soybeans (19 million acres); the region accounts for more than 40 percent of the national corn grain harvest and more than a third of the soybean harvest. Some 2.8 million acres of cropland in the UMRB have been enrolled in the Conservation Reserve Program (CRP) and have been planted to introduced grasses or trees, or are in wildlife habitat. Livestock operations are a significant part of the local farm economy, accounting for 35 percent of U.S. hog and pig sales and 17 percent of dairy sales in 2007.

Figure 1. *Location of and land cover in the Upper Mississippi River 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 3,703 of these sample points located in the UMRB. 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 Survey. *The most critical conservation concern in the region is the loss of nitrogen through leaching.*

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 UMRB, compared to losses that would be expected if no conservation practices were in use. Structural practices for controlling water erosion are in place on 45 percent of all cropped acres in the region. Ninety-one percent of the cropland acres meet criteria for no-till (28 percent) or mulch till (63 percent), and all but 5 percent have evidence of some kind of reduced tillage on at least one crop in the rotation. Ninety-six percent have structural or management practices, or both. 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 2003–06, in percent, Upper Mississippi River Basin

Wind erosion	Sediment losses with runoff	Nitrogen losses		Total phosphorus losses
		With runoff	Through leaching	
Percent reduction				
64	61	45	9	44

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 soluble 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 nitrogen 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 9 million acres—15 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 26 million acres—45 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 23 million acres—40 percent of the cultivated cropland in the region—have a low level of need for additional conservation treatment.*

The most critical conservation concern in the region is the loss of nitrogen through leaching. About 47 percent of cropped acres require additional nutrient management to address excessive levels of nitrogen loss in subsurface flow pathways, including tile drainage systems. Table 2 shows potential reductions in edge-of-field sediment, nitrogen, and phosphorus losses. 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. Potential for further reductions in edge-of-field losses of sediment and nutrients from cultivated cropland through conservation treatment on high- and moderate-treatment-need cropland, in percent, Upper Mississippi River Basin

Sediment losses with runoff	Nitrogen losses		Total phosphorus losses
	With runoff	Through leaching	
Percent reduction			
76	**58**	**48**	**45**

Comprehensive Conservation Planning and Implementation Are Essential

Nutrient loss from fields is within acceptable limits when erosion-control practices are paired with management of rate, form, timing, and method of nutrient application that maximizes the availability of nutrients for crop growth while minimizing environmental losses. Treatment of erosion alone can exacerbate the nitrogen leaching problem by re-routing surface runoff to subsurface flow pathways. Soil erosion control practices are effective in reducing the loss of nitrogen in surface runoff, but for some acres the re-routing of surface water runoff to subsurface flow along with incomplete nutrient management results in a small net increase in total nitrogen loss from the field.

Complete and consistent nutrient management (proper rate, form, timing, *and* method of application) is generally lacking throughout the region; only about 13 percent of the cropped acres meet criteria for nitrogen *and* phosphorus application for all crops in all years of the rotation. Suites of practices that include both soil erosion control and nutrient management—appropriate rate, form, timing, *and* method of application—are required to simultaneously address soil erosion and nutrient losses by wind, in runoff, and through leaching.

Targeting Enhances Effectiveness and Efficiency

Conservation practices have the greatest effect on the more vulnerable acres, such as highly erodible land and soils prone to leaching. Targeted treatment of these vulnerable acres is the most efficient strategy for reducing sediment, nutrient, and pesticide loads to water bodies in the region. 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-treatment-need acres to low-treatment-need acres.

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 2, 3, and 4 summarize the extent to which conservation practices on cultivated cropland acres have reduced—and can potentially further reduce—sediment, nitrogen, and phosphorus loads in the UMRB, on the basis of the model simulations. In each figure, the top map shows reductions in loadings to rivers and streams resulting from the use of conservation practices on cultivated cropland during the period 2003 to 2006, and potential for further reductions through use of additional conservation practices on high- and moderate-treatment-need cropland. The bottom map shows reductions in loads delivered from all sources to the Lower Mississippi River at Cairo, IL, and potential further reductions in loadings below the 2003–06 baseline through the application of additional practices on high- and moderate-treatment-need cropland.

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—as well as 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 (9 million acres), or loads for treatment of cropped acres with a *high* or *moderate* level of treatment need (35 million acres).

