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# Effects of Conservation Practices on Nitrogen Loss from Farm Fields

**A National Assessment Based on the 2003-06 CEAP Survey and APEX Modeling Databases**



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### **The Conservation Effects Assessment Project (CEAP)—Strengthening the science base for natural resource conservation**

The Conservation Effects Assessment Project (CEAP) was initiated by USDA's Natural Resources Conservation Service (NRCS), Agricultural Research Service (ARS), and National Institute of Food and Agriculture (NIFA) [formerly known as Cooperative State Research, Education, and Extension Service (CSREES)] in 2002 as a means to analyze societal and environmental benefits gained from the 2002 Farm Bill's substantial increase in conservation program funding. The CEAP-1 survey was conducted on agricultural lands across the United States in 2003-06. The goals of CEAP-1 were to estimate conservation benefits for reporting at the national and regional levels and to establish the scientific understanding of the effects and benefits of conservation practices at the watershed scale. As CEAP evolved, the scope was expanded to assess the impacts and efficacy of various conservation practices on maintaining and improving soil and water quality at regional, national, and watershed scales.

CEAP activities are organized into three interconnected efforts:

- *Bibliographies, literature reviews, and scientific workshops* to establish what is known about the environmental effects of conservation practices at the field and watershed scale.
- *National and regional assessments* to estimate the environmental effects and benefits of conservation practices on the landscape and to estimate conservation treatment needs. The four components of the national and regional assessment effort are *Cropland; Wetlands; Grazing Lands*, including rangeland, pastureland, and grazed forestland; and *Wildlife*.
- *Watershed studies* to provide in-depth quantification of water quality and soil quality impacts of conservation practices at the local level and to provide insight on what practices are most effective and where they are needed within a watershed to achieve environmental goals.

CEAP-1 benchmark results, currently published for 12 watersheds, provide a scientific basis for interpreting conservation practice implementation impacts and identifying remaining conservation practice needs. These reports continue to inform decision-makers, policymakers, and the public on the environmental and societal benefits of conservation practice use. CEAP-2, the second national survey of agricultural lands across the United States, is currently underway, with sampling occurring in 2015 and 2016.

Additional information on the scope of the project can be found at <http://www.nrcs.usda.gov/technical/nri/ceap/>.

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This report was prepared for NRCS by Robert Kellogg on October 31, 2016.

## Scope of This Report

The first CEAP national assessment was conducted using farmer survey data collected in 2003-06, where results were reported for Water Resource Regions that represented the major drainage basins in the United States. These reports were published by NRCS and are available on the Web at

<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/pub/>

A second CEAP national assessment is underway and will produce an updated national assessment using farmer survey data collected in 2015-16. For this updated CEAP national assessment, newly defined CEAP production regions will serve as the basis for the assessment. The 12 CEAP production regions were derived specifically for use with the 2015-16 survey data to draw sharper distinctions among regions with respect to the prevalent land use, cropping systems, climate, soils characteristics, and, consequently, conservation practice use and effectiveness. The 12 regions are:

Region number	Region name
1	Northwest Coastal
2	California Coastal
3	Northwest Non-Coastal
4	Southwest Non-Coastal
5	Northern Plains
6	Southern Plains
7	North Central and Midwest
8	South Central
9	Lower Mississippi and Texas Gulf Coast
10	Northeast
11	East Central
12	Southeast Coastal Plain

The purpose of this report is to present the previously published 2003-06 results for the new CEAP production regions. The APEX modeling data for each of the 2003-06 CEAP sample points remain unchanged, as do the rules of analysis as presented in the 12 CEAP publications summarizing the 2003-06 findings by major drainage basins. ***The only change is that the 2003-06 CEAP sample points are aggregated into different groupings for this report*** and, consequently, the sample acreage weight for each sample point has been adjusted to reproduce the 2003 NRI acreage by cropping system for the 12 new CEAP production regions. (The 2003 NRI, an interim release of the national-level NRI results prior to the full 2007 NRI release, was the domain for the sample draw (i.e., sample frame) for the 2003-06 CEAP sample, and thus provides the foundation acreage estimates for the 2003-06 CEAP sample.)

Only the 2003-06 CEAP sample points used in the previously published CEAP reports could be incorporated into the revised assessment. The additional sample points for the “West” region—368 sample points—could not be used because the full set of APEX modeling results were not available. In addition, after assigning the remaining 18,323 sample points to the 12 new CEAP production regions, four of the new regions did not have enough 2003-06 sample points to support a regional representation. The four regions for which data summaries ***could not be presented*** are:

Region number	Region name
1	Northwest Coastal
2	California Coastal
4	Southwest Non-Coastal
8	South Central

The regional summary results reported herein represent what NRCS ***would have published*** based on the 2003-06 survey data and the associated APEX modeling data had 2003-06 results been summarized according to the new CEAP production regions. In the course of assessing the 2015-16 results, NRCS staff and collaborators will compare findings to the 2003-06 survey data, but will re-estimate APEX model results for the 2003-06 data using the most recent version of the APEX model and will incorporate additional upgrades in methods and refinements in ancillary datasets such as weather and soils to be as comparable as possible to methods and data used for assessing the 2015-16 results. Thus, those forthcoming results for 2003-06 will differ from findings reported herein.

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## Summary of Findings

The purpose of this report is to assess how effective conservation practices are in reducing nitrogen loss from cultivated cropland acres. The 2003-06 CEAP farmer survey data and APEX simulation modeling results for cultivated cropland acres were used to make the assessment. Results for 2003-06 are available for 17,918 CEAP sample points, a subset of the National Resources Inventory (NRI) sample points. Regional results are summarized for eight newly defined CEAP production regions.

### To what extent are conservation practices used to control nitrogen loss?

Effective control of nitrogen loss from farm fields typically consists of a combination of practices that:

- avoid or limit the potential for nitrogen losses by using appropriate nitrogen management practices on *all* crops in the rotation,
- control erosion and the movement of soil within the field, and
- trap materials leaving the field using appropriate edge-of-field mitigation.

Erosion control practices include residue and tillage management (annual practices) and structural practices which, once implemented, are usually kept in place for several years. For all eight regions combined, 94 percent of cultivated cropland acres had some kind of practice use to control water erosion in 2003-06:

- 34 percent had one or more structural practice and some form of reduced tillage,
- 55 percent had some form of reduced tillage but no structural practices,
- 4 percent had one or more structural practice but no reduced tillage, and
- only 6 percent had no reduced tillage and no structural practices.

Nitrogen management practices address the rate, timing, and method of nitrogen application to promote crop growth. For all eight regions combined, the majority of acres met at least one of these three management practices in 2003-06:

- 63 percent of cropped acres met criteria for timing of nitrogen applications for all crops in the rotation, including both manure and commercial fertilizer applications, and another 3 percent of cropped acres did not have any nitrogen application;
- 58 percent of cropped acres met the criteria for the method of nitrogen application; and
- 50 percent of cropped acres met the criteria for the rate of nitrogen application.

However, only 25 percent of cropped acres met criteria for timing and method and rate. After accounting for the 3 percent of acres that did not receive nitrogen applications, about 72 percent of cropped acres did not fully meet the criteria for nitrogen management.

### How much nitrogen loss is there on cultivated cropland acres?

About 29 percent of the nitrogen applied as commercial nitrogen and as manure, as represented in the APEX model simulations based on the 2003-06 survey data, was lost from the farm fields through various loss pathways. The mean of the average annual estimates of total nitrogen loss was 34 pounds per acre per year. The amount varied considerably, however, among cultivated cropland acres:

- 35 percent had average annual total nitrogen loss (all loss pathways) less than 20 pounds per acre per year,
- 40 percent had total nitrogen loss between 20 and 40 pounds per acre per year,
- 17 percent had total nitrogen loss between 40 and 70 pounds per acre per year, and
- 8 percent had total nitrogen loss greater than 70 pounds per acre per year, including a small percentage with total losses greater than 100 pounds per acre per year.

Total nitrogen losses were highest for acres receiving manure. The average annual estimate of total nitrogen loss for acres receiving manure was 56 pounds per acre per year, compared to the average annual amount lost for acres not receiving manure of 32 pounds per acre per year.

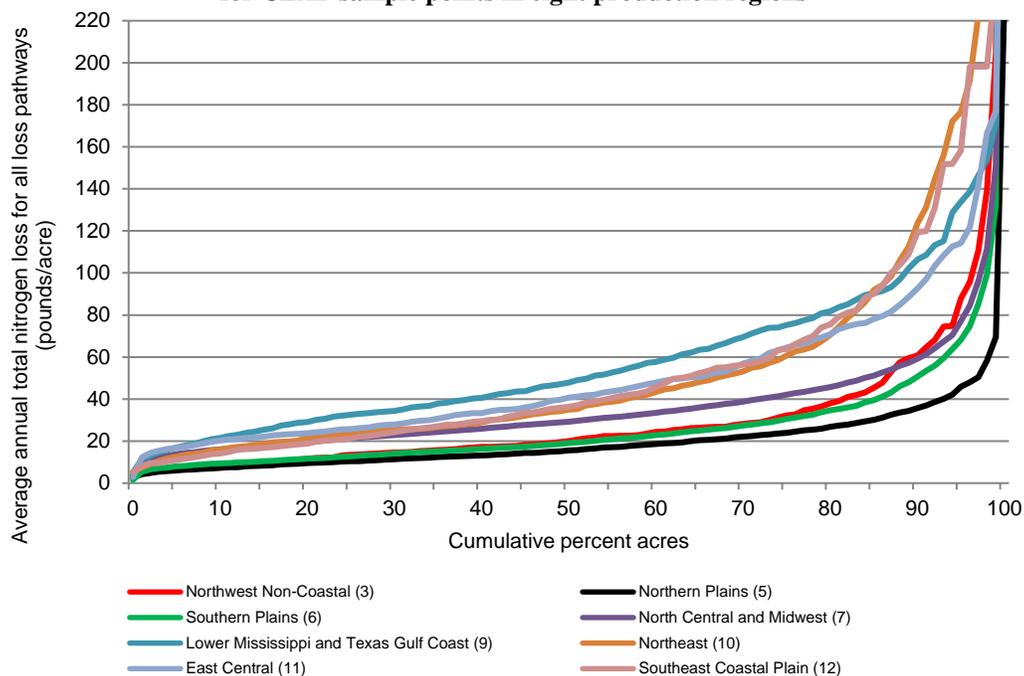
Total nitrogen lost from farm fields was lowest for the three westernmost regions. The four regions in the south and east have the largest losses of nitrogen from farm fields:

- the East Central (11) region had an average annual total nitrogen loss of 51 pounds per acre per year,
- the Southeast Coastal Plain (12) region had an average annual loss of 54 pounds per acre per year,
- the Northeast (10) region had an average annual loss of 56 pounds per acre per year, and
- the Lower Mississippi and Texas Gulf (9) region had an average annual loss of 58 pounds per acre per year.

The relatively high yields in the North Central and Midwest (7) region, which has the most cultivated cropland acres, had a smaller proportion of the amount of nitrogen applied being susceptible to the forces of wind and water. This region had the fourth lowest in average annual total nitrogen loss, following the three westernmost regions, with an average annual total nitrogen loss of 36 pounds per acre per year. This represents about 24 percent of the average annual amount of plant-available nitrogen in this region, the lowest proportion among all of the regions except for the Northern Plains (6) region. (The proportion for the Northern Plains (6) region was also about 24 percent.)

The regional cumulative distributions of nitrogen loss estimates shown in the figure below illustrate the extent to which losses vary among the eight production regions, after accounting for the benefits of conservation practices in use in 2003-06.

**Comparison of cumulative acre distributions of average annual amount of total nitrogen loss (all loss pathways) for CEAP sample points in eight production regions**



The APEX model simulation tracks nitrogen loss from farm fields through six loss pathways. On average for all sample points in the eight regions:

- nitrogen loss by volatilization averaged 6.5 pounds per acre per year, accounting for 19 percent of the total nitrogen loss;
- nitrogen loss through denitrification averaged 2.4 pounds per acre per year, accounting for 7 percent of the total nitrogen loss;
- nitrogen lost with windborne sediment averaged 4.5 pounds per acre per year, accounting for 13 percent of the total nitrogen loss;
- nitrogen dissolved in surface water runoff averaged 1.0 pounds per acre per year, accounting for 3 percent of the total nitrogen loss;
- nitrogen lost with waterborne sediment averaged 4.8 pounds per acre per year, accounting for 14 percent of the total nitrogen loss; and
- soluble nitrogen loss in subsurface flow pathways averaged 15.2 pounds per acre per year, accounting for 44 percent of the total nitrogen loss.

Losses of nitrogen in two loss pathways were essentially insignificant for most of the cropped acres:

- 78 percent of cropped acres had amounts of nitrogen loss through denitrification less than 2 pounds per acre per year; and
- 86 percent of cropped acres had amounts of nitrogen dissolved in surface water runoff less than 2 pounds per acre per year.

On the high side, 20 percent of cropped acres had losses of nitrogen in subsurface flow pathways in excess of 20 pounds per acre per year, including 12 percent with losses greater than 30 pounds per acre per year and 8 percent with losses greater than 40 pounds per acre per year.

The principal nitrogen loss pathways differed by region, reflecting differences in precipitation, surface water runoff, and soil properties:

- The average annual amount lost by volatilization ranged from a low of 5.4 pounds per acre per year in the Northeast (10) region to a high of 7.6 pounds per acre per year in the East Central (11) region. Volatilization losses exceeded 15 pounds per acre per year for a small number of acres in every region. In terms of the percent of total nitrogen loss, nitrogen lost by volatilization was one of the three principal loss pathways in the three westernmost regions and was also important within the Midwest and North Central (7) region.
- Loss of nitrogen through denitrification was not a principal loss pathway in any region. Amounts lost through this pathway were uniformly low except for in the Lower Mississippi and Texas Gulf (9) region, where nitrogen lost through denitrification accounted for 21 percent of the total nitrogen loss.
- Loss of nitrogen with windborne sediment was a principal loss pathway in the three westernmost regions, where wind erosion rates were high, but amounts lost were small in all but a few cropped acres in the other regions. The average annual amount of nitrogen lost with windborne sediment was nearly 8 pounds per acre per year in the Northern Plains (5) and the Southern Plains (6) regions.
- Nitrogen dissolved in surface water runoff is not a principal loss pathway for nitrogen in any of the eight regions. This in part reflects the widespread use of water erosion control practices, especially tillage and residue management. Retaining water on the field reduces the amount of surface water runoff and increases the amount that infiltrates into the soil. The two regions with the highest amount of nitrogen dissolved in surface water runoff were the East Central (11) region, with an average annual amount of 3.4 pounds per acre per year, and the Lower Mississippi and Texas Gulf (9) region, with an average annual amount of 3.0 pounds per acre per year.
- Nitrogen loss with waterborne sediment (nitrogen attached to sediment) is a principal loss pathway for nitrogen in four regions: the East Central (11) region, with an average annual amount of 13.3 pounds per acre per year; the Northeast (10) region, with an average annual amount of 12.9 pounds per acre per year; the Lower Mississippi and Texas Gulf (9) region, with an average annual amount of 10.0 pounds per acre per year; and the North Central and Midwest (7) region, with an average annual amount of 6.6 pounds per acre per year.
- Nitrogen loss in subsurface flow pathways was a principal loss pathway in every region. This loss pathway accounts for 75 percent of the total nitrogen loss in the Southeast Coastal Plain (12) region and 62 percent of the total nitrogen loss in the Northeast (10) region. Nitrogen losses in subsurface water flows were highest for the four regions in the east and south, where the average annual amount lost ranged from 51.2 pounds per acre per year in the East Central (11) region to 58.1 pounds per acre per year in the Lower Mississippi and Texas Gulf (9) region.

Adequate conservation treatment consists of combinations of conservation practices that treat the specific inherent vulnerability factors associated with each field. The adequacy of conservation practice use in 2003-06 was evaluated for two nitrogen loss outcomes:

- estimates of the total amount of nitrogen lost to surface water, obtained by adding the amount of waterborne nitrogen (nitrogen attached to sediment) to estimates of soluble nitrogen dissolved in surface water, and
- estimates of the amount of nitrogen loss in subsurface flow pathways.

Estimates of total nitrogen loss with surface water runoff greater than 15 pounds per acre per year are generally considered to be unacceptable and require additional conservation treatment. About 10 percent of all cultivated cropland acres in the eight regions—totaling 29 million acres—have average annual estimates of total nitrogen loss with surface water runoff greater than 15 pounds per acre per year. About three-fourths of these acres are concentrated in two regions: the North Central and Midwest (7) region, where 13 percent of cropped acres (15 million acres) had estimates of average annual total nitrogen loss with surface water runoff greater than 15 pounds per acre per year; and

the Lower Mississippi and Texas Gulf Coast (9) region, where 30 percent of cropped acres (6 million acres) had estimates of average total nitrogen loss with surface water runoff greater than 15 pounds per acre per year. Two other regions had a high percentage of cropped acres with excessive nitrogen loss rates—the Northeast (10) region, with 32 percent of cropped acres, and the East Central (11) region, with 37 percent. These two regions account for 18 percent of the cropped acres with excessive levels of total nitrogen loss with surface water runoff.

Estimates of nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year are also considered to be unacceptable and require additional nitrogen management (change of rate, timing, or method of application). About 16 percent of all cultivated cropland acres in the eight regions—totaling 46 million acres—have average annual estimates of nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year. About 43 percent of these acres are in the North Central and Midwest (7) region, where 17 percent of cropped acres (20 million acres) had excessive losses. Four other regions had a high percentage of cropped acres with excessive loss of nitrogen in subsurface flow pathways:

- the Southeast Coastal Plain (12) region, where 49 percent of cropped acres had excessive losses;
- the Lower Mississippi and Texas Gulf (9) region, where 32 percent of cropped acres had excessive losses;
- the Northeast (10) region, where 31 percent of cropped acres had excessive losses; and
- the East Central (11) region, where 27 percent of cropped acres had excessive losses.

### **To what extent do conservation practices reduce nitrogen loss?**

According to the model simulations, the use of conservation practices has reduced total nitrogen loss (all loss pathways) by an average annual amount of 14.9 pounds per acre per year, representing a 30-percent reduction. Without conservation practices, the average annual amount of total nitrogen loss would have been 49.3 pounds per acre per year, compared to an average of 34.4 pounds per acre per year for the baseline scenario, which includes a mix of fully treated, partially treated, and untreated acres. Reductions in total nitrogen loss due to conservation practices are much higher for some acres than others, reflecting both the level of treatment and the inherent erodibility of the soil. About 65 percent of the cropped acres had reductions in losses of more than 5 pounds per acre per year due to conservation practices. About 25 percent of the cropped acres had reductions in losses of more than 20 pounds per acre per year; these are the acres that were treated the most.

