USDA NRCS
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Natural Resources Conservation Service
Conservation Effects Assessment Project

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Summary of Findings

# Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Missouri River Basin

CONTENTS



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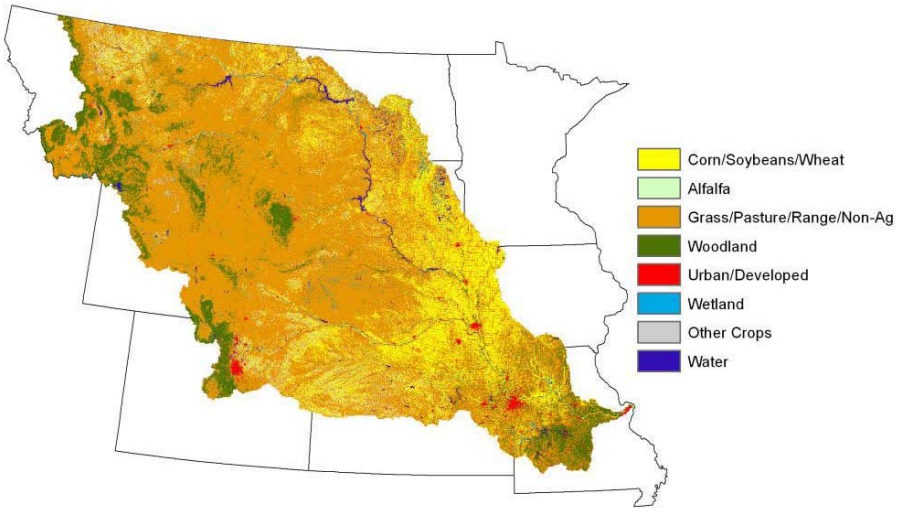
The U.S. Department of Agriculture's Conservation Effects Assessment Project (CEAP) has undertaken a series of studies designed to quantify the effects of conservation practices on cultivated cropland in the conterminous 48 States. The fifth study in this series is on the Missouri River Basin, the largest of the water resource regions that make up the Mississippi River drainage. The basin covers about 510,000 square miles and extends from the Continental Divide through the northern Great Plains to the Mississippi River north of St. Louis, MO. It includes all of Nebraska and parts of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wyoming (fig. 1).

Twenty-nine percent of the region is cultivated cropland. Twelve percent of all U.S. farms and 28 percent of all land in farms nationwide are in the Missouri River Basin. The vast Missouri River Basin differs from the other river basins in the northern part of the Mississippi River drainage—the Upper Mississippi River and Ohio-Tennessee River Basins—in the diversity of climate and agriculture across the region. Cropping systems in the eastern part of the basin are dominated by corn and soybean rotations. The western portion of the basin is dominated by wheat and other close-grown crops, and there are extensive areas of rangeland. Irrigation is more common on cropland in the western part of the region, and manure application on cropped acres is less common in the Missouri basin than in the Upper Mississippi and Ohio-Tennessee basins.

*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.*

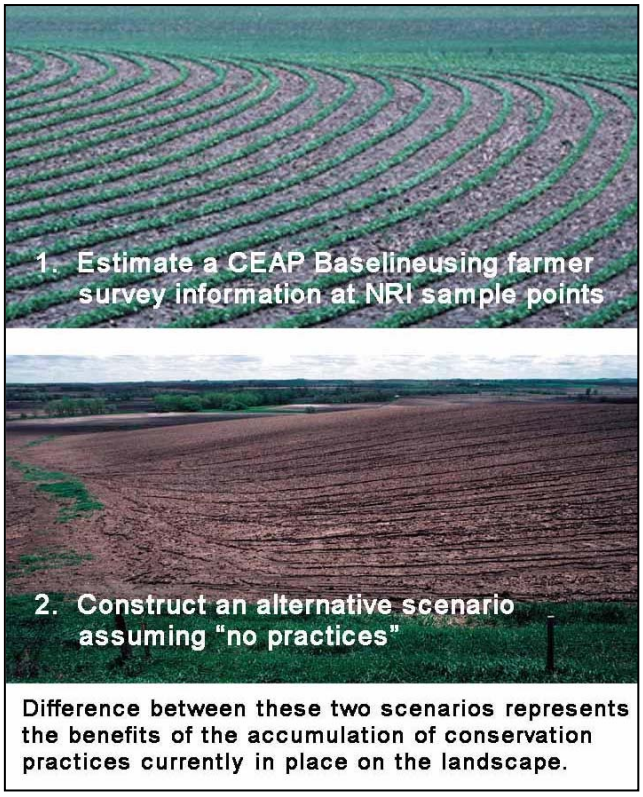
***Figure 1.*** *Location of and land cover in the Missouri River Basin*




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.