Tile Drainage

In the UMRB, about 57 percent of the cropped acres have some portion of the field that is tile drained, according to the farmer survey. For these acres, about 82 percent of the subsurface flow in the baseline—as well as the soluble nutrients carried in the subsurface flow—was allocated by the physical process model (APEX) to tile drainage flow in this region. Tile drainage flow is included in the water loss category "subsurface water flows" in the UMRB study.

Although the CEAP-NRI Cropland Survey provided information on whether or not the field with the CEAP sample point had tile drainage, tile drainage flow and loss of soluble nutrients in tile drainage water were not reported separately because other important information on the tile drainage characteristics were not covered in the survey. The missing information includes—

- the depth and spacing of the tile drainage field,
- the extent of the tile drainage network,
- the proportion of the field, or other fields, that benefited from the tile drainage system, and
- the extent to which overland flow and subsurface flow from surrounding areas enters through tile surface inlets.

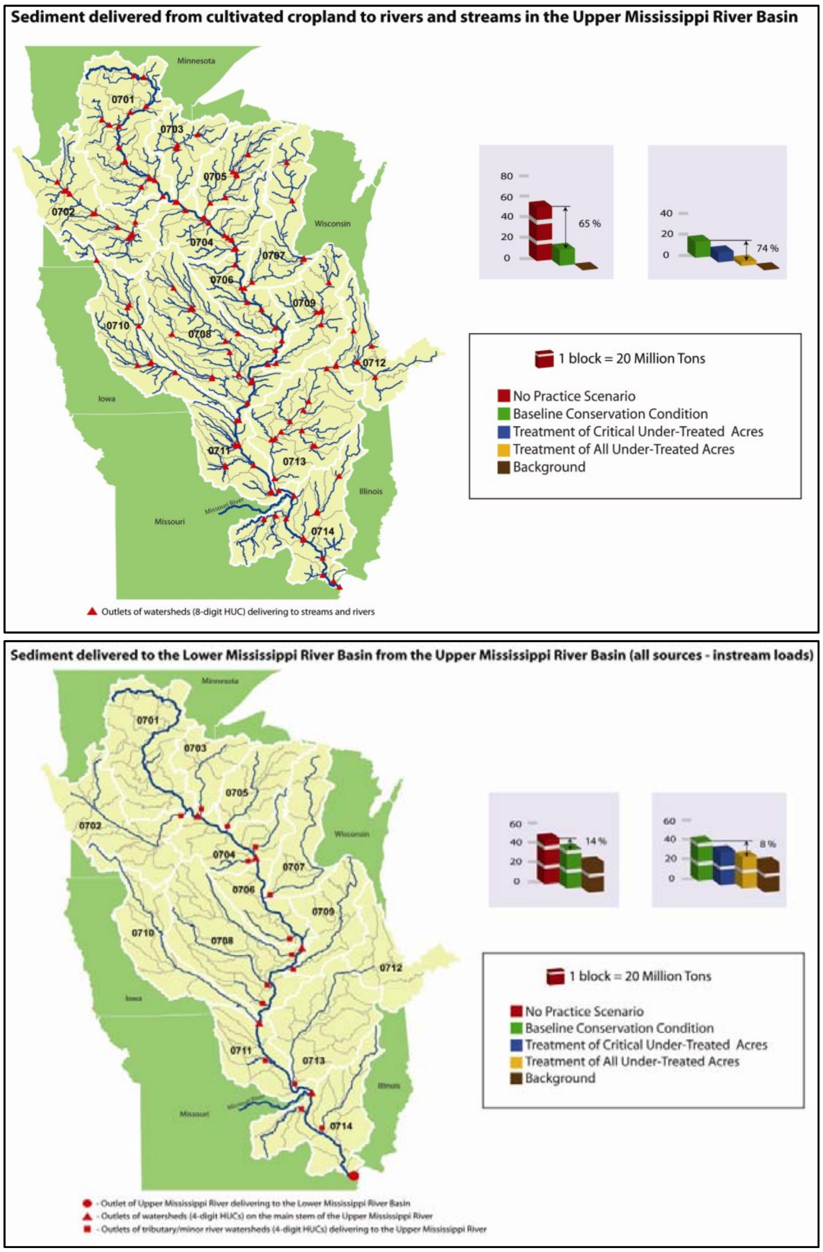
Without this additional information, it is not possible to accurately separate out the various components of subsurface flow when tile drainage systems are present.