In contrast, about 13 percent of cropped acres had negative reductions, indicating that total nitrogen losses increased slightly for those acres resulting from tradeoffs in the benefits of conservation practice use for wind and water erosion. This is largely due to increases in nitrogen loss in subsurface flow pathways caused by relatively weak nutrient management practices on acres with erosion control treatment. A portion of the reduction in nitrogen lost with surface runoff is re-routed to subsurface loss pathways, resulting in gains or only small reductions in nitrogen loss in subsurface flows. This re-routing of surface water runoff to subsurface flow pathways also results in additional nitrogen being extracted from the soil. For some acres, the amount of nitrogen extracted from the soil and in the re-routed surface water runoff offsets the overall positive effects of erosion control practices on total nitrogen loss. *These model simulation results underscore the importance of pairing water erosion control practices with effective nutrient management practices so that the full suite of conservation practices will provide the environmental protection needed.*

Conservation practices were most effective in reducing nitrogen losses in different regions depending on the loss pathway:

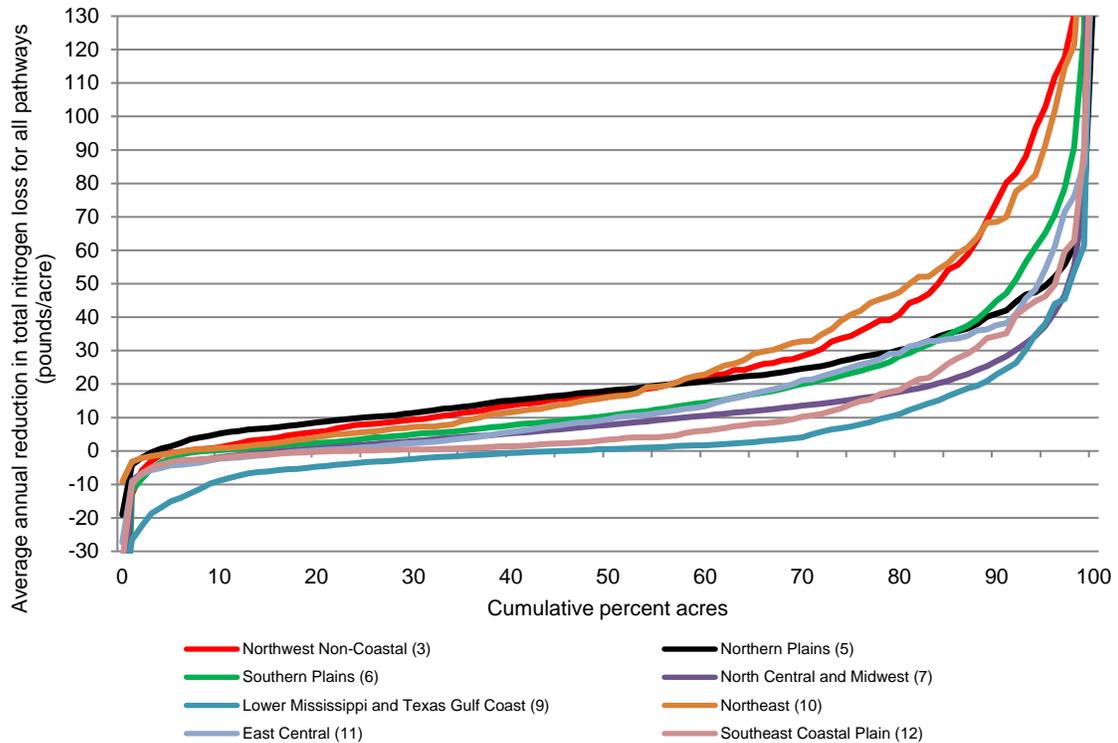
- Reductions in the amount of nitrogen loss by volatilization due to conservation practices was largest in the three westernmost regions, and was relatively small in other regions. In the Northwest Non-Coastal (3) region, for example, reductions due to conservation practices were greater than 5 pounds per acre per year for 30 percent of the cropped acres.
- The smallest reductions in nitrogen loss due to conservation practices were for nitrogen losses through denitrification, which were essentially negligible for most cropped acres in all regions.
- For nitrogen lost with windborne sediment, conservation practices were most effective in the three westernmost regions and the North Central and Midwest (7) region, where wind erosion is an important pathway for nitrogen loss. The largest reductions were in the Northern Plains (5) region, where the mean of the average annual reduction in nitrogen lost with windborne sediment was 8.0 pounds per acre per year, representing a 51-percent reduction.
- Conservation practices were effective in controlling nitrogen dissolved in surface water runoff in regions where this was a significant loss pathway. The largest reductions—averaging over 3.5 pounds per acre per

year—were in the two regions with the largest losses: 1) the Lower Mississippi and Texas Gulf Coast (9) region, and 2) the East Central (11) region.

- Reductions in nitrogen lost with waterborne sediment were largest in the Northeast (10) region and the East Central (11) region, where the average annual reduction in nitrogen lost with waterborne sediment was 5.5 pounds per acre per year. In contrast, reductions in the Northern Plains (5) region, where surface water runoff is very small, were negligible for nearly all cropped acres.
- The largest reductions due to conservation practices were for nitrogen loss in subsurface flow pathways, which is a principal loss pathway in every region. The largest reductions were in two regions: the Northeast (10) region, where the average annual reduction was 19.1 pounds per acre per year, representing a 35-percent reduction; and the Northwest Non-Coastal (3) region, where the average annual reduction was 17.2 pounds per acre per year, representing a 55-percent reduction.

The differences and similarities in the effectiveness of conservation practices on total nitrogen loss among regions are best illustrated by comparing the cumulative acre distributions of average annual reductions, shown in the figure below. For all loss pathways combined, the Lower Mississippi and Texas Gulf Coast (9) region had the smallest reductions in total nitrogen loss due to conservation practices. For this region, the average annual reduction in total nitrogen loss was only 4.2 pounds per acre per year, representing a 7-percent reduction due to the use of conservation practices. All other regions had an average annual reduction of 10 pounds per acre per year or more. Conservation practices were the most effective in controlling total nitrogen loss in two regions: the Northeast (10) region, where the average annual reduction was 28.0 pounds per acre per year, representing a 33-percent reduction; and the Northwest Non-Coastal (3) region, where the average annual reduction was 27.8 pounds per acre per year, representing a 47-percent reduction.

**Comparison of cumulative acre distributions of average annual REDUCTIONS in total nitrogen loss (all loss pathways) due to conservation practices for CEAP sample points in eight production regions**



## Introduction

Conservation practices have been used in the United States to control water erosion since the 1930s and 1940s. Hugh Hammond Bennett, the founder and first chief of the Soil Conservation Service (now Natural Resources Conservation Service) instilled in the national ethic the need to treat every acre to its potential by controlling soil erosion and surface water runoff. Land shaping structural practices (such as terraces, contour farming, and stripcropping) and sediment control structures were widely adopted during these early years. Conservation tillage emerged in the 1960s and 1970s as a key management practice for enhancing soil quality and further reducing soil erosion. Today, conservation tillage is widely used either alone or in combination with structural practices to control water erosion and sediment loss from farm fields.

During the 1990s, the focus of conservation efforts began to shift from soil conservation and sustainability to reducing pollution impacts associated with agricultural production. Prominent among new concerns were the environmental effects of nutrient export from farm fields. Traditional conservation practices used to control surface water runoff and erosion control were mitigating a significant portion of these nutrient losses. Additional gains were being achieved using nutrient management practices—application of nutrients (appropriate timing, rate, method, and form) to minimize losses to the environment and maximize the availability of nutrients for crop growth.

Today, nutrient management—especially nitrogen management—is a critical part of halting and sometimes reversing the long-term trend of excessive nutrients that are transported from farm fields into many of our Nation’s bays, estuaries, lakes, rivers, and streams.

NRCS has previously published a series of regional reports that assess the effects of conservation practices on reducing nitrogen from farm fields.<sup>1</sup> That assessment used a statistical sampling and modeling approach to estimate the effects of conservation practices. The National Resources Inventory (NRI) provided the statistical framework and soils data. Information on farming activities and conservation practices during the period 2003–06 was obtained for a subset of NRI sample points, and a field-level physical process simulation model called APEX was used to estimate losses of soil, nutrients, and pesticides at the edge of the field. The assessment was done 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. Survey data and modeling results were reported for Water Resource Regions that represented the major drainage basins in the United States.

The purpose of this report is to re-assess and summarize, at both the national and regional levels, how effective conservation practices are in reducing nitrogen loss from farm fields. For this assessment, the 2003-06 survey data and APEX

modeling results were aggregated according to the new CEAP production regions, shown in figure 2.

Sufficient sample size was available to conduct this reassessment for 8 of the 12 production regions, representing a total of 290 million cultivated cropland acres (table 1 and fig. 3). This coverage represents 95 percent of the 305 million total acres of cultivated cropland in the US in 2003, according to the 2003 NRI. As shown in figure 3, the bulk of the cultivated cropland (79 percent) is found in three regions:

- the North Central and Midwest (7) region, with 41 percent of the cultivated cropland in the eight regions,
- the Southern Plains (6) region, with 22 percent, and
- the Northern Plains (5) region, with 16 percent.

Results are reported for each of the eight regions and for all eight regions combined. Because the bulk of the cultivated cropland is found in the three regions listed above, the results reported for the eight regions combined largely reflects results for the combination of these three regions.

Table 1. Cultivated cropland acreage estimates for the 2003-06 CEAP sample for eight CEAP production regions, derived from the 2003 NRI.

CEAP production region	Number of 2003-06 CEAP sample points	Cultivated cropland acres based on the 2003 NRI	Percent of total acres
Northwest Non-Coastal (3)	817	11,477,012	4
Northern Plains (5)	1,518	47,688,900	16
Southern Plains (6)	2,606	63,563,684	22
North Central and Midwest (7)	8,065	117,423,200	41
Lower Mississippi and Texas Gulf Coast (9)	1,820	21,162,500	7
Northeast (10)	888	6,547,500	2
East Central (11)	915	8,723,200	3
Southeast Coastal Plain (12)	1,289	13,502,000	5
<b>All eight regions</b>	<b>17,918</b>	<b>290,087,996</b>	<b>100</b>

Note: See Appendix A for documentation of how the original CEAP sample weights for the 2003-06 CEAP sample were adjusted to represent cultivated cropland acreage for the new CEAP production regions.



Figure 1. Conservation practices reduce erosion and improve water quality.

<sup>1</sup> <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/pub/>

Figure 2. CEAP production regions (boundaries defined by 8-digit hydrologic unit codes).

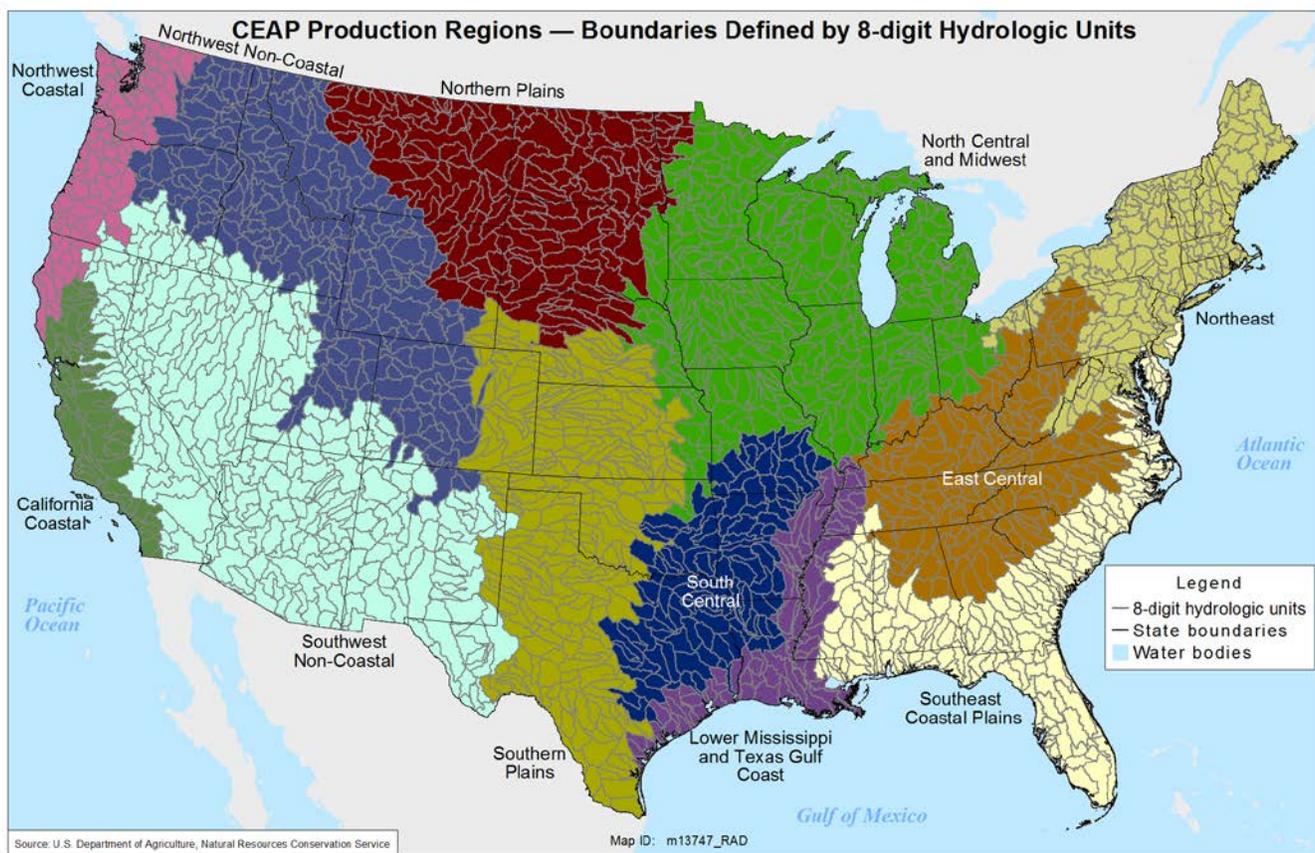
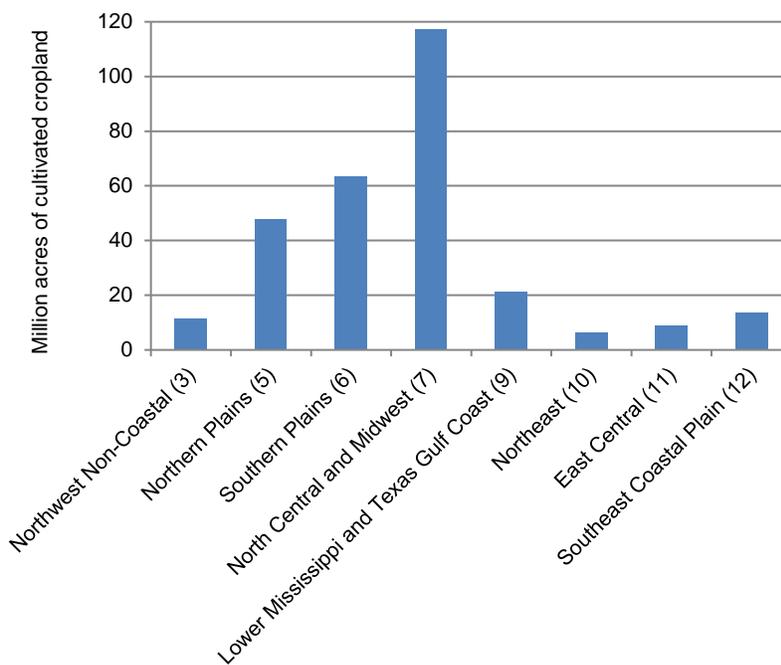


Figure 3. Cultivated cropland acreage derived from the 2003 NRI for the eight CEAP production regions covered in this report.



## Use of Conservation Practices to Control Nitrogen Loss from Farm Fields

Effective control of nitrogen loss from farm fields typically consists of a combination of practices that:

- avoid or limit the potential for nitrogen losses by using appropriate nitrogen management practices on *all* crops in the rotation;
- control erosion and the movement of soil within the field; and
- trap materials leaving the field using appropriate edge-of-field mitigation.

Nitrogen management practices address the rate, timing, and method of nitrogen application to promote crop growth. Erosion control practices include residue and tillage management (annual practices) and structural practices which, once implemented, are usually kept in place for several years.

### Structural Practices

Data on erosion control structural practices for the farm field associated with each CEAP sample point were obtained from four sources.

1. **The NRI-CEAP Cropland Survey** included questions about the presence of 12 types of structural practices: terraces, grassed waterways, vegetative buffers (in-field), hedgerow plantings, riparian forest buffers, riparian herbaceous buffers, windbreaks or herbaceous wind barriers, contour buffers (in-field), field borders, filter strips, critical area planting, and grade stabilization structures.
2. For fields with conservation plans, **NRCS field offices** provided data on all structural practices included in the plans.
3. **The USDA-Farm Service Agency (FSA)** provided practice information for fields that were enrolled in the Continuous CRP for these structural practices: contour grass strips, filter strips, grassed waterways, riparian buffers (trees), and field windbreaks (Alex Barbarika, USDA/FSA, personal communication).
4. **The 2003 NRI** provided additional information for practices that could be reliably identified from aerial photography as part of the NRI data collection process. These practices include contour buffer strips, contour farming, contour stripcropping, field stripcropping, terraces, cross wind stripcropping, cross wind trap strips, diversions, field borders, filter strips, grassed waterways or outlets, hedgerow planting, herbaceous wind barriers, riparian forest buffers, and windbreak or shelterbelt establishment.

Structural practices evaluated in the APEX model include:

- in-field practices for water erosion control, divided into two groups:
  - practices that control overland flow (terraces, contour buffer strips, contour farming, stripcropping, contour stripcropping), and
  - practices that control concentrated flow (grassed waterways, grade stabilization structures, diversions, and other structures for water control);
- edge-of-field practices for buffering and filtering surface runoff before it leaves the field (riparian forest buffers, riparian herbaceous cover, filter strips, field borders); and
- wind erosion control practices (windbreaks/shelterbelts, cross wind trap strips, herbaceous wind barriers, hedgerow planting).

**Structural practices for water erosion control.** Structural practices for water erosion control are in widespread use on cultivated cropland acres (fig. 4). Overall, about 38 percent of cultivated cropland acres had one or more structural water erosion control practice in 2003-06 (table 2). Overland flow practices were the most prevalent; 26 percent of cultivated cropland acres had some kind of overland flow practice installed. Concentrated flow control practices were used on 21 percent of cultivated cropland acres. Edge-of-field buffering and filtering practices were in much lower use in 2003-06, reported to be in use on only 5 percent of cultivated cropland acres for all eight regions combined.

Cultivated cropland acres designated as HEL (Highly Erodible Land)<sup>2</sup> had slightly lower proportions of acres treated with structural practices for water erosion control as non-HEL in 2003-06 for all 8 regions combined (table 2). Acres designated as HEL represent about 29 percent of all cultivated cropland acres in the eight regions. For HEL in all eight regions, about 34 percent of acres had one or more water erosion control practice. Overland flow practices were used on 21 percent of HEL cropped acres; concentrated flow control practices were used on 18 percent; and edge-of-field buffering and filtering practices were in use on only 6 percent.



Figure 4. Structural practices such as these terraces and buffers intercept, redirect, and filter runoff water.

Table 2. Structural water erosion control practices in use in 2003-06, by region and for all regions combined—percent of Highly-Erodible land (HEL), percent of non-HEL, and percent of all cultivated cropland acres.

	Overland flow control practices*			Concentrated flow control practices**			Edge-of-field buffering and filtering practices***			One or more structural erosion control practices		
	% of HEL	% of Non-HEL	% of all acres	% of HEL	% of Non-HEL	% of all acres	% of HEL	% of Non-HEL	% of all acres	% of HEL	% of Non-HEL	% of all acres
Production region												
Northwest Non-Coastal (3)	15	29	22	8	20	14	7	5	6	25	43	34
Northern Plains (5)	11	17	13	10	14	12	2	0	2	19	28	22
Southern Plains (6)	42	39	41	18	16	17	2	1	2	46	42	44
North Central and Midwest (7)	16	48	23	23	50	29	10	8	9	37	70	45
Lower Mississippi and Texas Gulf Coast (9)	9	31	12	9	24	11	3	7	3	17	45	20
Northeast (10)	22	50	36	7	20	14	6	5	5	29	56	43
East Central (11)	26	55	41	22	41	32	9	6	8	43	72	58
Southeast Coastal Plain (12)	22	41	24	11	31	13	6	5	6	29	49	31
All eight regions	21	38	26	18	29	21	6	4	5	34	50	38

\* Includes terraces, contour buffer strips, contour farming, stripcropping, contour stripcropping, field border, and in-field vegetative barriers.

\*\* Includes Grassed waterways, grade stabilization structures, diversions, and other structures for water control.