The national sample for the farmer survey consists of 18,700 sample points with 3,916 of these sample points located in the Missouri River 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 region. Although only about 18 percent of the cultivated cropland in this region has a high or moderate need for conservation treatment, this represents more than 15 million cropped acres.*

### *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 Missouri River 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 41 percent of all cropped acres in the region, and structural practices for controlling wind erosion are in place on 10 percent. Ninety-three percent of the cropland acres meet criteria for no-till (46 percent) or mulch till (47 percent), and all but 3 percent have evidence of some kind of reduced tillage on at least one crop in the rotation. Ninety-eight percent have structural or management practices, or both. Farmers meet criteria for high or moderately high levels of nitrogen or phosphorus management on more than 60 percent of the cropped acres. About 60 percent of cropped acres are gaining soil organic carbon—84 percent in the eastern part of the region and 42 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, Missouri River Basin**

| Location | Sediment | | Nitrogen | | | Phosphorus | |
|---|---|---|---|---|---|---|---|
| | Windborne | With runoff | Windborne | With runoff | Through leaching | Windborne | Soluble * |
| | *Percent reduction* | | | | | | |
| Eastern part of region | 66 | 72 | 47 | 72 | 21 | 63 | 58 |
| Western part of region | 55 | 79 | 46 | 66 | 60 | 55 | 63 |
| Entire region | 58 | 73 | 46 | 58 | 45 | 58 | 59 |

*** 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 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 1 million acres—1 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 14 million acres—17 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 68 million acres—82 percent of the cultivated cropland in the region—have a low level of need for additional conservation treatment.*

Although the proportion of cropped acres having a high or moderate level of need for additional treatment is lower than that in other regions in the study series, the total number of acres in these treatment categories is high because the basin is so large. Table 2 shows potential for further reductions (beyond 2003–06 baseline levels) 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 comprehensive conservation treatment of high- and moderate-treatment-need cropland, Missouri River Basin**

| Location | Sediment | | Nitrogen loss— | | Soluble phosphorus * |
|---|---|---|---|---|---|
| | Windborne | With runoff | With runoff | Through leaching | |
| | *Percent reduction* | | | | |
| Entire region | 22 | 37 | 24 | 12 | 20 |

*** 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**

### *Comprehensive Conservation Planning and Implementation Are Essential*

The resource concern with the most widespread need for additional conservation treatment related to cropland in the region is wind erosion, which accounts for most of the soil and nutrient losses from farm fields in this region, especially the drier western parts. Despite reductions in wind erosion following conservation practice implementation, model simulations show that in at least some years annual wind erosion rates can exceed 4 tons per acre on 12 percent of the cultivated cropland, and can exceed 2 tons per acre on 20 percent.

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*

The practices in use during the period 2003 to 2006 achieved about 75 percent of potential reductions in sediment loss, 68 percent of potential reductions in nitrogen loss, and 76 percent of potential reductions in phosphorus loss. Significant per-acre reductions in sediment and nutrient losses could be achieved by focusing on the 15 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.

**Emerging Conservation Challenges for the Missouri River Basin**

The evaluation of conservation practices and associated estimates of conservation treatment needs are based on practice use derived from a survey of farming and conservation practices conducted during the years 2003 to 2006. Since that time, however, States in the Missouri River Basin have continued to work with farmers to enhance conservation practice adoption in an ongoing effort to reduce nonpoint source pollution contributing to water quality concerns. As a result, some practices may be currently in wider use within the watershed other than those the CEAP survey shows for the period 2003 to 2006. A challenge for this region will be to ***maintain*** the conservation gains already achieved in the face of rising commodity prices and expansion of cropped acreage.