Sediment Loss

In figure 2, 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 65 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 74 percent below baseline levels.

The bottom map shows that the use of conservation practices on cropland has reduced ***sediment loads delivered from all sources to the Lower Mississippi River*** at Cairo, IL, by 14 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 Lower Mississippi River by 8 percent below baseline levels.

Figure 2. *Summary of the effects of conservation practices on sediment loads delivered to rivers and streams in the UMRB (top) and to the outlet of the basin at Cairo, IL (bottom), and potential for further reductions with application of additional conservation treatment on high- and moderate-treatment-need cropland*

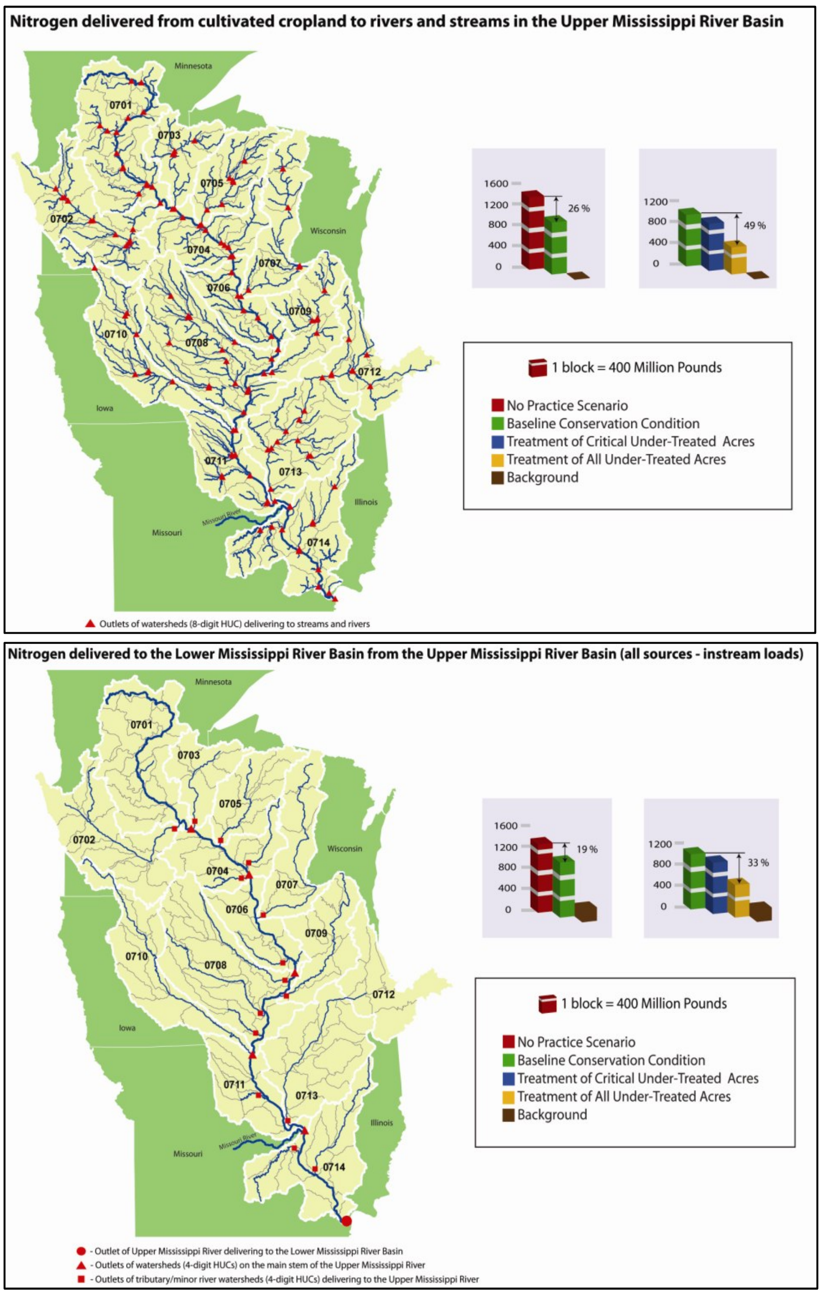


Nitrogen Loss

In figure 3, 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 26 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 49 percent below baseline levels.