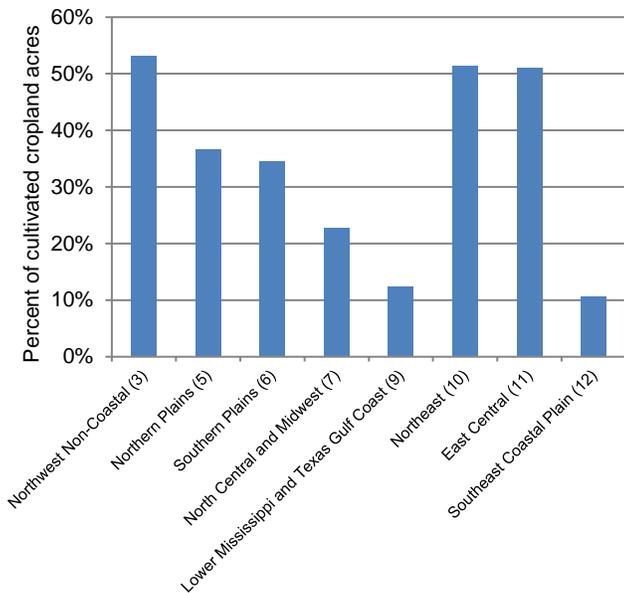
\*\*\* Includes Riparian forest buffers, riparian herbaceous buffers, and filter strips

Source: Conservation practice use as reported in the 2003-06 NRI-CEAP Cropland Survey and other sources and subsequently used in the APEX simulation modeling.

However, HEL is much more concentrated in some regions than others, as shown in figure 5. About half of the cultivated cropland acres in three regions are HEL: the Northwest Non-Coastal (3) region, the Northeast (10) region, and the East Central (11) region.

Not all cultivated cropland acres require structural conservation practices for water erosion control. Acres that are essentially flat with permeable soil types are more prone to infiltration of water and have a low potential for erosion.

Figure 5. Percent of cultivated cropland acres classified as HEL (Highly-Erodible Land), by region.

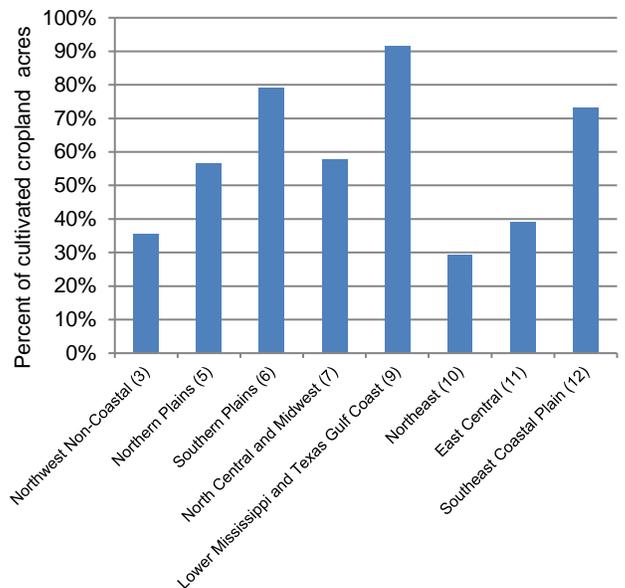


Note: For all eight regions combined, HEL represents 29 percent of cultivated cropland acres.

About 63 percent of cultivated cropland acres in the eight regions have field slopes of 2 percent or less, some of which may not need to be treated with structural practices. The prevalence of field slopes of 2 percent or less varies from region to region, as shown in figure 6. Regions with the most acres with field slopes of 2 percent or less are:

- the Lower Mississippi and Texas Gulf Coast (9) region, with 91 percent;
- the Southern Plains (6) region, with 79 percent; and
- the Southeast Coastal Plain (12) region, with 73 percent.

Figure 6. Percent of cultivated cropland acres with field slopes of 2 percent or less, by region.



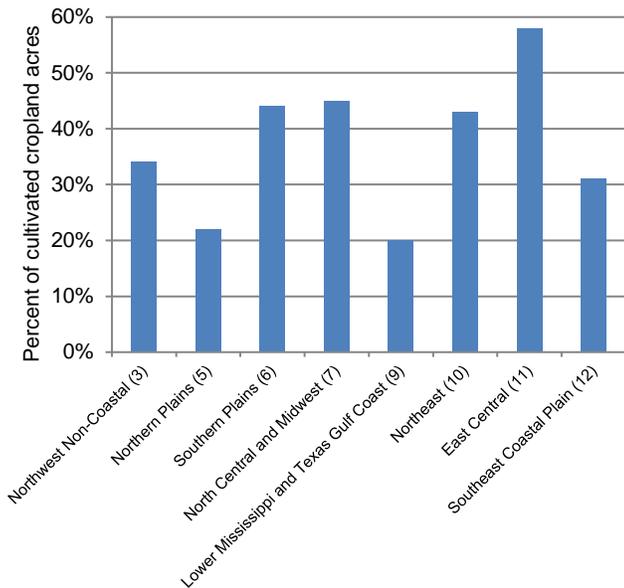
Note: For all eight regions combined, 63 percent of cultivated cropland acres have field slopes of 2 percent or less.

Structural practices for water erosion control were most prevalent in the East Central (11) region (table 2 and fig. 7), where 58 percent of cultivated cropland acres had one or more water erosion control practice in 2003-06. Structural practices were least prevalent in the Lower Mississippi and Texas Gulf Coast (9) region and the Northern Plains (5) region, where only 20-22 percent of cultivated cropland acres had one or more water erosion control practice in 2003-06.

Table 2 shows that, for most regions, non-HEL acres are treated with structural practices for water erosion control at higher proportions than HEL acres. For example, in the North Central and Midwest (7) region, overland flow practices were used on 48 percent of non-HEL acres but only 16 percent of HEL acres. Similarly, concentrated flow control practices were used on 50 percent of non-HEL cropped acres in this region but only 23 percent of HEL acres. HEL acres accounted for 23 percent of the cultivated cropland acres in this region.

The Southern Plains (6) region was the only region where HEL acres were treated with structural practices for water erosion control at a higher proportion than non-HEL acres for one or more structural conservation practice—46 percent of HEL acres versus 42 percent for non-HEL acres (table 2). HEL acres accounted for 34 percent of the cultivated cropland acres in this region.

Figure 7. Percent of cultivated cropland acres with one or more structural practice for water erosion control, by region.



To better represent the overall level of water erosion control that the various combinations of structural practice use represents, four levels of conservation treatment (high, moderately high, moderate, and low) were defined for each sample point, as follows.

- **High treatment:** Edge-of-field mitigation *and* at least one in-field structural practice (concentrated flow or overland flow practice) required.
- **Moderately high treatment:** Either edge-of-field mitigation required or both concentrated flow and overland flow practices required.
- **Moderate treatment:** No edge-of-field mitigation, either concentrated flow or overland flow practices required.
- **Low treatment:** No edge-of-field or in-field structural practices.

For the eight regions combined, only about 3 percent of cropped acres have a “high” level of treatment (combination of edge-of-field buffering or filtering and at least one in-field structural practice) (fig. 14 and table 3). Another 12 percent of cultivated cropland acres have a “moderately high” level of treatment, which could be achieved for some acres with edge-of-field buffering and filtering practices alone. The 62 percent of acres with a “low” level of treatment did not have any structural practice use, but this group includes 44 percent of cropped acres in the eight regions where field slopes were 2 percent or less.

Two regions stand out as having more structural practice use than the other regions—the East Central (11) region and the North Central and Midwest (7) region (table 3 and fig. 15). The East Central (11) region had 23 percent of cropped acres in the “high” or “moderately high” level of structural practice treatment, including 5 percent with a “high” level of treatment.

This region is one of the three regions with about half of cropped acres designated as HEL (fig. 5), and had 61 percent of cropped acres with field slopes more than 2 percent (fig. 6). The North Central and Midwest (7) region had 21 percent of cropped acres in the “high” or “moderately high” level of structural practice treatment, including 5 percent with a “high” level of treatment.

Two regions have the lowest level of structural practice use—the Northern Plains (5) region and the Lower Mississippi and Texas Gulf Coast (9) region. The Lower Mississippi and Texas Gulf Coast (9) region also has 91 percent of cropped acres with field slopes of 2 percent or less and only 12 percent of acres designated as HEL.

<sup>1</sup> HEL acres have a higher vulnerability to erosion due to the forces of wind or water. Soils are classified as HEL if they have an erodibility index (EI) score of 8 or higher. A numerical expression of the potential of a soil to erode, EI considers the physical and chemical properties of the soil and climatic conditions where it is located. EI is derived from the Sheet and Rill Erosion Equation USLE and the Wind Erosion Equation WEQ. The higher the index, the greater the investment needed to maintain the sustainability of the soil resource base if intensively cropped.



Figure 8. Manure injection reduces loss from volatilization and incorporates the material into the soil in one operation.



Figure 11. Honey wagon applications are cost efficient but require tillage to incorporate the waste material. Some nitrogen will be lost from volatilization using this application technique.



Figure 9. Injecting fertilizer into irrigation water (fertigation) is the most precise method of fertilizer application, allowing accurate applications to meet crop needs.



Figure 12. Lagoon hog waste management systems reduce runoff and allow for safe land application of nutrients contained in manure.



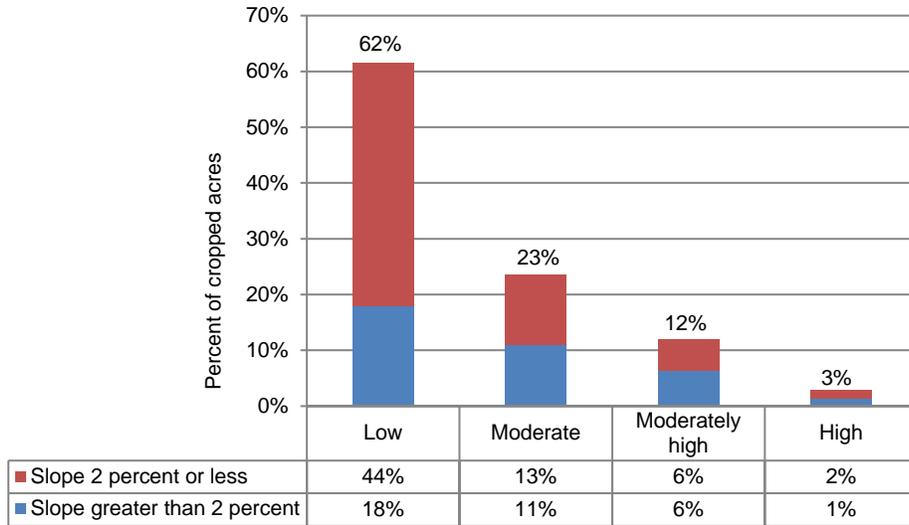
Figure 10. Applying fertilizer in multiple applications along with contouring reduces nitrogen loss and is an improvement over single heavy applications of fertilizer material.



Figure 13. Soil testing is essential for

high-level nutrient management.

Figure 14. Percent of cropped acres at four conservation treatment levels for structural practices for water erosion control, all eight regions combined.



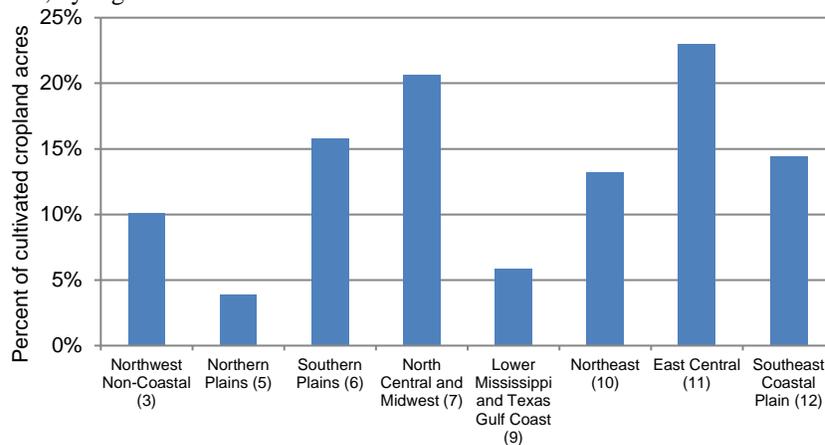
Criteria for four levels of treatment with structural conservation practices are:

- **High treatment:** Edge-of-field mitigation *and* at least one in-field structural practice (concentrated flow or overland flow practice) required.
- **Moderately high treatment:** Either edge-of-field mitigation required or both concentrated flow and overland flow practices required.
- **Moderate treatment:** No edge-of-field mitigation, either concentrated flow or overland flow practices required.
- **Low treatment:** No edge-of-field or in-field structural practices.

Table 3. Percent of cropped acres at four conservation treatment levels for structural practices for water erosion control, by region.

	Low	Moderate	Moderately high	High
Production region				
Northwest Non-Coastal (3)	66	24	7	3
Northern Plains (5)	78	18	3	1
Southern Plains (6)	56	29	15	1
North Central and Midwest (7)	55	24	16	5
Lower Mississippi and Texas Gulf Coast (9)	80	15	4	2
Northeast (10)	57	30	10	4
East Central (11)	42	35	18	5
Southeast Coastal Plain (12)	69	17	12	3
All eight regions	62	23	12	3

Figure 15. Percent of cultivated cropland acres with “high” or “moderately high” levels of conservation treatment with structural practices for water erosion control, by region.



**Structural practices for wind erosion control.** In some regions, nitrogen loss from farm fields with windborne sediment is an important loss pathway. Wind erosion control practices are designed to reduce the force of the wind on the field. NRCS practice standards for wind erosion control practices include cross wind ridges, cross wind trap strips, herbaceous wind barriers, and windbreak/shelterbelt establishment.

Structural practices for wind erosion control are in not in widespread use. Cultivated cropland acreage with wind erosion control practices averages 6 percent for all eight regions combined—8 percent of HEL acres and 6 percent of non-HEL acres (table 4). The Northern Plains (5) region has the highest percentage of use—22 percent of HEL acres and 17 percent of non-HEL acres. The Lower Mississippi and Texas Gulf Coast (9) region has the lowest, with only 1 percent of cultivated cropland acres treated for wind erosion with structural practices.



Figure 16. Windbreaks protect the soil from erosion and reduce transport of plant nutrients attached to dust particles.



Figure 17. Highly erodible land can often be safely farmed with adequately planned and applied conservation systems that provide protection from wind and water erosion and subsequently reduce the potential for water pollution.

Table 4. Wind erosion control practices\* in use in 2003-06, by region and for all regions combined—percent of Highly-Erodible land (HEL), percent of non-HEL, and percent of all cultivated cropland acres.

	% of HEL	% of Non-HEL	% of all acres
Production region			
Northwest Non-Coastal (3)	2	2	2
Northern Plains (5)	22	17	19
Southern Plains (6)	5	6	6
North Central and Midwest (7)	4	3	3
Lower Mississippi and Texas Gulf Coast (9)	<1	1	1
Northeast (10)	8	4	6
East Central (11)	3	2	3
Southeast Coastal Plain (12)	7	2	3
All eight regions	8	6	6

\* Includes windbreaks/shelterbelts, cross wind trap strips, herbaceous windbreak, and hedgerow planting.

Source: Conservation practice use as reported in the 2003-06 NRI-CEAP Cropland Survey and other sources and subsequently used in the APEX simulation modeling.



Figure 18. Trees, shrubs, and grass planted along the edges of streams and other water courses are called riparian buffers. They are very effective in filtering polluted water before it enters the stream. They also provide some protection from the forces of wind.

## Conservation Tillage and Residue Management Practices

Model simulation of the use of conservation tillage and residue management practices were based on the field operations and machinery types reported in the NRI-CEAP Cropland Survey for each sample point. The survey obtained information on the timing, type, and frequency of each tillage implement used during the previous 3 years, including the crop to which the tillage operation applied. Model outcomes affected by tillage practices, such as erosion and runoff, were determined using APEX processes of the daily tillage activities as reported in the survey.

To evaluate the level of conservation tillage and residue management, the Soil Tillage Intensity Rating (STIR)<sup>3</sup> was used for tillage intensity, and gains or losses in soil organic carbon (based on model simulation results) were used as an indicator of residue management.

**Tillage intensity.** STIR values represent the soil disturbance intensity, which was estimated for each crop at each sample point.<sup>4</sup> The soil disturbance intensity is a function of the kinds of tillage, the frequency of tillage, and the depth of tillage. STIR values were calculated for each crop and for each of the 3 years covered by the NRI-CEAP Cropland Survey (accounting for multiple crops or cover crops).

STIR criteria used to define four levels of tillage intensity were as follows:

- No-till—average annual STIR over all crop years in the rotation is less than 30;
- Mulch till—average annual STIR over all crop years in the rotation is between 30 and 100;
- Some reduced tillage—STIR values indicate there was some reduced tillage on some crops in the rotation but the average annual tillage intensity is greater than criteria for mulch till; and
- Continuous conventional tillage—the STIR value for every crop year in the rotation is more than 100.



Figure 19. No-till farming protects natural resources in a variety of ways. It basically halts sheet and rill erosion on some sites.

Most cropland acres met criteria for either mulch till or no-till. For all eight regions combined, about 32 percent of cultivated cropland acres met the tillage intensity criteria for no-till, including 42 percent of HEL acres and 28 percent of non-HEL acres (table 5). About 50 percent of cultivated cropland acres met the tillage intensity criteria for mulch till, including 42 percent of HEL acres and 54 percent of non-HEL acres. About 7 percent of cropped acres did not meet criteria for mulch till or no-till, but had reduced tillage on some crops in the rotation. Only about 10 percent of the cropped acres in all eight regions were conventionally tilled in 2003-06.

No-till was in most use in two regions (table 5 and fig. 21):

- the East Central (11) region, where 52 percent of cultivated cropland met criteria for no-till, including 51 percent of HEL acres, and
- the Northern Plains (5) region, where 47 percent of cultivated cropland met criteria for no-till, including 63 percent of HEL acres.

No-till was used on less than 20 percent of cropped acres in two regions—the Northwest Non-Coastal (3) region and the Southern Plains (6) region.

Use of mulch till was common in all eight regions (table 5 and fig. 22). Mulch till was most prevalent in the Northwest Non-Coastal (3) region, where 62 percent of cultivated cropland acres met criteria for mulch till, including 64 percent of HEL acres. Mulch till was least prevalent in the East Central (11) region, where only 35 percent of cultivated cropland acres met criteria for mulch till.

Use of continuous conventional tillage was highest in the Southern Plains (6) region, where 26 percent of the cultivated cropland acres are conventionally tilled (table 5).



Figure 20. Mulch tillage and no-till farming are very effective conservation practices that reduce erosion, improve soil quality, and eventually increase the nutrient holding capacity of the soil.

<sup>3</sup> A description of the Soil Tillage Intensity Rating (STIR) can be found on the NRCS website.

<sup>4</sup> Percent residue cover was not used to evaluate no-till or mulch till because this criterion is not included in the current NRCS practice standard for

Residue and Tillage Management. Residue is, however, factored into erosion and runoff estimates in APEX.

Table 5. Conservation tillage use in 2003-06, by region and for all regions combined—percent of Highly-Erodible land (HEL), percent of non-HEL, and percent of all cultivated cropland acres.

	No-till*			Mulch till**			Some reduced tillage***			Continuous conventional tillage****		
	% of HEL	% of Non-HEL	% of all acres	% of HEL	% of Non-HEL	% of all acres	% of HEL	% of Non-HEL	% of all acres	% of HEL	% of Non-HEL	% of all acres
Production region												
Northwest Non-Coastal (3)	21	16	19	64	60	62	9	14	11	6	10	8
Northern Plains (5)	63	38	47	30	46	40	5	11	9	2	6	4
Southern Plains (6)	18	20	19	47	45	46	9	9	9	26	26	26
North Central and Midwest (7)	52	29	34	43	61	57	3	5	5	2	5	4
Lower Mississippi and Texas Gulf Coast (9)	50	21	24	34	57	54	5	8	7	12	15	14
Northeast (10)	27	19	23	51	59	55	8	13	10	14	9	12
East Central (11)	51	53	52	33	38	35	10	5	8	6	4	5
Southeast Coastal Plain (12)	31	33	32	55	48	49	8	8	8	5	12	11
All eight regions	42	28	32	42	54	50	6	8	7	10	11	10

\* Average annual Soil Tillage Intensity Rating (STIR) over all crop years in the rotation is less than 30.

\*\* Average annual Soil Tillage Intensity Rating (STIR) over all crop years in the rotation is between 30 and 100.