- Cultivated acres are increasing in the region as farmers expand their operations in response to the increased demand for food and fuel crops. In some areas, this expansion has resulted in "sodbusting"—cultivation of previously uncultivated acres.
- Acres in the Conservation Reserve Program (CRP) are increasingly being converted back to cultivation rather than being re-enrolled in the program. The majority of these acres are highly erodible. CRP acres converted back to cultivation will require appropriate suites of conservation practices to minimize environmental impacts.
- Where climate allows, crop mixes are shifting to continuous row cropping (corn and soybeans primarily) and away from the close-grown crops that provide more protection against wind and water erosion. In some areas, climate change has extended the growing season sufficiently to allow more production of row crops.
- Water use efficiency is an ongoing necessity in many parts of the region in order to maintain current levels of crop production.
- Expansion of subsurface drainage, if not accompanied by comprehensive nutrient management practices (timing, method, form, and rate of application) could significantly increase amounts of nitrogen and phosphorus lost from farm fields through leaching.
- The more permanent conservation practices (terraces, wind barriers, and irrigation systems) that predominate in this region have a life span that will require continued maintenance and eventual replacement.

## 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 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.

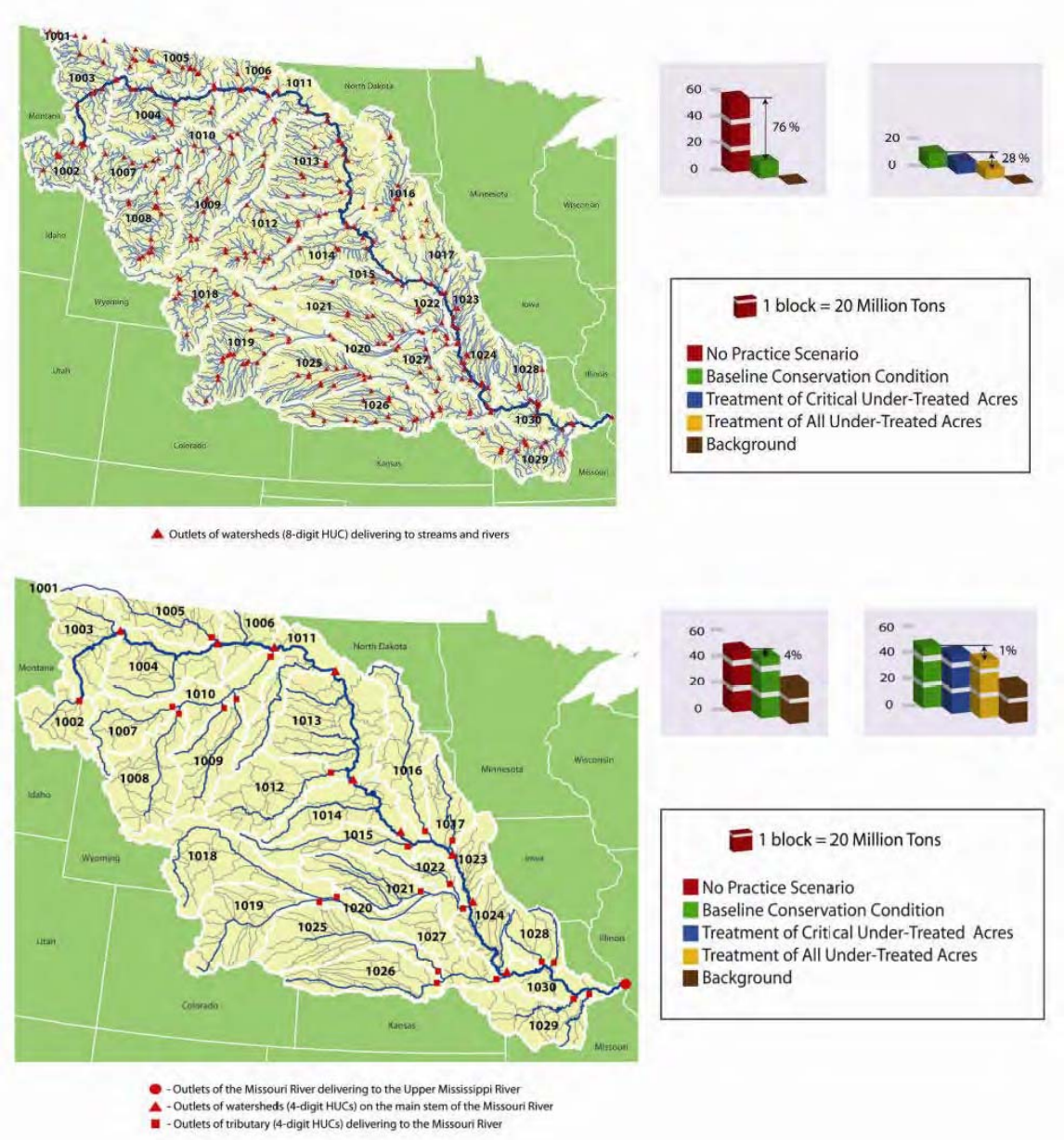
The effects of practices in use during the period 2003 to 2006 are determined by contrasting loads for the baseline conservation condition to loads for the no-practice scenario. The effects of additional conservation treatment on loads are determined by contrasting the loads for the baseline condition to either loads for treatment of cropped acres with a *high* level of treatment need (1 million acres), or loads for treatment of cropped acres with a *high* or *moderate* level of treatment need (15 million acres).