The bottom map shows that the use of conservation practices on cropland has reduced ***total nitrogen loads delivered from all sources to the Lower Mississippi River*** at Cairo, IL, by 19 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 33 percent below baseline levels.

Figure 3. *Summary of the effects of conservation practices on nitrogen loads delivered to rivers and streams in the UMRB (top) and to the outlet of the basin at Cairo, IL (bottom), and potential for further reductions with application of additional conservation treatment on high- and moderate-treatment-need cropland*

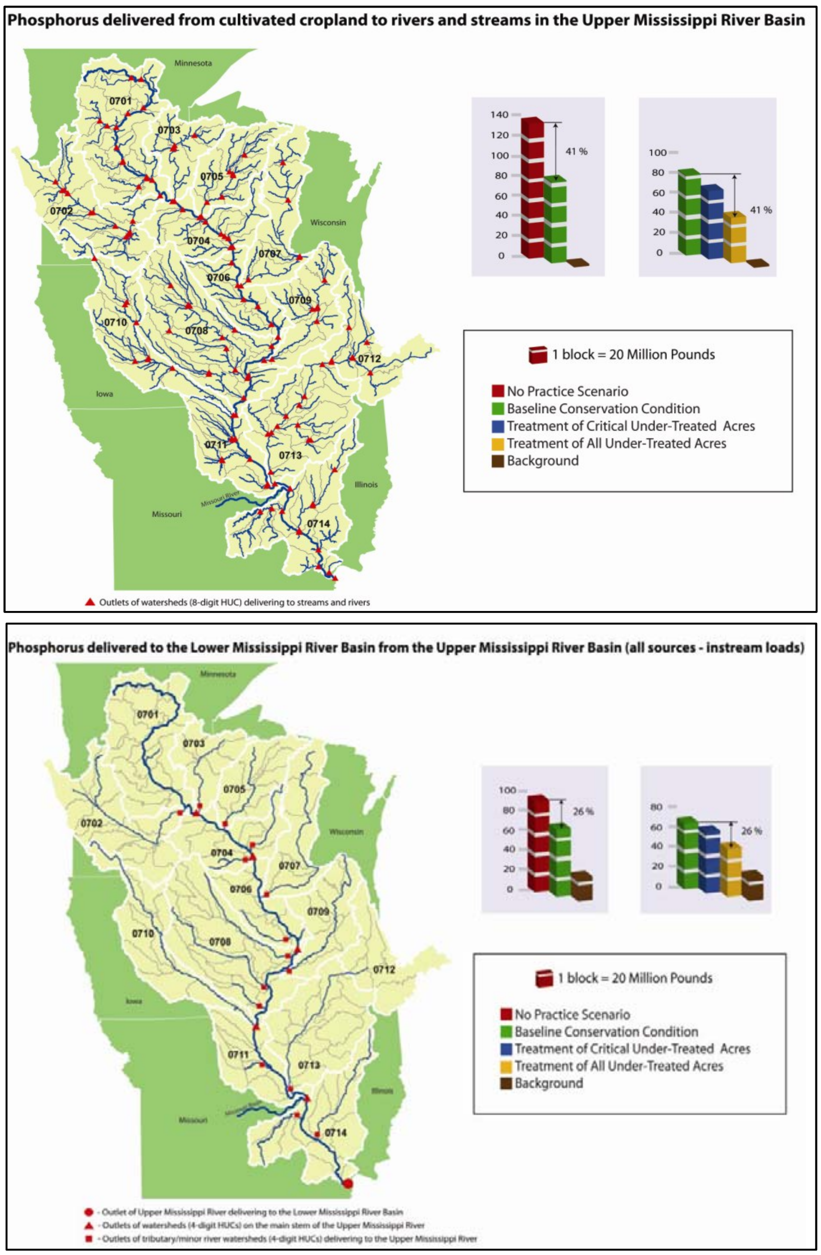


Phosphorus Loss

In figure 4, 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 41 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 41 percent below baseline levels.

The bottom map shows that the use of conservation practices on cropland has reduced ***total phosphorus loads delivered from all sources to the Mississippi River*** by 26 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 another 26 percent below baseline levels.