\*\*\* Reduced tillage on some crops in rotation but average annual tillage intensity greater than criteria for mulch till.

\*\*\*\* Soil Tillage Intensity Rating (STIR) for every crop year in the rotation is more than 100.

Note: Percent residue cover was not used to determine no-till or mulch till.

Source: Conservation tillage levels were derived from field operations as reported in the 2003-06 NRI-CEAP Cropland Survey and subsequently used in the APEX simulation modeling.

Figure 21. Percent of cultivated cropland acres meeting STIR criteria for no-till, by region.

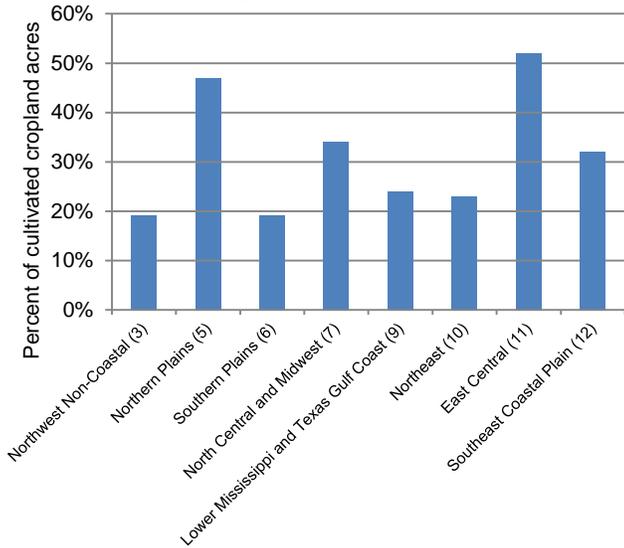
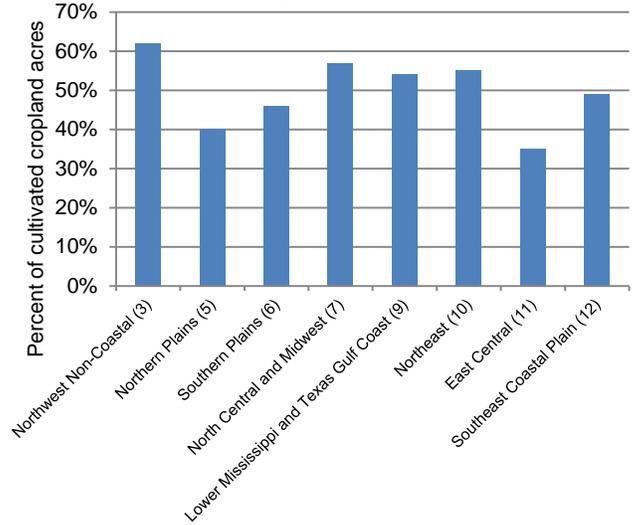


Figure 22. Percent of cultivated cropland acres meeting STIR criteria for mulch till, by region.



**Soil organic carbon.** The average annual change in soil organic carbon was used as an indicator of residue management. Higher levels of residue are correlated with increasing rates of soil organic carbon accumulation in the soil over time. Soil organic carbon improves water holding capacity and reduces erodibility through enhanced soil aggregate stability. Removal of residue by the farmer decreases this benefit.

In the APEX model simulation, the daily level of soil organic carbon is tracked and included in the model output. The annual change is calculated as the difference between the end-of-year carbon value and the beginning-of-year carbon value for each of the 47 years in the model simulation. (If soil organic carbon was decreasing in a given year, the value for that year would be negative.) The average annual change in soil organic carbon in pounds per acre is determined as the mean over the 47 years of model simulation results for each sample point.

Residue management was considered to be “good” for a sample point if the average annual change in soil organic carbon was positive, indicating soil organic carbon was increasing every year, on average. It was considered to be “poor” if the average annual change in soil organic carbon was negative, indicating soil organic carbon was decreasing every year, on average.

According to the simulation model results, 51 percent of cultivated cropland acres had gains in soil organic carbon for all eight regions combined (table 6 and fig. 23). However, some regions had indications of much better residue management than other regions (fig. 25). The North Central and Midwest (7) region had by far the highest percentage of acres gaining in soil organic carbon—73 percent. The lowest percentages were in two regions—the Southeast Coastal Plain (12) region with 23 percent and the Northeast (10) region with 27 percent. Percentages of cultivated cropland acres gaining in soil organic carbon for the remaining regions ranged from 33 to 44 percent.

Table 6. Percent of cultivated cropland acres gaining in soil organic carbon, by region.

	Percent
Northwest Non-Coastal (3)	33
Northern Plains (5)	44
Southern Plains (6)	34
North Central and Midwest (7)	73
Lower Mississippi and Texas Gulf Coast (9)	35
Northeast (10)	27
East Central (11)	43
Southeast Coastal Plain (12)	23
All eight regions	51

Figure 23. Distribution of average annual change in soil organic carbon for sample points in all eight regions.

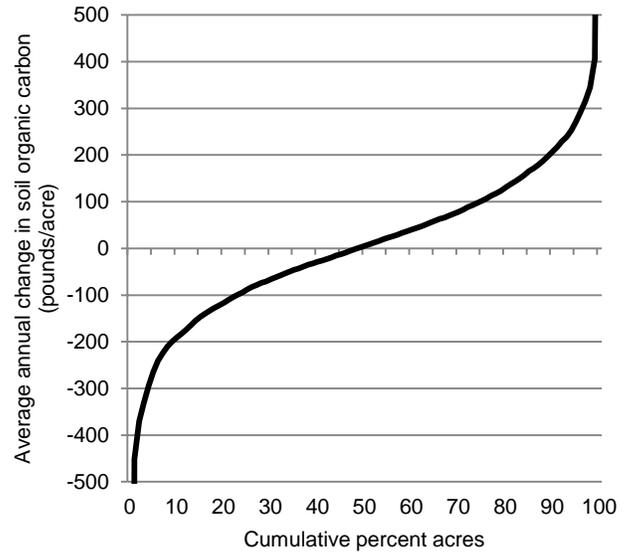
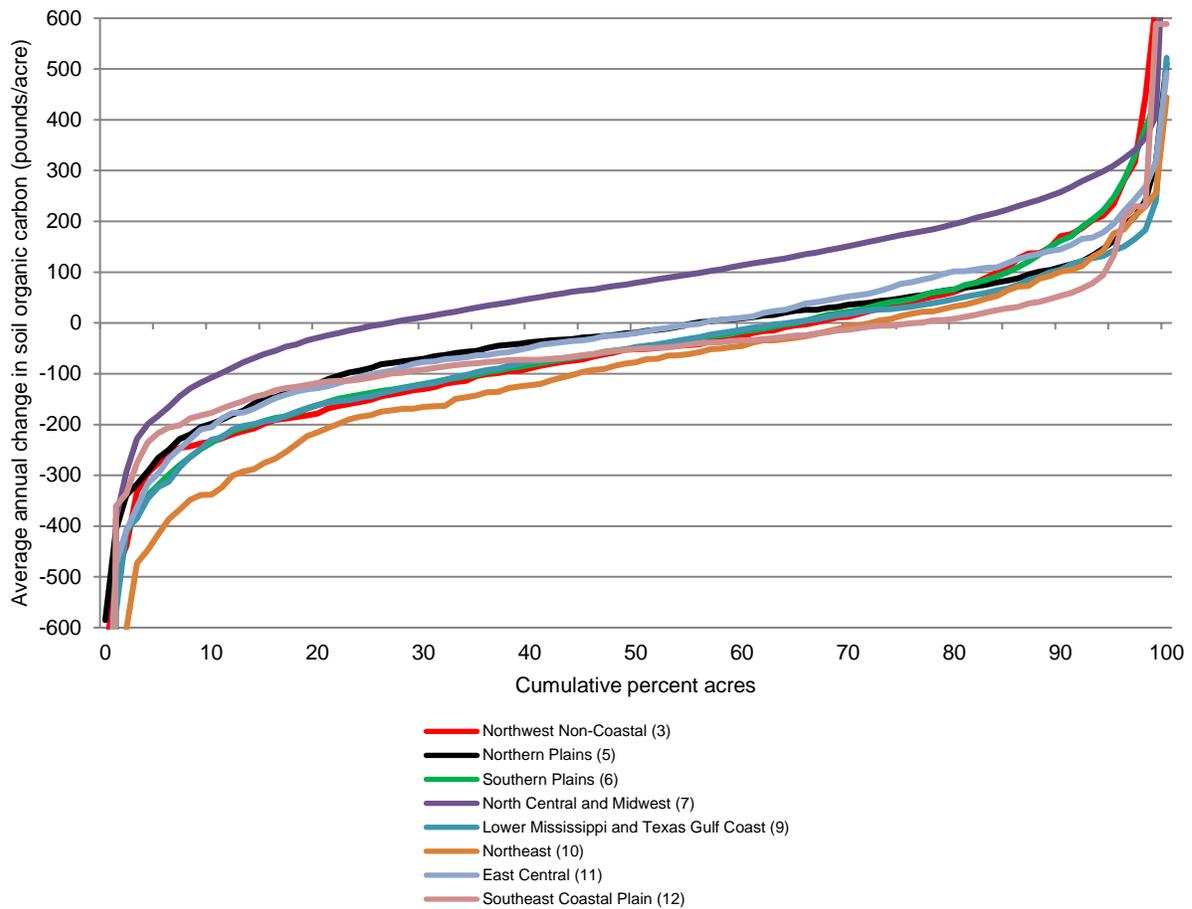


Figure 24. Soil quality improves slowly after conservation practices are applied. Soil organic carbon increases as crop residues decay and form humus. Soil microbes also increase due to the constant supply of carbon sources as food.

Figure 25. Distributions of average annual change in soil organic carbon for sample points in each of the eight regions.



**Conservation treatment levels.** As was done for structural practices, four levels of conservation treatment (high, moderately high, moderate, or low) were defined for conservation tillage use at each sample point. The criteria combined tillage intensity and residue management, where residue management was represented by the change in the average annual soil organic carbon level derived from the APEX simulation model.<sup>5</sup> Criteria for four levels of treatment with conservation tillage management are:

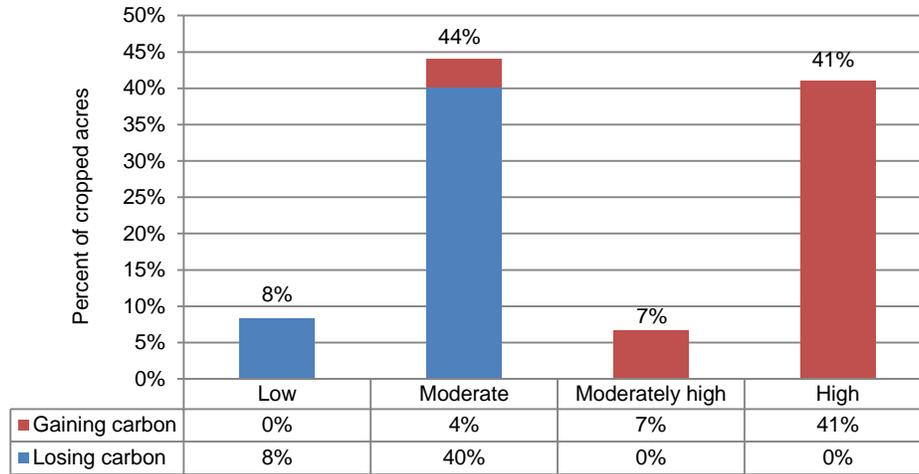
- **High treatment:** *All crops* meet tillage intensity criteria for either no-till or mulch till and crop rotation is gaining soil organic carbon.
- **Moderately high treatment:** *Average annual* tillage intensity meets criteria for mulch till or no-till and crop rotation is gaining soil organic carbon; some crops in rotation exceed tillage intensity criteria for mulch till.
- **Moderate treatment:** Some crops have reduced tillage but rotation is losing soil organic carbon, or crop rotation is gaining soil organic carbon and the *average annual* tillage intensity exceeds criteria for mulch till.
- **Low treatment:** Continuous conventional tillage and crop rotation is losing soil organic carbon.

For the eight regions combined, 41 percent of acres had a “high” level of tillage and residue management (fig. 26, table 7). Another 7 percent had a “moderately high” level. The “high” and “moderately high” treatment levels represent the 48 percent of cropped acres that meet tillage intensity criteria for either no-till or mulch till with gains in soil organic carbon. Only 8 percent had a “low” treatment level, since few acres had continuous conventional tillage and were also losing soil organic carbon. The remaining 44 percent had a “moderate” treatment level. These were acres that had some kind of reduced tillage but less than mulch till; most acres in this treatment level are losing soil organic carbon.

<sup>5</sup> STIR values in combination with carbon trends are in line with the use of the Soil Conditioning Index (SCI), which approximates the primary criteria for NRCS residue management standards. The NRCS practice standard, as

applied at the field, may include other considerations to meet site specific resource concerns that are not considered in this evaluation.

Figure 26. Percent of cropped acres at four conservation treatment levels for tillage and residue management practices, all eight regions combined.



Criteria for four levels of treatment with tillage management are:

- **High treatment:** All crops meet tillage intensity criteria for either no-till or mulch till and crop rotation is gaining soil organic carbon.
- **Moderately high treatment:** Average annual tillage intensity meets criteria for mulch till or no-till and crop rotation is gaining soil organic carbon; some crops in rotation exceed tillage intensity criteria for mulch till.
- **Moderate treatment:** Some crops have reduced tillage but rotation is losing soil organic carbon, or crop rotation is gaining soil organic carbon and tillage intensity exceeds criteria for mulch till.
- **Low treatment:** Continuous conventional tillage and crop rotation is losing soil organic carbon.

Table 7. Percent of cropped acres at four conservation treatment levels for tillage and residue management practices, by region.

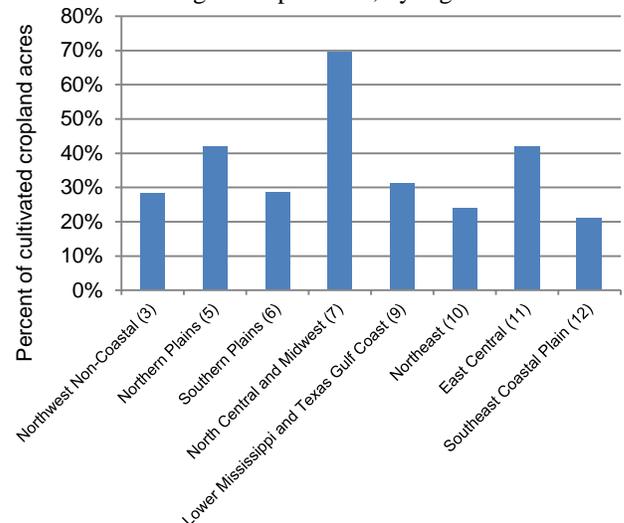
	Low	Moderate	Moderately high	High
Production region				
Northwest Non-Coastal (3)	5	66	9	20
Northern Plains (5)	3	55	4	38
Southern Plains (6)	22	50	5	23
North Central and Midwest (7)	3	28	8	61
Lower Mississippi and Texas Gulf Coast (9)	12	56	5	26
Northeast (10)	10	67	9	15
East Central (11)	5	53	7	35
Southeast Coastal Plain (12)	10	69	7	14
All eight regions	8	44	7	41

The North Central and Midwest (7) region stands apart from other regions with a “high” treatment level for 61 percent of cultivated cropland acres and 69 percent of acres with either a “high” or “moderately high” treatment level (table 7 and fig. 27).

Two regions had the lowest percentages of cropped acres with either a “high” or “moderately high” treatment level—the Southeast Coastal Plain (12) region with 21 percent and the Northeast (10) region with 24 percent. These are also the two regions that had the lowest percentages of acres gaining soil organic carbon (table 6).

Percentages of cropped acres with either a “high” or “moderately high” treatment level for the remaining regions ranged from 28 to 42 percent (fig. 27).

Figure 27. Percent of cultivated cropland acres with “high” or “moderately high” levels of conservation treatment for tillage and residue management practices, by region.



## Nitrogen Management Practices

Nitrogen and other nutrients are essential inputs to profitable crop production. They promote plant growth and increase crop yields. Nitrogen is applied to farm fields either as commercial fertilizer or manure. Not all of the nitrogen applied to the land, however, is taken up by crops. Some is lost to the environment through wind and water processes, which can contribute to offsite water quality problems.

Nutrient management systems can minimize nitrogen losses from farm fields while providing adequate soil fertility and nutrient availability to ensure realistic yields. Such systems are tailored to address the specific crop rotation, nutrient sources available in the soil, and other site characteristics of each field. Nutrient management systems have four basic criteria for application of commercial fertilizers and manure.<sup>6</sup>

1. Apply nutrients at the **appropriate rate** based on soil and plant tissue analyses and realistic yield goals.
2. Apply the **appropriate form** of fertilizer and organic material with compositions and characteristics that resist nutrient losses from the agricultural management zone.
3. Apply at the **appropriate time** to supply nutrients to the crop when the plants have the most active uptake and biomass production, and avoid times when adverse weather conditions can result in large losses of nutrients from the agricultural management zone.
4. Apply using the **appropriate application method** that provides nutrients to the plants for rapid, efficient uptake and reduces the exposure of nutrient material to forces of wind and water.

Depending on the field characteristics, these nutrient management techniques can be coupled with other conservation practices such as conservation crop rotations, cover crops, residue management practices, and structural practices to minimize the potential for nutrient losses. Even though nutrient transport and losses from farm fields cannot be completely eliminated, they can be minimized by careful management and kept within an acceptable level.

The presence or absence of nitrogen management practices was based on information on the timing, rate, and method of application for manure and commercial fertilizer as reported in the NRI-CEAP Cropland Survey. The appropriate form of nutrients applied was not evaluated because the survey was not sufficiently specific about the material formulations that were used. The following criteria were used to identify the appropriate rate, time, and method of nitrogen application for each crop or crop rotation.

- All commercial fertilizer and manure applications are within 3 weeks prior to plant date, at planting, or within 60 days after planting.
- The method of application for commercial fertilizer or manure is some form of incorporation or banding or spot treatment or foliar applied.
- The rate of nitrogen application, including the sum of both commercial fertilizer and manure nitrogen available for crops in the year of application, is:
  - less than 1.4 times the amount of nitrogen removed in the crop yield at harvest for *each* crop, except for cotton and small grain crops;
  - less than 1.6 times the amount of nitrogen removed in the crop yield at harvest for small grain crops (wheat, barley, oats, rice, rye, buckwheat, emmer, spelt, and triticale); and
  - less than 60 pounds of nitrogen per bale of cotton harvested.

The 1.4 ratio of application rate to yield represents 70-percent use efficiency for applied nitrogen, which has traditionally been accepted as good nitrogen management practice. The 30 percent “lost” includes plant biomass left in the field, volatilization during and following application, immobilization by soil and soil microbes, and surface runoff and leaching losses. A slightly higher ratio is used for small grain crops to maintain yields at current levels.

These nutrient management criteria are intended to represent practice recommendations commonly found in comprehensive nutrient management conservation plans and are consistent with recommended rates. They do not, however, necessarily represent the best possible set of nutrient management practices. For example, lower application rates are possible when timing and method criteria are also met and when soil erosion and runoff are controlled.

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<sup>6</sup> These criteria are also referred to as “4R nutrient stewardship—right rate, right time, right place, and right source.”

For APEX modeling, it was necessary to adjust the rates of nitrogen application reported in the survey to account for missing data and data-entry errors to prevent insufficient crop growth throughout the 47 years in the model simulation. Crop growth, and thus canopy development its influence on erosion, is a function of available nutrients in the APEX model. Insufficient nutrients in the model simulation results in overestimates of soil erosion and thus overestimates of sediment and nutrient losses from farm fields.