### *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 76 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 28 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 4 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.

***Figure 2.*** *Summary of the effects of conservation practices on sediment loads delivered to rivers and streams in the Missouri River Basin (top) and to the Mississippi River (bottom)*

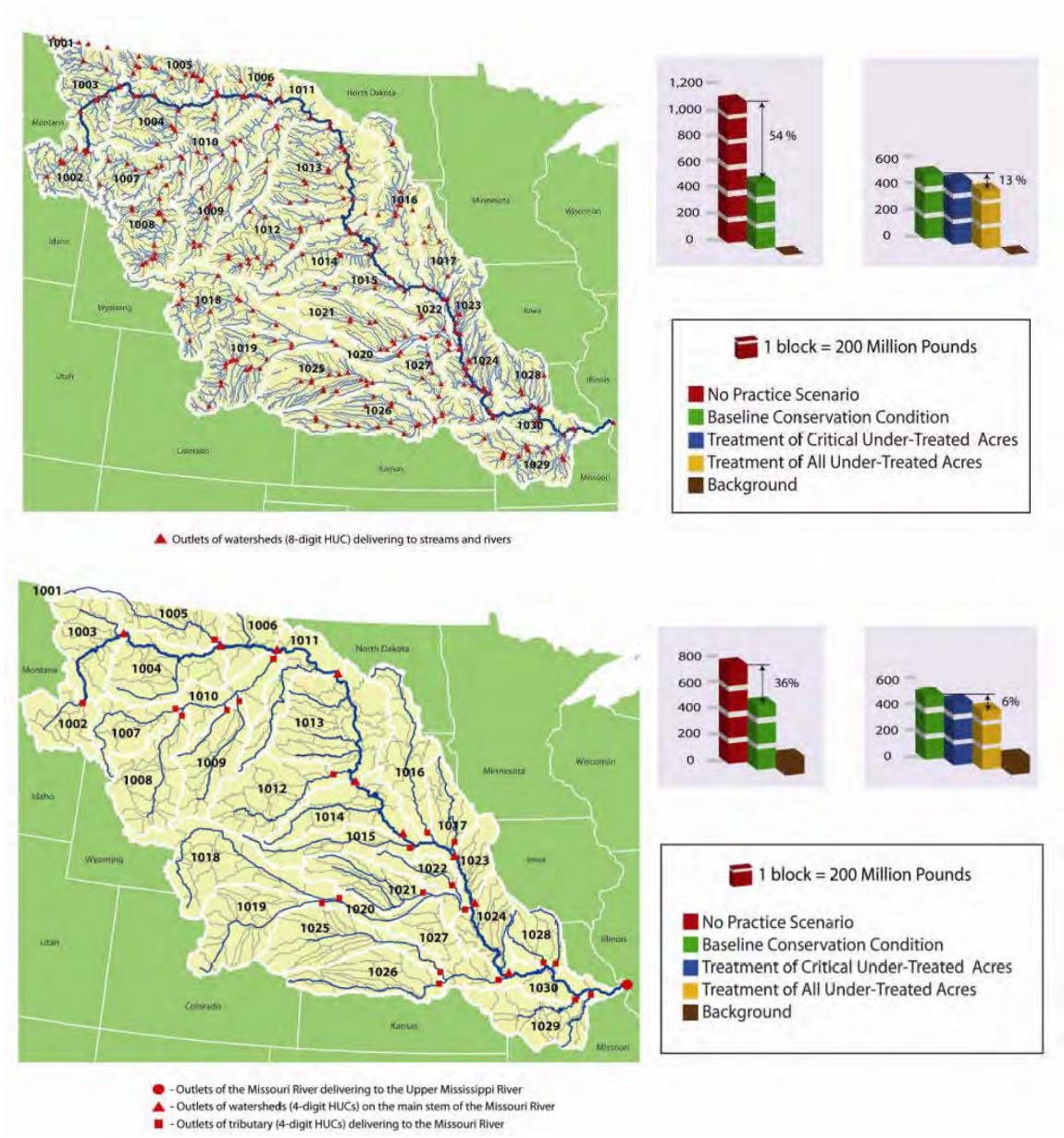


### *Nitrogen Loss*

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 54 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 13 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 36 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 6 percent.