Figure 3. *Summary of the effects of conservation practices on phosphorus loads delivered to rivers and streams in the UMRB (top) and to the outlet of the basin at Cairo, IL (bottom), and potential for further reductions with application of additional conservation treatment on high- and moderate-treatment-need cropland*



Regional Comparisons:
Upper Mississippi, Ohio-Tennessee, and Missouri River Basins

The Upper Mississippi, Ohio-Tennessee, and Missouri River Basins make up the northern part of the vast Mississippi river drainage area. Vulnerability factors are generally similar among the three basins, except that average annual precipitation in the Upper Mississippi basin is 11 inches per year more than in the Missouri basin but 8 inches per year less than in the Ohio-Tennessee basin.

Table 3 compares several factors across the three regions. *The major difference in findings among the three regions 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.*

Conservation practice use is extensive in all three basins. Structural or management practices for erosion control are in use on 96 percent of cropped acres in the Upper Mississippi basin, a slightly lower percentage than in the other two basins. Nutrient management practices are more prevalent in the Missouri basin than in either the Upper Mississippi or Ohio-Tennessee basins; barely 40 percent of the cropped acres in the UMRB 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 three 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.

The UMRB has a smaller percentage of high- and moderate-treatment-need cropland than does the Ohio-Tennessee River Basin and a larger percentage than does the Missouri River Basin (60 percent in the Upper Mississippi, 70 percent in the Ohio-Tennessee, 18 percent in the Missouri). The UMRB, however, has twice as many acres or more needing treatment than do the other two regions (35 million acres in the Upper Mississippi, 17½ million acres in the Ohio-Tennessee, 15 million acres in the Missouri). See figure 5.

Figure 5. *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), and Missouri River Basin (MO)*

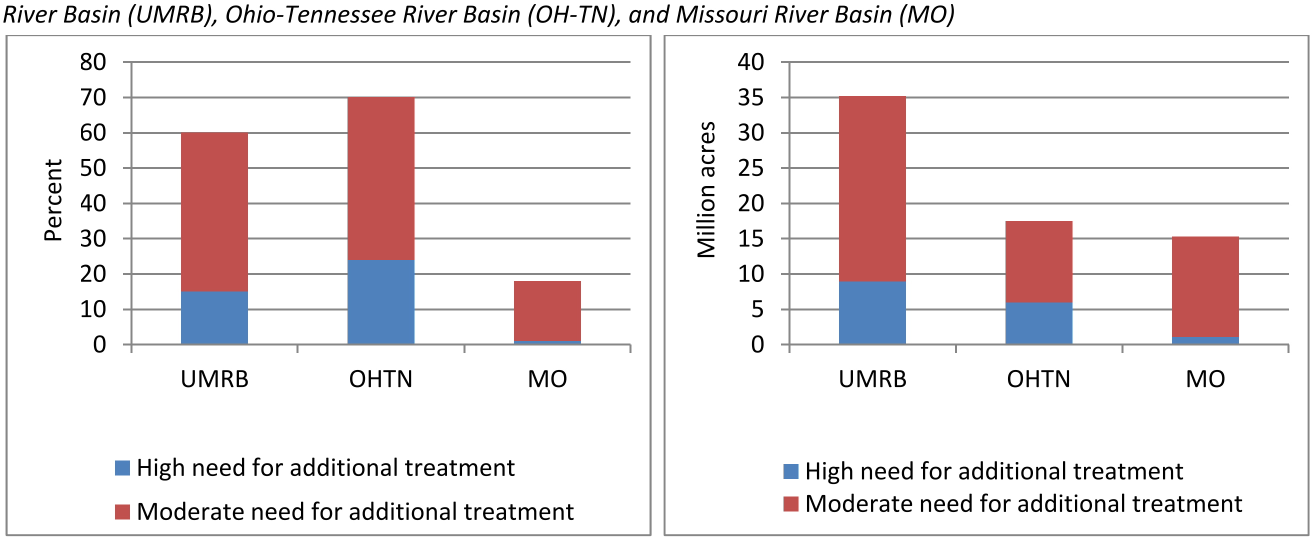


Table 3. Comparison of conservation factors in the Upper Mississippi, Ohio-Tennessee, and Missouri River Basins

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

*Findings from the UMRB study were revised in December 2010 (revision completed July 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 Upper Mississippi River Basin* is one 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 Upper Mississippi River 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 released August 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
Lower Mississippi River Basin
Northeast Region, including the Delaware River Watershed
South Atlantic-Gulf Region
Texas Gulf Water Resource Region
Souris-Red-Rainy Water Resource Regions
Pacific Northwest and Western Water Resource Regions