Additional commercial nitrogen fertilizer was added to crop samples for which model results indicated that more nitrogen was needed for reasonable crop yields as estimated by the simulation model. The amount of nitrogen added brought application rates for these sample points up to levels consistent with application rates for the unadjusted set of crop samples. Nitrogen was added by increasing the existing applications proportionately (thus preserving the reported timing and methods), when present, or were applied at plant.<sup>7</sup>

Overall for all eight regions combined, about 29 percent of cultivated cropland acres had commercial nitrogen fertilizer application rates adjusted upward relative to survey data to assure sufficient crop growth in the APEX model simulation.

**Nitrogen management practices for all eight regions combined.** For all eight regions combined, the majority of acres met at least one of the three management practices—timing, rate, or method of application for manure and commercial fertilizer—in 2003-06. However, much fewer acres met criteria for all three.

As shown in table 8, 63 percent of cropped acres met criteria for timing of nitrogen applications for all crops in the rotation, including both manure and commercial fertilizer applications. This excludes the 3 percent of cropped acres that did not have any nitrogen application. Thus, about 34 percent of acres did not meet the criteria for timing for one or more crops in the rotation.

For the method of nitrogen application, 58 percent of cropped acres met the criteria for nitrogen management, and about 39 percent did not meet the criteria for one or more crops in the rotation.

For the rate of nitrogen application, 50 percent of cropped acres met the criteria for nitrogen management, and about 47 percent did not meet the rate criteria.

Only 25 percent of cropped acres met criteria for timing and method and rate. After accounting for the 3 percent of acres that did not receive nitrogen applications, about 72 percent of

cropped acres did not fully meet the criteria for nitrogen management.

Acres with manure applied—about 10 percent of cropped acres in all eight regions—met the criteria for nitrogen application much less frequently than for acres receiving only commercial fertilizer (table 8). For cultivated cropland acres receiving manure:

- 13 percent met criteria for timing of nitrogen applications (both commercial fertilizer and manure applications) for all crops in the rotation, compared to 68 percent for application of commercial nitrogen fertilizer only;
- 40 percent met criteria for method of nitrogen applications (both commercial fertilizer and manure applications) for all crops in the rotation, compared to 60 percent for application of commercial nitrogen fertilizer only; and
- 39 percent met criteria for the rate of nitrogen application for the crop rotation (both commercial fertilizer and manure applications), compared to 51 percent for application of commercial nitrogen fertilizer only.

Only 3 percent of cultivated cropland acres that received manure in 2003-06 met nitrogen management criteria for timing and rate and method of application, compared to 27 percent for acres without manure applied but had commercial nitrogen fertilizer applied (table 8). An additional 4 percent of the acres without manure applied also did not have any commercial nitrogen applied.

As was done for structural practices and tillage and residue management practices, four levels of conservation treatment (high, moderately high, moderate, or low) were defined for nitrogen management at each sample point using combinations of appropriate timing, rate, and method criteria.

For this purpose, lower nitrogen rate criteria are appropriate for acres that meet application timing and method criteria and also are fully treated for soil erosion control because more of the nitrogen applied is retained on the field and is therefore available for crop growth. These lower application rate criteria are:

- 1.2 times the amount of nitrogen removed in the crop yield at harvest for *each* crop, except for cotton and small grain crops;
- 1.5 times the amount of nitrogen removed in the crop yield at harvest for small grain crops; and
- 50 pounds of nitrogen per bale of cotton harvested.

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<sup>7</sup> For additional information on adjustment of nutrient application rates, see the CEAP documentation report “Adjustment of CEAP Cropland Survey

Nutrient Application Rates for APEX Modeling,” available at the CEAP website or from the CEAP team in NRCS.

Table 8. Nitrogen (N) management practices based on survey data for 2003-06 for cultivated cropland acres.

Production region	No crops in rotation have application of N	All crops in rotation have application of N within 3 weeks before planting or within 60 days after planting	All crops in rotation have N applied with incorporation or banding/foliar/spot treatment	Each crop in the crop rotation meets the N rate criteria*	Appropriate timing and rate and method of application (excludes acres with no N applied)
<b>Percent of all acres</b>					
Northwest Non-Coastal (3)	1	72	71	69	47
Northern Plains (5)	1	75	70	67	42
Southern Plains (6)	6	68	62	56	29
North Central and Midwest (7)	2	53	54	44	18
Lower Mississippi and Texas Gulf Coast (9)	14	69	56	26	15
Northeast (10)	2	50	45	46	17
East Central (11)	3	69	31	41	13
Southeast Coastal Plain (12)	4	60	45	41	16
All eight regions	3	63	58	50	25
<b>Percent of acres without manure applied</b>					
Northwest Non-Coastal (3)	1	74	72	71	48
Northern Plains (5)	1	77	72	68	43
Southern Plains (6)	6	71	62	57	30
North Central and Midwest (7)	2	61	56	44	21
Lower Mississippi and Texas Gulf Coast (9)	14	70	57	27	15
Northeast (10)	4	80	51	47	27
East Central (11)	3	77	33	40	14
Southeast Coastal Plain (12)	4	64	44	43	17
All eight regions	4	68	60	51	27
<b>Percent of acres with manure applied</b>					
Northwest Non-Coastal (3)	0	15	52	34	13
Northern Plains (5)	0	4	34	55	<1
Southern Plains (6)	0	7	43	29	2
North Central and Midwest (7)	0	12	40	40	3
Lower Mississippi and Texas Gulf Coast (9)	0	30	15	13	<1
Northeast (10)	0	16	39	45	5
East Central (11)	0	23	24	49	7
Southeast Coastal Plain (12)	0	19	48	23	4
All eight regions	0	13	40	39	3

\* The rate of nitrogen application, including the sum of both commercial fertilizer and manure nitrogen available for crops in the year of application, is—

- less than 1.4 times the amount of nitrogen removed in the crop yield at harvest for *each* crop, except for cotton and small grain crops;
- less than 1.6 times the amount of nitrogen removed in the crop yield at harvest for small grain crops (wheat, barley, oats, rice, rye, buckwheat, emmer, spelt, and triticale);
- less than 60 pounds of nitrogen per bale of cotton harvested.

The rate of nitrogen application was evaluated after adjusting the rates of application reported in the survey to account for missing data and data-entry errors so as to prevent insufficient crop growth throughout the 47 years in the model simulation. See text.

Note: The assessment included application of both commercial nitrogen fertilizers and manure.

The four levels of nitrogen management are:

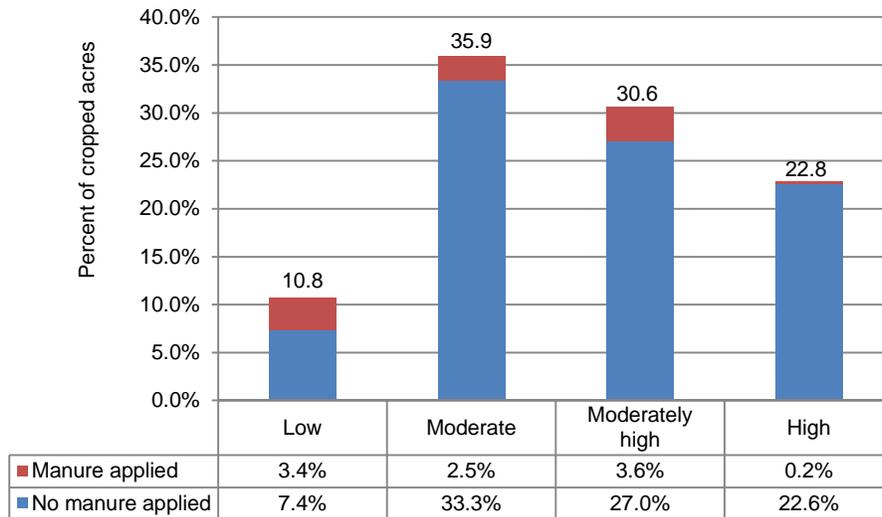
- **High treatment:** all crops have (1) total nitrogen application rates (including manure) less than 1.2 times the nitrogen in the crop yield for crops other than cotton and small grains, less than 1.5 times the nitrogen in the crop yield for small grains, and less than 50 pounds of nitrogen applied per cotton bale, (2) all applications occur within 3 weeks before planting or within 60 days after planting, and (3) all applications are incorporated or banding/foliar/spot treatment was used. Acres without any nitrogen application are included in this management level.
- **Moderately high treatment:** All crops have total nitrogen application rates (including manure) less than 1.4 times the nitrogen in the crop yield for crops other than cotton and small grains, less than 1.6 times the nitrogen in the crop yield for small grains, and less than 60 pounds of

nitrogen applied per cotton bale for all crops. Timing and method of application criteria may or may not be met.

- **Moderate treatment:** All crops meet either the above criteria for timing *or* method, but some or all crops do not meet criteria for rate.
- **Low treatment:** Some or all crops in the rotation do not meet criteria for rate, and some crops may meet criteria for timing or method but not all crops.

The high treatment level represents consistent use of appropriate rate, timing, and method for all crops, including the lower nitrogen application rate criteria appropriate for full conservation treatment conditions. For all eight regions combined, 23 percent of cropped acres meet *all* nutrient management criteria including the lower nitrogen rate criteria and including acres not receiving nutrient applications (table 9, fig. 28).

Figure 28. Percent of cropped acres at four conservation treatment levels for nitrogen management, all eight regions combined.



Criteria for four levels of nitrogen management are:

- **High treatment:** All crops have: (1) total nitrogen application rates (including manure) less than 1.2 times the nitrogen in the crop yield for crops other than cotton and small grains, less than 1.5 times the nitrogen in the crop yield for small grains, and less than 50 pounds of nitrogen applied per cotton bale; (2) all applications occur within 3 weeks before planting or within 60 days after planting; and (3) all applications are incorporated or banding/foliar/spot treatment is used.
- **Moderately high treatment:** All crops have total nitrogen application rates (including manure) less than 1.4 times the nitrogen in the crop yield for crops other than cotton and small grains, less than 1.6 times the nitrogen in the crop yield for small grains, and less than 60 pounds of nitrogen applied per cotton bale for all crops. Timing and method of application criteria may or may not be met.
- **Moderate treatment:** All crops meet either the above criteria for timing *or* method, but some or all crops do not meet criteria for rate.
- **Low treatment:** Some or all crops in the rotation do not meet criteria for rate, and some crops may meet criteria for timing or method but not all crops.

Table 9. Percent of cropped acres for four conservation treatment levels of nitrogen management, by region.

	Low	Moderate	Moderately high	High
Production region				
Northwest Non-Coastal (3)	7	23	28	43
Northern Plains (5)	5	26	28	40
Southern Plains (6)	6	32	31	31
North Central and Midwest (7)	16	39	34	11
Lower Mississippi and Texas Gulf Coast (9)	6	54	15	25
Northeast (10)	18	34	34	14
East Central (11)	14	43	32	11
Southeast Coastal Plain (12)	13	42	29	16
All eight regions	11	36	31	23

Another 31 percent have a “moderately high” level of nitrogen management, including about one-third of the acres that received manure. These acres met the criteria for application rates that would apply if timing and/or method were not also met.

About 36 percent of cultivated cropland acres met criteria for a “moderate” level of nitrogen management. These acres do not meet application rate criteria but do meet criteria for either timing or method or both for all crops in the rotation.

Only 11 percent of cultivated cropland acres have a “low” level of nitrogen management. Nearly one-third of the acres receiving manure have a “low” level of nitrogen management (fig. 14).

### Nitrogen management practices by production region.

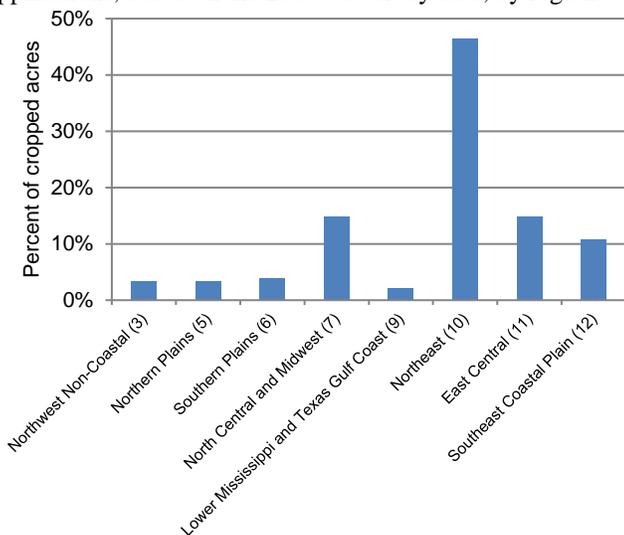
Two regions stand out as having the best overall nitrogen management (table 8):

- the Northwest Non-Coastal (3) region, where 47 percent of cropped acres met nitrogen management criteria for all three application elements, including 69 percent that met the rate criteria, 71 percent that met the criteria for application method, and 72 percent that met the timing criteria; and
- the Northern Plains (5) region, where 42 percent of cropped acres met nitrogen management criteria for all three application elements, including 67 percent that met the rate criteria, 70 percent that met the criteria for application method, and 75 percent that met the timing criteria.

These two regions also had the highest percentages of acres with a ‘high’ level of nitrogen management, including acres that did not have nitrogen applications—43 percent for the Northwest Non-Coastal (3) region and 40 percent for the Northern Plains (5) region (table 9). Neither of these two regions had significant acreage that received manure (fig. 29).

The North Central and Midwest (7) region and the East Central (11) region had the poorest nitrogen management, each with only 11 percent of cropped acres with a ‘high’ level of nitrogen management. Two other regions also had very low percentages of cropped acres with a ‘high’ level of nitrogen management—the Northeast (10) region with only 14 percent, and the Southeast Coastal Plain (12) region with only 16 percent. Ten percent or more of the cropped acres in each of these four regions received manure applications (fig. 29). In the Northeast (10) region, 47 percent of the cropped acres received manure applications.

Figure 29. Percent of cultivated cropland acres with manure applications, based on the 2003-06 survey data, by region.



Note: About 10 percent of cropped acres (28 million acres) had manure applied in 2003-06 on cultivated cropland acres in the eight regions.

### Combinations of Water Erosion Control Practices and Nitrogen Management Practices

Nearly all cultivated cropland acres had conservation practices or nitrogen management practices in use that would be expected to reduce phosphorous losses from farm fields to some extent.

For all eight regions combined, 94 percent of cultivated cropland acres had some kind of practice use to control water erosion (table 10):

- 34 percent had one or more structural practice and some form of reduced tillage,
- 55 percent had some form of reduced tillage but no structural practices,
- 4 percent had one or more structural practice but no reduced tillage, and
- only 6 percent had no reduced tillage and no structural practices.

There are important regional differences in the use of these practices, as shown in previous sections, but at least one water erosion control practice is used on nearly all cultivated cropland acres in each region (table 10). The East Central (11) region had at least one water erosion control practice on 99 percent of the cultivated cropland acres in that region. The North Central and Midwest (7) region had at least one water erosion control practice on 97 percent of cropped acres. Even the region with the least percentage of treated acres—87 percent for the Southern Plains (6) region—still had most acres treated, including 31 percent of the acres with one or more structural practice and some form of reduced tillage.

When nitrogen management practices are factored in, less than 1 percent of cultivated cropland acres in the eight regions had neither erosion control practices nor nitrogen management levels of ‘moderate’ or better.

To evaluate the overall level of conservation treatment for water erosion control together with nitrogen management, four conservation treatment levels for nitrogen runoff control were defined for each sample point (high, moderately high, moderate, or low), as was done previously for each of the three practice groups (figure 14 for structural practices, figure 23 for tillage and residue management, and figure 28 for nitrogen management).

First, scores were assigned to the four treatment levels for each of the three practice groups as follows:

- sample points with a ‘high’ treatment level were assigned a score of 4;
- sample points with a ‘moderately high’ treatment level were assigned a score of 3;
- sample points with a ‘moderate’ treatment level were assigned a score of 2; and
- sample points with a ‘low’ treatment level were assigned a score of 1.

Table 10. Percent of cropped acres with combinations of structural practices and residue and tillage management practices, by region.

Production region	Percent of acres with one or more structural practice and some form of reduced tillage	Percent of acres with some form of reduced tillage but no structural practices	Percent of acres with one or more structural practice only	Percent of acres with no structural practices and no reduced tillage
Northwest Non-Coastal (3)	33	60	2	6
Northern Plains (5)	22	74	<1	4
Southern Plains (6)	31	42	13	13
North Central and Midwest (7)	43	52	1	3
Lower Mississippi and Texas Gulf Coast (9)	17	68	3	11
Northeast (10)	37	51	6	6
East Central (11)	53	41	4	1
Southeast Coastal Plain (12)	28	61	3	8
All eight regions	34	55	4	6

If the field slope was 2 percent or less, the nitrogen runoff control treatment level was based on combinations of the residue and tillage management level and the nitrogen management level, determined as follows:

- **High treatment:** Sum of residue and tillage management score and nitrogen management score is equal to 8. (i.e., “high” treatment level for both residue and tillage management and nitrogen management).
- **Moderately high treatment:** Sum of scores equal to 6 or 7.
- **Moderate treatment:** Sum of scores equal to 4 or 5.
- **Low treatment:** Sum of scores equal to 2 or 3.

If slope was greater than 2 percent, the nitrogen runoff control treatment level was based on combinations of all three treatment groups, determined as follows:

- **High treatment:** Sum of structural practice score, residue and tillage management score, and nitrogen management score is equal to 12. (i.e., “high” treatment level for all three practice groups.)
- **Moderately high treatment:** Sum of scores equal to 9, 10, or 11.
- **Moderate treatment:** Sum of scores equal to 6, 7 or 8.
- **Low treatment:** Sum of scores equal to 3, 4, or 5.

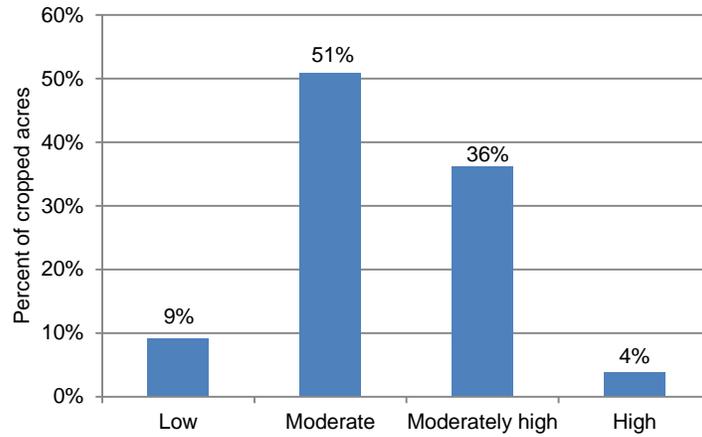
The percentages of cropped acres at each of these four conservation treatment levels for nitrogen runoff control are presented in figure 30 and table 11 for all eight regions combined. Only about 4 percent of cultivated cropland acres in all eight regions had a “high” level of nitrogen runoff control treatment. However, another 36 percent of cultivated cropland acres had a “moderately high” level of nitrogen runoff control treatment.

Most cultivated cropland acres—51 percent—had a “moderate” level of nitrogen runoff control treatment. Only 9 percent had a “low” level of nitrogen runoff control treatment.

The North Central and Midwest (7) region had the best overall coverage in providing nitrogen runoff control treatment for cultivated cropland acres when combinations of erosion control and nitrogen management practices are evaluated (table 11 and fig. 31). In this region, 48 percent of cropped acres had a “high” or “moderately high” level of treatment for nitrogen runoff control.

The Northeast (10) region stands out as having the least treatment for nitrogen runoff control (table 11 and fig. 31), primarily because of insufficient nitrogen management, especially for acres receiving manure. In this region, only 14 percent of cropped acres had a “high” or “moderately high” level of treatment for nitrogen runoff control.

Figure 30. Percent of cropped acres at four conservation treatment levels for nitrogen runoff control, all eight regions combined.