***Figure 3.*** *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)*

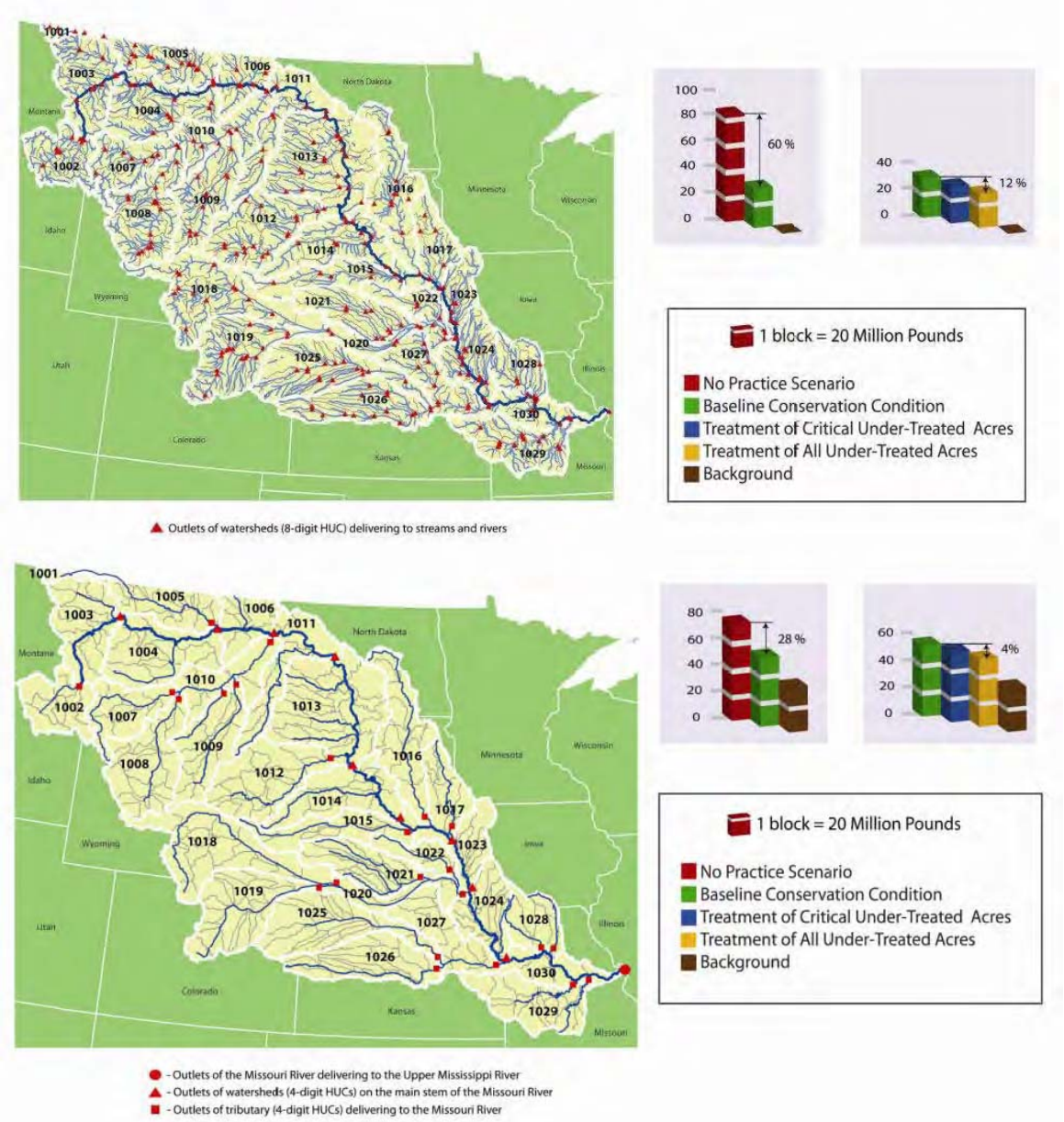


### *Phosphorus Loss*

In figure 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 60 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 12 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 28 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 4 percent.

***Figure 4.*** *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:

## Missouri, Upper Mississippi, and Ohio-Tennessee River Basins

The Missouri, Upper Mississippi, and Ohio-Tennessee 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 Missouri basin is 11 inches per year less than in the Upper Mississippi basin and about half that in the Ohio-Tennessee basin. Because of the low precipitation, soils in the Missouri basin are much more prone to wind erosion, especially in the western part of the region.

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 98 percent of cropped acres in the Missouri basin, a slightly higher 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; 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 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.