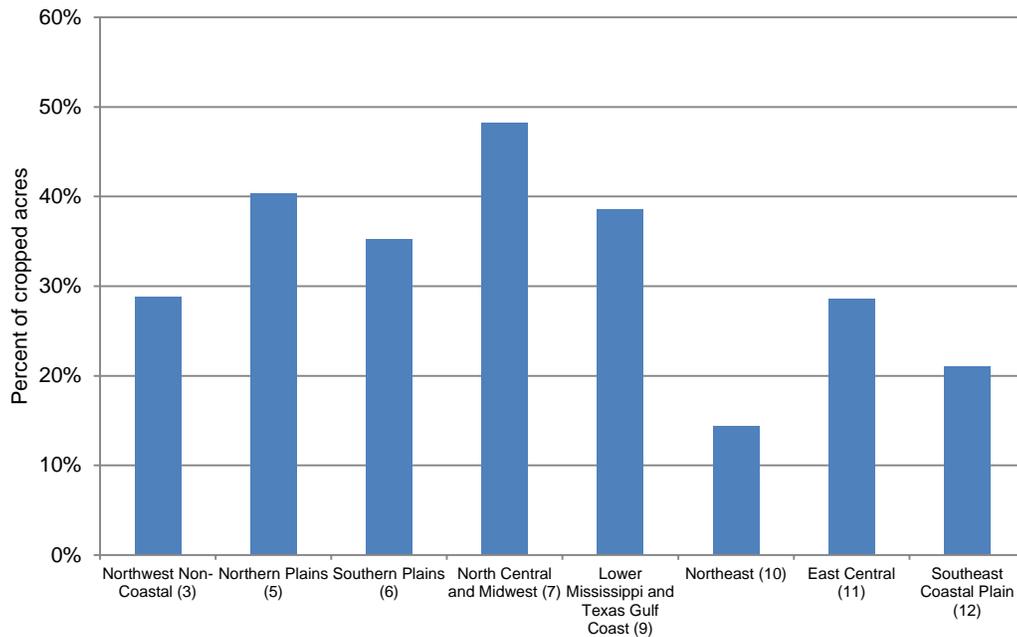


See text for criteria used to define the four nitrogen runoff control treatment levels.

Table 11. Percent of cropped acres at four conservation treatment levels for nitrogen runoff control, by region.

	Low	Moderate	Moderately high	High
Production region				
Northwest Non-Coastal (3)	15	56	26	3
Northern Plains (5)	7	53	34	6
Southern Plains (6)	8	57	32	3
North Central and Midwest (7)	8	44	44	4
Lower Mississippi and Texas Gulf Coast (9)	12	50	33	6
Northeast (10)	22	64	13	1
East Central (11)	13	59	27	2
Southeast Coastal Plain (12)	19	60	20	1
All eight regions	9	51	36	4

Figure 31. Percent of cultivated cropland acres with “high” or “moderately high” levels of conservation treatment for nitrogen runoff control, by region.



## APEX Modeling and the Baseline Scenario

Nitrogen loss from farm fields was estimated using a field-scale physical process model—the Agricultural Policy Environmental Extender (APEX). APEX simulates all of the basic biological, chemical, hydrological, and meteorological processes of farming systems and their interactions. Soil erosion is simulated over time, including wind erosion, sheet and rill erosion, and the loss of sediment beyond the edge of the field. The nitrogen, phosphorus, and carbon cycles are simulated, including chemical transformations in the soil that affect their availability for plant growth or for transport from the field.

On a daily basis, APEX simulates the farming operations used to grow crops, such as planting, tillage before and after planting, application of nutrients and pesticides, application of manure, irrigation, and harvest. Weather events and their interaction with crop cover and soil properties are simulated; these events affect crop growth and the fate and transport of water and chemicals through the soil profile and over land to the edge of the field. Over time, the chemical makeup and physical structure of the soil may change, which in turn affect crop yields and environmental outcomes. Crop residue remaining on the field after harvest is transformed into organic matter. Organic matter may build up in the soil over time, or it may degrade, depending on climatic conditions, cropping systems, and management.

A baseline scenario consists of APEX model simulation results that account for cropping patterns, farming activities, and conservation practices as reported in the NRI-CEAP Cropland Survey for 2003-06. Model simulation results for the baseline scenario therefore reflect the mix of treated and untreated acres for the time period 2003-06.

Weather is the predominant factor determining the loss of soil and nutrients from farm fields. To capture the effects of weather, the baseline scenario was simulated using 47 years of actual daily weather data for the time period 1960 through 2006. In the model simulations, weather is the only input variable that changes year to year. Since only the cropping patterns and practices for the 2003–06 time period were simulated, model estimates of losses from farm fields are *not actual* losses for each of these 47 years. Rather, the yearly model estimates, when aggregated over the 47 years, provide estimates of what would be expected at a sample point over the long-term in the future if weather continues to vary as it has in the past. Thus, we report model simulation estimates of *what would be expected after accounting for weather variability* so as to best inform decision makers on what has been accomplished and what remains to be done.

All model results reported herein are in terms of the 47-year averages at each sample point. For every model output, the 47-year average is first calculated for each sample point, and then more aggregated statistics are determined for the full set or a subset of sample points. Estimates determined by aggregating over sample points are always weighted by the acreage weight associated with each sample point (see Appendix A).

For example, APEX model results showed that nitrogen loss for the baseline scenario was 34.4 pounds per acre per year, on average, for all cultivated cropland acres in the eight regions. This estimate was calculated as follows:

1. First, the annual nitrogen loss was obtained from APEX model output at each sample point for each of the 47 years of model simulation data.
2. Second, the average annual loss at each of the 17,918 CEAP sample points was calculated as the mean of the 47 years of nitrogen loss estimates.
3. Then the acreage-weighted mean of these average annual estimates over all sample points was calculated, representing the mean of the average annual amount of nitrogen loss from farm fields—34.4 pounds per acre per year.

In addition to reporting the mean of the average annual estimates, various percentiles of the distribution of average annual estimates are also presented. For example, the median of the average annual values is sometimes reported, representing the average annual estimate for the sample point where half of the acres have higher values and half have lower values—the 50<sup>th</sup> percentile value. Cumulative distributions are also shown so as to represent the variability among the average annual estimates within the sample; these distributions are obtained using the percentile values for each percentile from 1 to 100.

The APEX model tracks nitrogen loss from farm fields through six pathways:

- nitrogen loss by volatilization;
- nitrogen loss through denitrification;
- nitrogen lost with windborne sediment;
- nitrogen lost with waterborne sediment;
- soluble nitrogen lost with surface water runoff;
- soluble nitrogen that infiltrates into the soil profile but later returns to surface water through subsurface flow pathways; and
- soluble nitrogen that percolates through the soil profile into the groundwater.

The bulk of nitrogen losses from farm fields are the result of surface water runoff, infiltration of water into the soil, sediment loss beyond the edge of the field from water erosion, and wind erosion. Consequently, in addition to reporting the average annual estimates of nitrogen loss from farm fields, results are also presented for:

- water sources (precipitation and irrigation),
- water loss from farm fields,
- sediment loss from farm fields, and
- wind erosion rates.

Water sources and loss, sediment loss, and wind erosion results for the baseline scenario are presented in the following three sections of this chapter to provide perspective for the nitrogen loss results presented in the next chapter.

## Water Sources and Water Loss Pathways

Water is a potent force that interacts with or drives almost all environmental processes acting within an agricultural production system. Hydrologic conditions prevalent in each production region are critical to understanding the estimates of nitrogen loss from farm fields. The APEX model simulates hydrologic processes at the field scale—precipitation, irrigation, evapotranspiration, surface water runoff, infiltration, and percolation beyond the bottom of the soil profile.

Precipitation and irrigation—the sources of water for a field—vary substantially among the eight production regions, as shown in table 12 and figures 32 and 33. Cultivated cropland in the Northern Plains (5) region and the Northwest Non-Coastal (3) region have the lowest precipitation, averaging about 17 inches per year for the 47 years simulated with APEX. Irrigation is widely used on cultivated cropland in the Northwest Non-Coastal (3) region (37 percent of cultivated cropland acres), averaging an additional 17 inches of water per acre on irrigated acres (table 12).

Precipitation is highest for cultivated cropland acres in the Lower Mississippi and Texas Gulf Coast (9) region and the Southeast Coastal Plain (12) region, averaging about 50 inches per year in each region. Nearly half of the cultivated cropland acres in the Lower Mississippi and Texas Gulf Coast (9) region are also irrigated, averaging an additional 19 inches of water per year on irrigated acres (table 12).

About 20 percent of cultivated cropland acres in the Southeast Coastal Plain (12) region are also irrigated, averaging an additional 17 inches of water per year on irrigated acres.

Figure 32. Water sources—precipitation and irrigation water applied—for farm fields, as represented in the APEX model simulations.

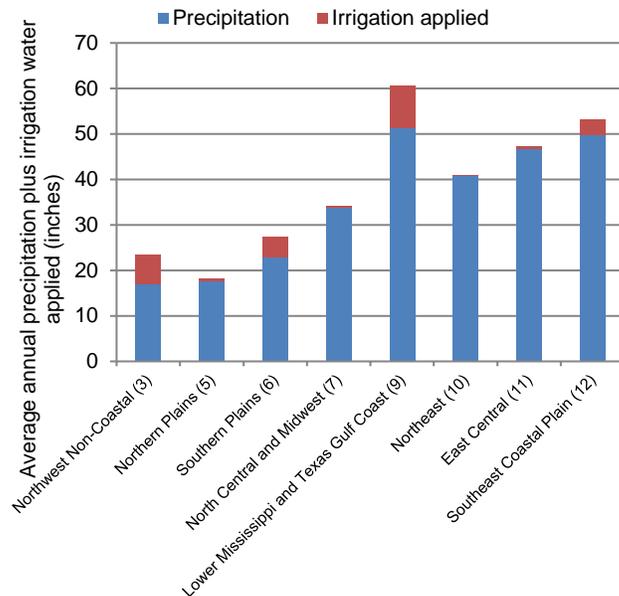


Figure 33. Distributions of average annual water sources (precipitation plus irrigation water applied) for CEAP sample points in eight production regions.

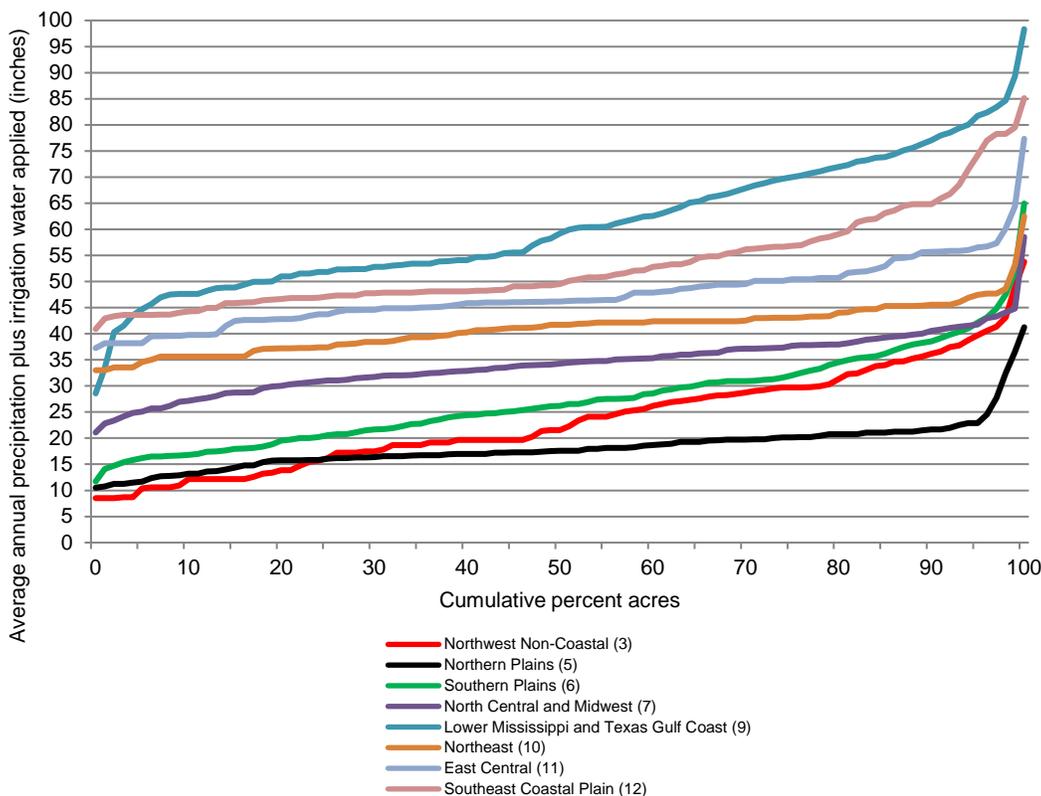


Table 12. Water sources and water loss for cultivated cropland, as represented in the APEX model simulations.

	Northwest Non-Coastal (3)	Northern Plains (5)	Southern Plains (6)	North Central and Midwest (7)
Water sources				
Non-irrigated cultivated cropland acres				
Percent of acres non-irrigated	63%	96%	74%	96%
Average annual precipitation (inches)				
Mean	18	18	24	34
20-to-80 percentile range	12-23	16-20	18-29	30-38
Irrigated cultivated cropland acres				
Percent of acres irrigated	37%	4%	26%	4%
Average annual precipitation (inches)				
Mean	15	18	21	31
20-to-80 percentile range	11-19	15-24	17-25	26-36
Average annual irrigation water applied (inches)				
Mean	17	13	17	10
20-to-80 percentile range	11-23	10-18	11-21	7-13
Water loss pathways				
Average annual evapotranspiration (inches)				
Mean	17.3	16.3	23.2	23.5
Percent of all 3 loss pathways	79%	90%	87%	69%
20-to-80 percentile range	12.1-22.6	14.0-18.5	17.9-27.2	21.5-25.5
Average annual surface water runoff (inches)				
Mean	1.7	0.7	1.4	4.3
Percent of all 3 loss pathways	8%	4%	5%	13%
20-to-80 percentile range	0.4-2.9	0.3-0.9	0.2-2.3	2.3-6.1
Average annual subsurface water flows (inches)				
Mean	2.9	1.2	2.2	6.4
Percent of all 3 loss pathways	13%	7%	8%	19%
20-to-80 percentile range	0.3-5.3	0.1-1.9	<0.1-3.8	3.9-8.6

Table 15.—continued.

	Lower Mississippi and Texas Gulf Coast (9)	Northeast (10)	East Central (11)	Southeast Coastal Plain (12)
Water sources				
Non-irrigated cultivated cropland acres				
Percent of acres non-irrigated	52%	98%	96%	80%
Average annual precipitation (inches)				
Mean	52	41	47	50
20-to-80 percentile range	48-56	37-43	43-50	46-55
Irrigated cultivated cropland acres				
Percent of acres irrigated	48%	2%	4%	20%
Average annual precipitation (inches)				
Mean	51	44	46	50
20-to-80 percentile range	48-54	42-46	45-48	47-52
Average annual irrigation water applied (inches)				
Mean	19	8	13	17
20-to-80 percentile range	12-26	3-11	9-16	13-25
Water loss pathways				
Average annual evapotranspiration				
Mean (inches)	36.4	25.5	28.7	32.6
Percent of all 3 loss pathways	61%	62%	60%	59%
20-to-80 percentile range (inches)	31.4-41.8	22.6-28.2	25.2-32.0	29.0-36.0
Average annual surface water runoff				
Mean (inches)	13.1	6.1	8.2	6.0
Percent of all 3 loss pathways	22%	15%	17%	11%
20-to-80 percentile range (inches)	10.5-15.6	4.2-7.9	4.8-11.3	3.2-8.1
Average annual subsurface water flows				
Mean (inches)	10.0	9.4	10.8	16.3
Percent of all 3 loss pathways	17%	23%	23%	30%
20-to-80 percentile range (inches)	6.8-13.4	7.7-11.1	8.5-12.5	10.2-20.9

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

Most of the water that leaves the field is lost through evaporation and transpiration (evapotranspiration) (table 12). On average, about 80-90 percent of the water loss for cultivated cropland acres is through evapotranspiration in the three westernmost regions—the Northwest Non-Coastal (3) region, the Northern Plains (5) region, and the Southern Plains (6) region. About 69 percent of the water loss for cultivated cropland acres is through evapotranspiration in the North Central and Midwest (7) region. For the remaining four regions, evapotranspiration accounts for about 60 percent of the water loss from cultivated cropland acres.

The remaining water loss from farm fields is either surface water runoff or water that infiltrates into the soil and then is transported from the field through various subsurface flow pathways.<sup>8</sup> The APEX model simulations show that, overall, more water is lost through subsurface flow pathways than as surface water runoff for all but one region—the Lower Mississippi and Texas Gulf Coast (9) region (table 12 and figs. 34 and 35). Subsurface flow pathways include—

- deep percolation to groundwater, including groundwater return flow to surface water,
- subsurface flow that is intercepted by tile drains or drainage ditches, when present, and
- lateral subsurface outflow or quick-return flow that emerges as surface water runoff, such as natural seeps.

The Southeast Coastal Plain (12) region has the largest amount of water lost through subsurface flow pathways—16 inches per year, on average, which is nearly three times higher than the amount lost as surface water runoff in that region.

Surface water runoff directly effects sheet and rill erosion and edge-of-field sediment loss from farm fields. For all eight regions combined, average annual surface water runoff was 3.8 inches per year. Surface water runoff is highest in the Lower Mississippi and Texas Gulf Coast (9) region, where it averages 13.1 inches per year (table 12 and fig. 34). It is lowest in the three westernmost and driest regions—the Northern Plains (5) region, the Southern Plains (6) region, and the Northwest Non-Coastal (3) region—where it averaged less than 2 inches per year. In the remaining four regions, the average annual surface water runoff ranges from a low of 4.3 inches per year in the North Central and Midwest (7) region to a high of 8.2 inches per year in the East Central (11) region.

Figure 34. Mean of the average annual surface water runoff from farm fields, by production region.

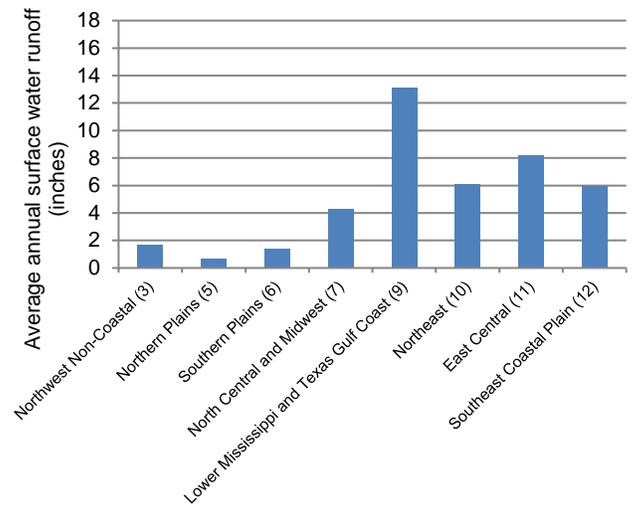
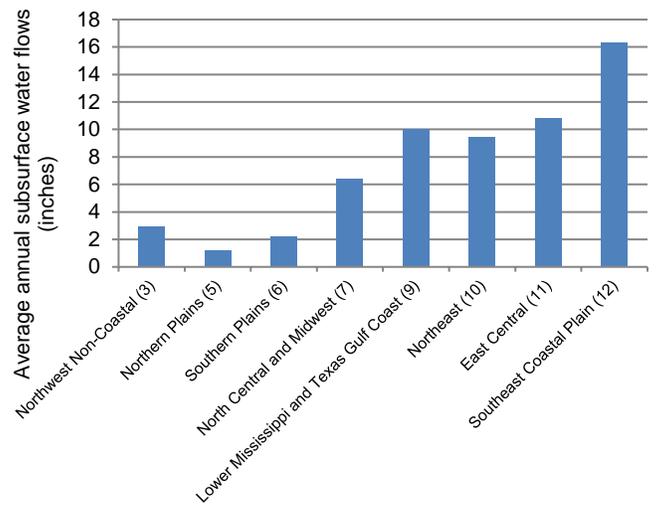


Figure 35. Mean of the average annual loss of water from farm fields through subsurface water flows, by production region.



<sup>8</sup> Model simulations did not include increased infiltration for some structural practices—model parameter settings conservatively prevented infiltration of

run-on water and its dissolved contaminants in conservation buffers including field borders, filter strips and riparian forest buffers.

## Edge-of-Field Sediment Loss from Water Erosion

The APEX component for water-induced erosion simulates erosion caused by rainfall, runoff, and irrigation. APEX contains eight equations capable of simulating rainfall and runoff erosion: universal soil loss equation (USLE); Onstad-Foster modification of the USLE; revised universal soil loss equation (RUSLE); RUSLE2; the modified universal soil loss equation (MUSLE); two variations of MUSLE; and a MUSLE function that accepts input coefficients. In any given simulation, only one of the equations interacts with other APEX components. For this study, a modified version of MUSLE, called MUST, was used for this purpose.<sup>9</sup>

The model variant MUST has an internal sediment delivery ratio to estimate the amount of eroded soil that actually leaves the boundaries of the field. A large percentage of the eroded material is redistributed and deposited within the field or trapped by buffers and other conservation practices and does not leave the boundary of the field, which is taken into account in the sediment delivery calculation. The estimate also includes some gully erosion and some ephemeral gully erosion. For this reason, sediment loss rates can exceed sheet and rill erosion rates in some cases.

Sediment loss is thus the portion of the sheet and rill eroded material that is transported beyond the edge of the field and settles offsite as well as some sediment that originates from gully erosion processes.<sup>10</sup> Acres with characteristics such as steeper slopes and soil types that promote surface water runoff are more vulnerable than other acres to sediment losses beyond the edge of the field.

According to the APEX model simulations, the mean of the average annual sediment loss estimates for cultivated cropland acres in all eight regions was 0.79 ton per acre per year (table 13). Sediment loss for HEL acres averaged 1.40 tons per acre per year, compared to only 0.55 tons per acre for non-HEL acres.

The median value for sediment loss for all acres—0.185—is much lower than the mean, indicating that the distribution of average annual estimates consists mostly of acres with low average annual sediment loss, in part due to the ameliorating effects of erosion control practices in use in 2003-06. In contrast, a few acres have very large losses; these are acres that are more vulnerable to erosion than other acres, such as HEL acres, and are inadequately treated with conservation practices. As shown in figure 36, about 77 percent of the cropped acres have average annual sediment loss estimates less than the mean of 0.79 tons per acre per year. Ten percent of cropped acres have average annual sediment loss above 2

tons per acre per year. Three percent have average annual sediment loss above 5 tons per acre per year.

Sediment loss is highest in the Lower Mississippi and Texas Gulf Coast (9) region, averaging 2.66 tons per acre per year for cultivated cropland (table 13 and figure 37). This region also had the largest amount of precipitation and irrigation water applied (fig. 33) and the largest amount of surface water runoff per year (fig. 34). Sediment loss averaged higher in this region for both HEL and non-HEL than in any of the other regions (table 13 and figs. 38 and 39).

Figure 36. Distribution of average annual sediment loss from water erosion (tons/acre) for sample points in all eight regions.

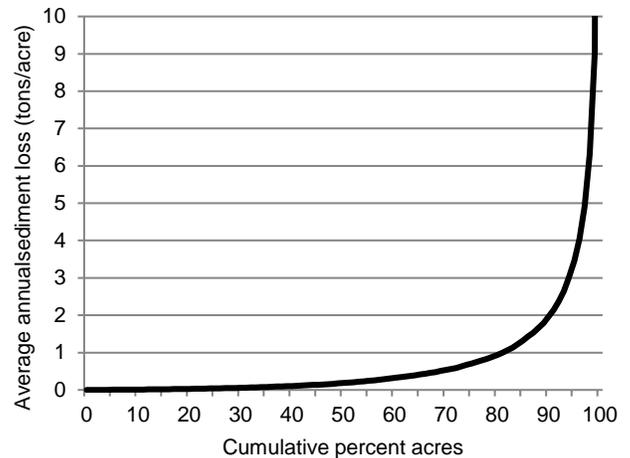
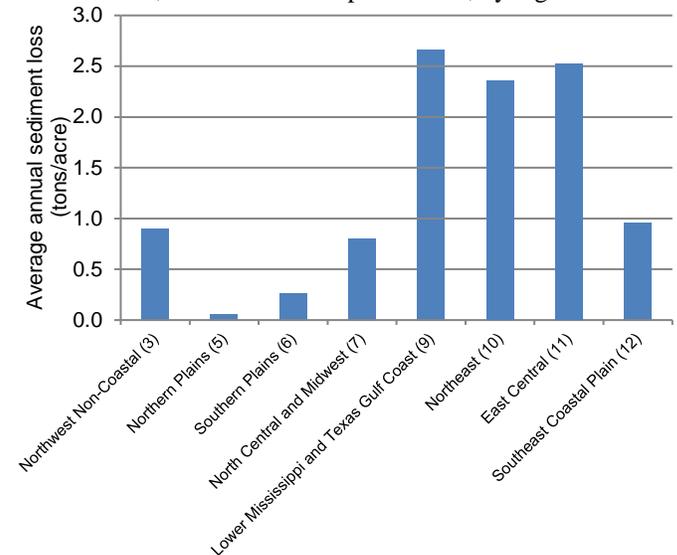


Figure 37. Mean of the average annual sediment loss from water erosion, all cultivated cropland acres, by region.



<sup>9</sup> For the study on the Texas Gulf Basin, the APEX model was set up to estimate sediment loss using MUSLE as the specified driver in APEX. This change was necessary to achieve better calibration of instream sediment loads in streams and rivers in this region when running the SWAT model as part of the modeling to estimate offsite effects of conservation practices.

<sup>10</sup> Estimates of sediment loss from water erosion do not include wind-eroded material that is subsequently deposited along field borders or in ditches and transported as sediment with rainfall and runoff events. However, wind eroded material incorporated into the soil with tillage or biological activity prior to a runoff event would be included.

Figure 38. Mean of the average annual sediment loss from water erosion, HEL acres, by region.

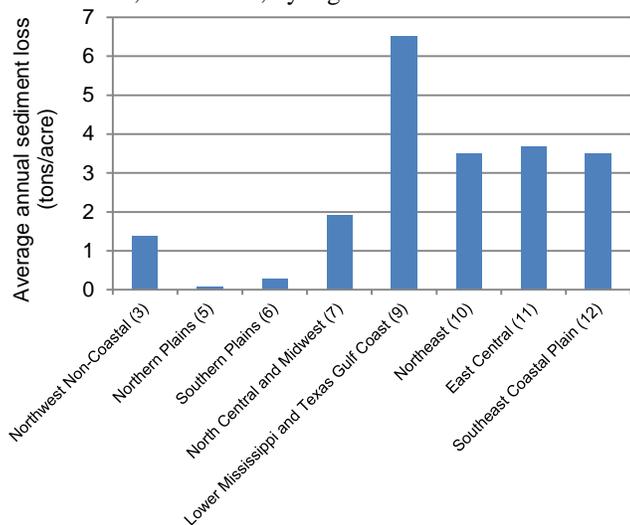


Figure 39. Mean of the average annual sediment loss from water erosion, non-HEL acres, by region.

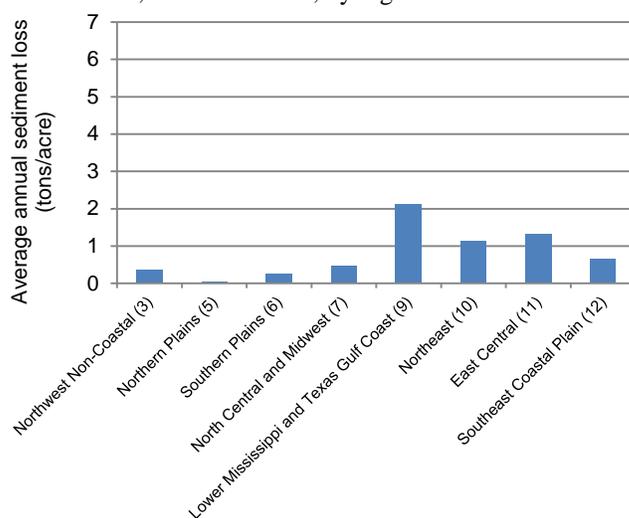


Table 13. Average annual sediment loss at edge of field from water erosion (tons/acre),\* by region.

	Mean	Median	20 <sup>th</sup> percentile	80 <sup>th</sup> percentile
<b>All cultivated cropland acres</b>				
Production region				
Northwest Non-Coastal (3)	0.901	0.144	0.026	0.840
Northern Plains (5)	0.063	0.032	0.010	0.081
Southern Plains (6)	0.260	0.057	0.008	0.307
North Central and Midwest (7)	0.797	0.340	0.091	1.050
Lower Mississippi and Texas Gulf Coast (9)	2.663	1.519	0.588	3.512
Northeast (10)	2.360	1.035	0.290	3.686
East Central (11)	2.523	1.073	0.286	3.213
Southeast Coastal Plain (12)	0.960	0.321	0.079	1.028
All eight regions	0.793	0.185	0.029	0.934
<b>HEL acres</b>				
Production region				
Northwest Non-Coastal (3)	1.385	0.248	0.045	1.715
Northern Plains (5)	0.089	0.043	0.009	0.117
Southern Plains (6)	0.274	0.045	0.005	0.313
North Central and Midwest (7)	1.921	1.078	0.287	2.940
Lower Mississippi and Texas Gulf Coast (9)	6.500	3.666	1.646	9.278
Northeast (10)	3.505	2.079	0.593	5.268
East Central (11)	3.675	1.998	0.450	6.831
Southeast Coastal Plain (12)	3.503	1.335	0.359	4.189
All eight regions	1.399	0.250	0.024	1.913
<b>Non-HEL acres</b>				
Production region				
Northwest Non-Coastal (3)	0.354	0.077	0.017	0.307
Northern Plains (5)	0.048	0.028	0.010	0.065
Southern Plains (6)	0.253	0.067	0.010	0.301
North Central and Midwest (7)	0.467	0.258	0.076	0.713
Lower Mississippi and Texas Gulf Coast (9)	2.115	1.373	0.550	2.990
Northeast (10)	1.147	0.562	0.207	1.511
East Central (11)	1.320	0.644	0.187	1.508
Southeast Coastal Plain (12)	0.659	0.274	0.073	0.836
All eight regions	0.547	0.170	0.030	0.739

\*Estimated using MUSS, which includes some sediment from gully erosion. See text.

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

Average annual sediment loss for cropped acres was only slightly lower for two other regions—the East Central (11) region, with an average of 2.52 tons per acre per year, and the Northeast (10) region, with an average of 2.36 tons per acre per year (table 13 and fig. 37).

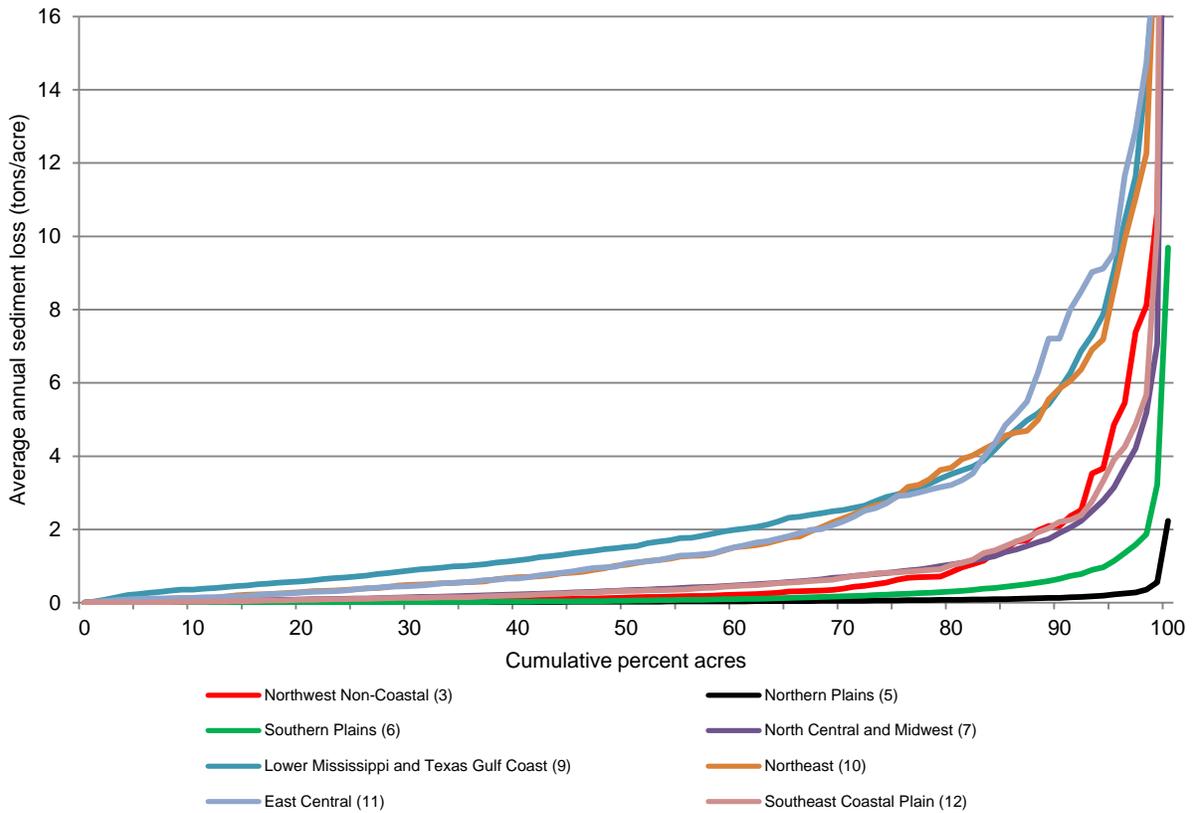
The distributions of the average annual sediment loss (tons/acre) for sample points in each of the eight production regions are contrasted in figure 40, which demonstrates the extent to which these three regions stand out as having the highest sediment losses at the edge of the field. Figure 40 shows that 32-40 percent of cultivated acres in these three regions exceeded 2 tons per acre per year.

Average annual sediment loss estimates in the Northern Plains (5) and Southern Plains (6) regions were low for all but a very few cultivated cropland acres (figs. 37-40). The average annual sediment loss was only 0.06 ton per acre per year in the Northern Plains (5) region and only 0.26 ton per acre per year in the Southern Plains (6) region.

The remaining three regions averaged less than 1 ton per acre per year of sediment loss for all cropped acres (table 13 and figure 23), but figure 40 shows that annual average sediment loss exceeds 2 tons per acre per year for between 9 and 12 percent of cultivated cropland acres in these three regions.

The largest of the losses shown in figure 40 are a combination of inadequate conservation treatment and a high intrinsic propensity for erosion determined by high slopes, soil types that erode more easily, and higher levels of precipitation and/or irrigation water applied. The smallest of the losses are acres that are essentially flat with permeable soil types that are more prone to infiltration than surface water runoff, or they are adequately treated with conservation practices. Adequate conservation treatment consists of combinations of conservation practices that treat the specific inherent vulnerability factors associated with each field.

Figure 40. Distributions of average annual sediment loss from water erosion for CEAP sample points in eight production regions.



## Wind Erosion

Wind velocity, vegetative cover, soil texture and structure of the soil are primary determinants of wind erosion. Wind erosion removes the most fertile parts of the soil such as the lighter, less dense soil constituents including organic matter, clays, and silts. Wind erosion occurs when the soil is unprotected and wind velocity exceeds about 13 miles per hour near the surface. Wind erosion is estimated in APEX using the Wind Erosion Continuous Simulation (WECS) model. The estimated wind erosion rate is the amount of eroded material leaving the downwind edge of the field.

A concern of crop producers with wind erosion is crop damage to young seedlings exposed to windblown material. Wind erosion rates as low as 0.5 ton per acre have been known to cause physical damage to young seedlings.

Wind erosion can also deposit sediment rich in nutrients into adjacent ditches and surface drainage systems, where it is then transported to water bodies with runoff. Wind erosion rates greater than 2 tons per acre per year can result in significant losses of soil and associated contaminants over time. Wind erosion rates greater than 4 tons per acre can result in excessive soil loss annually and can also have adverse effects on human health.

According to the APEX model simulations, the mean of the average annual wind erosion rate for cultivated cropland acres in all eight regions was 1.35 tons per acre per year (table 14). The median, however, was much lower—0.17 tons per acre

per year—indicating that wind erosion problems are important for a minority of cultivated cropland acres throughout the eight regions. Table 14 and figure 41 shows that wind erosion concerns are mostly concentrated in the three westernmost regions:

- the Southern Plains (6) region, where the mean of the average annual wind erosion rate was 3.71 tons per acre per year and 23 percent of cropped acres had average annual wind erosion rates greater than 4 tons per acre per year,
- the Northwest Non-Coastal (3) region, where the mean of the average annual wind erosion rate was 2.07 tons per acre per year and 15 percent of cropped acres had average annual wind erosion rates greater than 4 tons per acre per year, and
- the Northern Plains (5) region, where the mean of the average annual wind erosion rate was 1.51 tons per acre per year and 10 percent of cropped acres had average annual wind erosion rates greater than 4 tons per acre per year.

Average annual wind erosion rates were below 1 ton per acre per year for all cropped acres in the Northeast (10) region, the East Central (11) region, and the Southeast Coastal Plain (12) region (fig. 41).

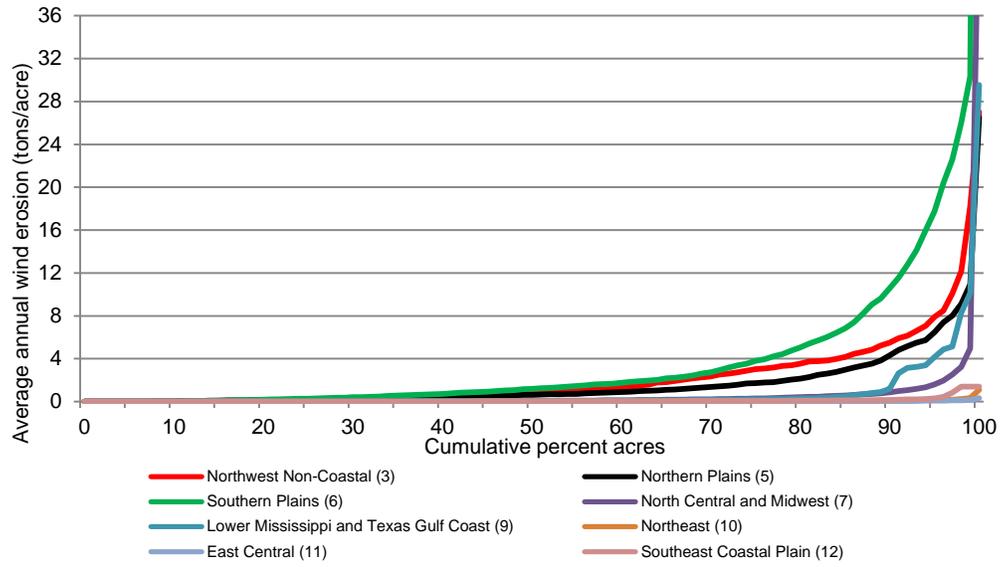
The North Central and Midwest (7) region and the Lower Mississippi and Texas Gulf Coast (9) region have a few acres with high average annual wind erosion rates, as shown in figure 41, but the bulk of the cultivated cropland acres in these two regions are low.

Table 14. Average annual wind erosion (tons/acre) for cultivated cropland acres,\* by region.

Production region	Mean	Median	20 <sup>th</sup> percentile	80 <sup>th</sup> percentile
Northwest Non-Coastal (3)	2.067	0.731	0.040	3.543
Northern Plains (5)	1.514	0.630	0.147	2.149
Southern Plains (6)	3.709	1.201	0.181	5.045
North Central and Midwest (7)	0.386	0.065	0.007	0.413
Lower Mississippi and Texas Gulf Coast (9)	0.638	0.048	0.004	0.282
Northeast (10)	0.036	0.013	0.001	0.052
East Central (11)	0.017	0.003	0.000	0.023
Southeast Coastal Plain (12)	0.086	0.019	0.002	0.083
All eight regions	1.351	0.168	0.010	1.345

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

Figure 41. Distributions of average annual wind erosion rates for CEAP sample points in eight production regions.