Conservation treatment needs in the Missouri 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 1 percent of cultivated cropland in the region has a high need for additional conservation treatment, and only 17 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. 5), but because of the size of the Missouri basin the acreages are comparable.

***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)*

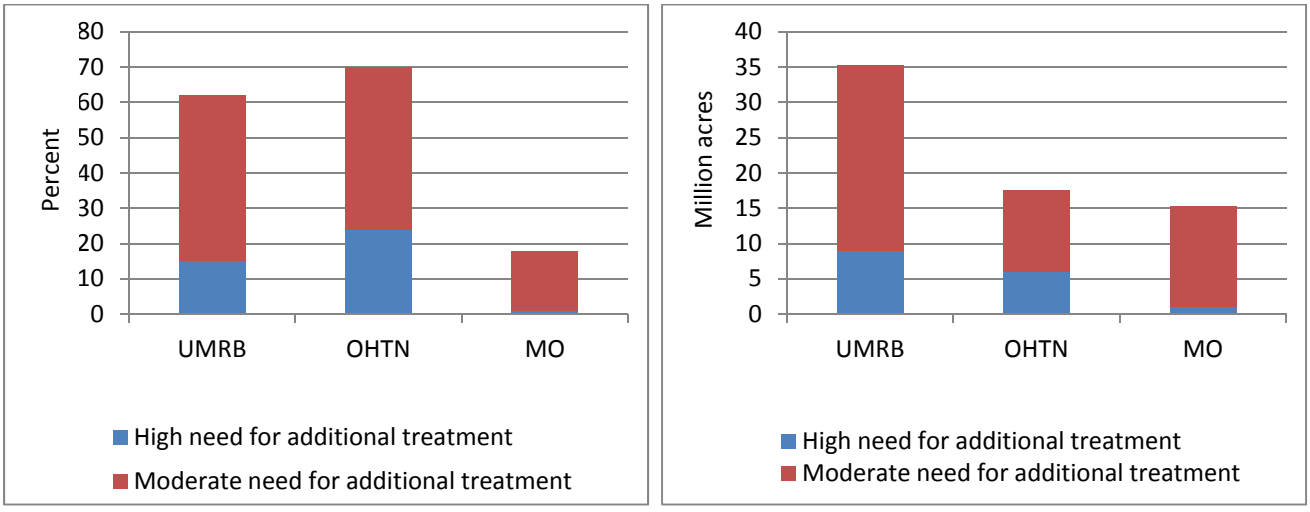


**Table 3. Comparison of conservation factors in the Upper Mississippi, Ohio-Tennessee, and Missouri River Basins**

| 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 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 Missouri River Basin* is the fifth 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 Missouri 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 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
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