## Nitrogen Loss from Farm Fields

### Nitrogen Loss for All Regions Combined

Plant-available nitrogen sources included in the model simulations were:

- application of commercial fertilizer,
- application of manure,
- nitrogen produced by legume crops (soybeans, alfalfa, dry beans, and peas),
- a small amount of manure deposited by grazing livestock, and
- atmospheric nitrogen deposition.

On average, these sources provided about 117 pounds of nitrogen per acre per year for cropped acres in the eight regions (table 15). Model simulations show that a small amount of nitrogen—about 3 pounds per acre per year, on average across all cropped acres—was extracted from nitrogen stocks in the soil and was also available for use by crops or was lost from farm fields.

The amount of plant-available nitrogen from all sources varied considerably among cropped acres (fig. 42):

- 20 percent of cropped acres had less than 60 pounds per acre per year;
- Another 20 percent had between 60 and 100 pounds per acre per year;
- 50 percent had between 100 and 180 pounds per acre per year; and
- 10 percent had more than 180 pounds per acre per year.

Most of the total nitrogen available for crops—64 percent—was applied as commercial fertilizer or as manure (table 15, fig. 42), averaging about 75 pounds per acre per year. For about 60 percent of cropped acres, a significant amount of nitrogen was made available from the production of legume crops (fig. 42), averaging about 31 percent of available nitrogen (36 pounds per acre per year) when averaged over all cropped acres (table 15). About 5 percent of the plant-available nitrogen, averaging about 6 pounds per acre per year, was obtained from the atmosphere, mostly with rainfall (table 15).

The amount of nitrogen applied as commercial fertilizer or as manure ranged from zero for about 3 percent of the cropped acres to less than 50 pounds per acre for about 30 percent of the acres to 50-100 pounds per acre for about half of the acres and to amounts exceeding 200 pounds per acre for a few acres (fig. 43). Acres with manure applied generally had higher application rates (table 15). For example, figure 43 shows that about half of the acres receiving manure had application rates of 100 pounds per acre or more, compared to only 17 percent of the acres not receiving manure. The average annual nitrogen application rate for acres receiving manure was 119 pounds per acre per year, compared to the average annual amount applied for acres not receiving manure of 70 pounds per acre per year (table 15).

Figure 42. Distributions of the three sources of nitrogen available to crops (average annual amount in pounds per acre) for sample points in all eight regions.

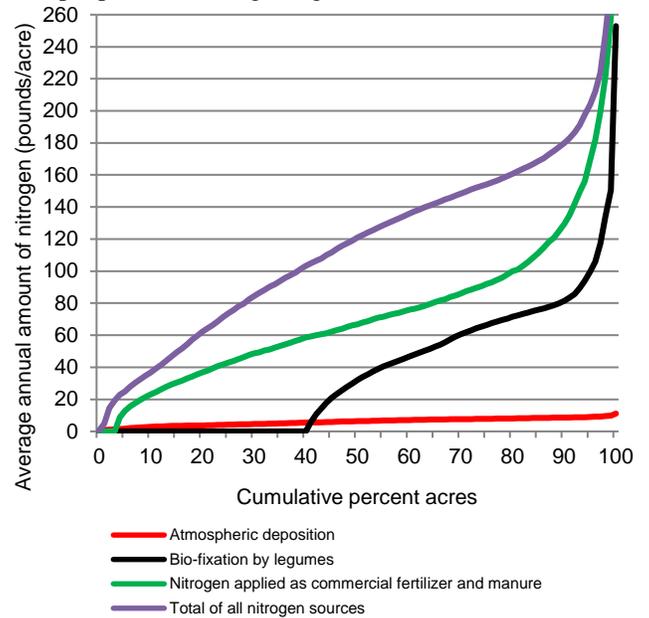
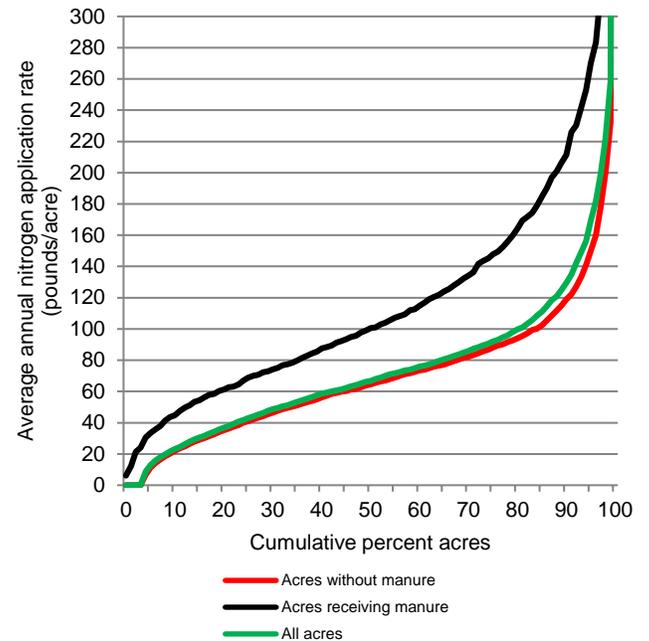


Figure 43. Distributions of the average annual amount of nitrogen applied for sample points in all eight regions.



Note: About 10 percent of cropped acres had manure applied in the eight regions

Table 15. Average annual estimates of nitrogen sources and losses from farm fields for cultivated cropland acres in all eight regions combined.

	Mean	Median	20 <sup>th</sup> percentile	80 <sup>th</sup> percentile
<b>All cultivated cropland acres, pounds per acre</b>				
Nitrogen sources				
Atmospheric deposition	6.0	6.4	3.8	8.1
Bio-fixation by legumes	36.4	32.0	0.0	71.5
Nitrogen applied as commercial fertilizer and manure	74.6	66.8	36.9	99.9
Total of all nitrogen sources	117.0	121.0	62.3	160.7
Nitrogen in crop yield removed at harvest	84.8	89.5	44.1	119.3
Nitrogen loss pathways				
Nitrogen loss by volatilization	6.5	5.6	3.2	9.1
Nitrogen loss through denitrification	2.4	0.7	0.1	2.2
Nitrogen lost with windborne sediment	4.5	1.5	0.1	7.3
Nitrogen dissolved in surface water runoff	1.0	0.4	0.0	1.5
Nitrogen loss with waterborne sediment (sediment attached)	4.8	1.9	0.3	7.1
Nitrogen loss in subsurface flow pathways	15.2	7.6	1.5	20.7
Total nitrogen loss for all loss pathways	34.4	25.6	14.8	45.8
Change in soil nitrogen	-3.2	-2.3	-12.9	7.3
<b>Acres without manure applied, pounds per acre</b>				
Nitrogen sources				
Atmospheric deposition	5.9	6.2	3.7	8.0
Bio-fixation by legumes	36.1	31.6	0.0	71.7
Nitrogen applied as commercial fertilizer and manure	69.8	64.5	35.1	94.0
Total of all nitrogen sources	111.8	116.0	58.0	156.9
Nitrogen in crop yield removed at harvest	82.4	86.8	41.0	117.6
Nitrogen loss pathways				
Nitrogen loss by volatilization	6.3	5.5	3.1	8.8
Nitrogen loss through denitrification	2.3	0.7	0.1	2.1
Nitrogen lost with windborne sediment	4.5	1.6	0.1	7.4
Nitrogen dissolved in surface water runoff	1.0	0.4	0.0	1.6
Nitrogen loss with waterborne sediment (sediment attached)	4.4	1.7	0.3	6.6
Nitrogen loss in subsurface flow pathways	13.6	7.1	1.3	19.1
Total nitrogen loss for all loss pathways	32.1	24.9	14.3	43.2
Change in soil nitrogen	-3.6	-2.5	-13.0	6.8
<b>Acres with manure applied, pounds per acre</b>				
Nitrogen sources				
Atmospheric deposition	7.3	7.6	5.9	8.8
Bio-fixation by legumes	38.8	35.0	0.0	69.1
Nitrogen applied as commercial fertilizer and manure	119.1	100.6	61.3	164.3
Total of all nitrogen sources	165.2	155.1	115.2	204.8
Nitrogen in crop yield removed at harvest	107.5	109.0	76.5	133.1
Nitrogen loss pathways				
Nitrogen loss by volatilization	8.7	7.6	4.4	12.0
Nitrogen loss through denitrification	3.3	1.1	0.2	3.6
Nitrogen lost with windborne sediment	4.2	0.9	0.1	6.0
Nitrogen dissolved in surface water runoff	1.0	0.6	0.2	1.3
Nitrogen loss with waterborne sediment (sediment attached)	8.6	4.0	1.1	12.8
Nitrogen loss in subsurface flow pathways	29.9	13.8	4.6	38.9
Total nitrogen loss for all loss pathways	55.6	36.4	22.2	77.7
Change in soil nitrogen	0.8	0.5	-12.5	14.0

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

As represented in the APEX model, 71 percent of the nitrogen sources was taken up by the crop and removed at harvest in the crop yield, on average. The remaining 29 percent was lost from farm fields through various loss pathways.<sup>11</sup>

The amount of nitrogen taken up by crops and removed with the crop yield at harvest is directly related to the amount of nitrogen applied, and also varies by crop. On average, the amount taken up by the crop and removed at harvest was 85 pounds per acre per year (table 15). However, the amount ranged from less than 60 pounds per acre per year for 30 percent of the acres to rates greater than 120 pounds per acre per year for 20 percent of the acres (fig. 44). The average was somewhat higher for acres receiving manure because of the higher application rates (table 15).

Some acres utilize more nitrogen than is applied, drawing it from reserves in the soil, while for other acres nitrogen levels build up in the soil over time. In the model simulations, about 40 percent of the cultivated cropland acres were building up nitrogen stocks in the soil and about 60 percent were extracting nitrogen from the soil (fig. 45). The largest gains in soil nitrogen were for acres receiving manure. The average change in soil nitrogen for acres receiving manure was 0.8 pound per acre per year, compared to an average of -3.6 pounds per acre per year for acres not receiving manure (table 15). The 80<sup>th</sup> percentile change in soil nitrogen for acres receiving manure was 14 pounds per acre per year, compared to the 80<sup>th</sup> percentile change in soil nitrogen of 7 pounds per acre per year for acres without manure applied.

The mean of the average annual estimates of total nitrogen loss was about 34 pounds per acre per year (table 15). The median of the estimate of total nitrogen loss for all loss pathways combined was 26 pounds per acre per year, substantially lower than the mean, indicating that the distribution includes some acres with much higher losses than most of the other acres. Based on the distribution of total nitrogen loss for all cultivated cropland acres in the eight regions, shown in figure 46:

- 35 percent had average annual total nitrogen loss (all loss pathways) less than 20 pounds per acre per year;
- 40 percent had total nitrogen loss between 20 and 40 pounds per acre per year;
- 17 percent had total nitrogen loss between 40 and 70 pounds per acre per year; and
- 8 percent had total nitrogen loss greater than 70 pounds per acre per year, including a small percentage with total losses greater than 100 pounds per acre per year.

Total nitrogen losses were highest for acres receiving manure. The average annual estimate of total nitrogen loss for acres receiving manure was 56 pounds per acre per year, compared to the average annual amount lost for acres not receiving manure of 32 pounds per acre per year (table 15).

Figure 44. Distribution of the average annual amount of nitrogen in the crop yield removed at harvest for sample points in all eight regions.

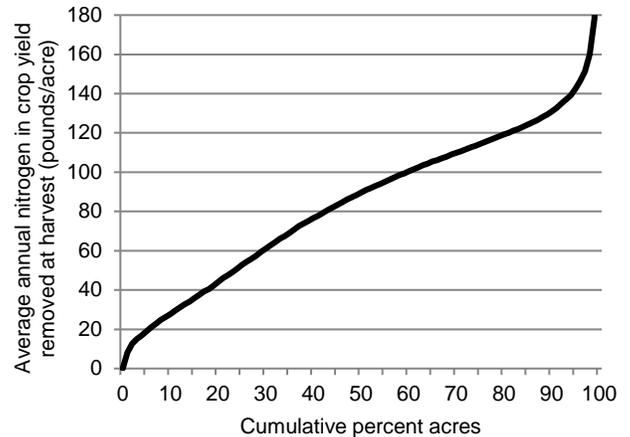


Figure 45. Distribution of the average annual amount of change in soil nitrogen for sample points in all eight regions.

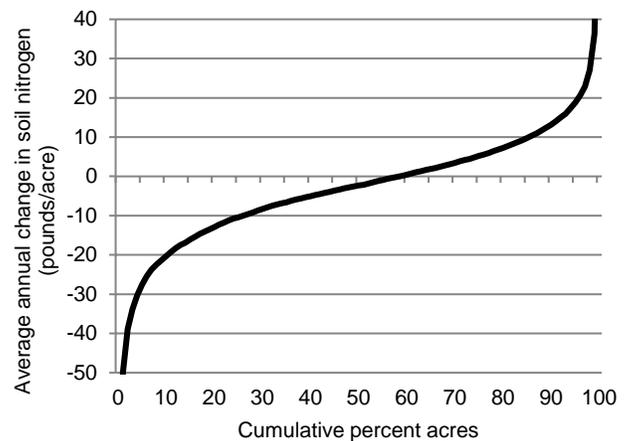
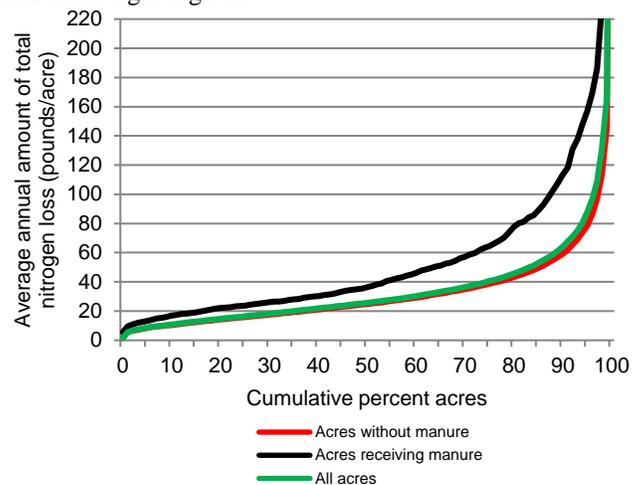


Figure 46. Distributions of average annual amount of total nitrogen lost from farm fields (all loss pathways) for sample points in all eight regions.



<sup>11</sup> A very small amount of nitrogen, less than 1 percent of all sources, was also stored in the residue left on the surface for acres with tillage and residue

management practices. Note: About 10 percent of cropped acres had manure applied in the eight regions.

The APEX model simulation tracks nitrogen loss from farm fields through six loss pathways. On average for all sample points in the eight regions (table 15, fig. 47):

- nitrogen loss by volatilization averaged 6.5 pounds per acre per year, accounting for 19 percent of the total nitrogen loss;
- nitrogen loss through denitrification averaged 2.4 pounds per acre per year, accounting for 7 percent of the total nitrogen loss;
- nitrogen lost with windborne sediment averaged 4.5 pounds per acre per year, accounting for 13 percent of the total nitrogen loss;
- nitrogen dissolved in surface water runoff averaged 1.0 pounds per acre per year, accounting for 3 percent of the total nitrogen loss;
- nitrogen lost with waterborne sediment averaged 4.8 pounds per acre per year, accounting for 14 percent of the total nitrogen loss; and
- soluble nitrogen loss in subsurface flow pathways averaged 15.2 pounds per acre per year, accounting for 44 percent of the total nitrogen loss.

Nitrogen losses in all loss pathways except nitrogen lost with windborne sediment were higher, on average, for acres receiving manure than for acres without manure applications (table 15).

The amount of nitrogen lost in each of the six loss pathways varies considerably from acre to acre, as shown by the distributions presented in figure 48. Losses were relatively low for half or more of the acres for each of the six loss pathways, whereas acres with the highest losses represent a minority of cropped acres.

Losses of nitrogen in two loss pathways were essentially insignificant for most of the cropped acres (fig. 48):

- 78 percent of cropped acres had amounts of nitrogen loss through denitrification less than 2 pounds per acre per year; and
- 86 percent of cropped acres had amounts of nitrogen dissolved in surface water runoff less than 2 pounds per acre per year.

On the high side, 20 percent of cropped acres had losses of nitrogen in subsurface flow pathways in excess of 20 pounds per acre per year, including 12 percent with losses greater than 30 pounds per acre per year and 8 percent with losses greater than 40 pounds per acre per year (fig. 48).

Figure 47. Percent of total nitrogen loss by loss pathway, all eight regions combined.

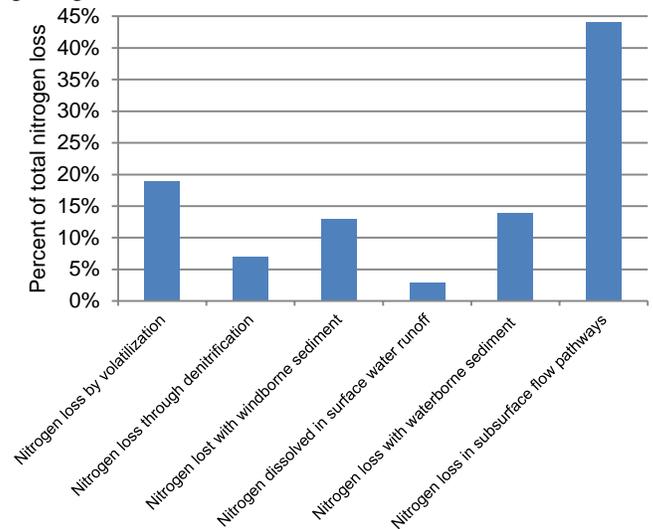
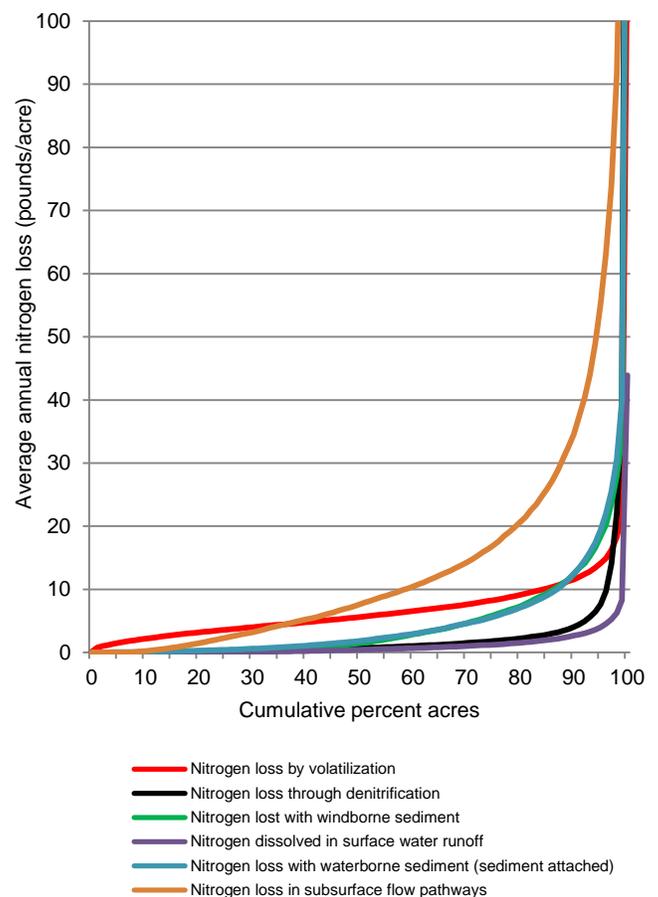


Figure 48. Distributions of average annual amount of nitrogen lost through six loss pathways for sample points in all eight regions.



## Nitrogen Loss by Production Region

A large part of the variability shown in the distributions presented in figures 39 through 43 and figure 45 is because of differences in climate, soils, crops grown, nutrient management, and use of conservation practices from region to region.

The Northern Plains (5) region and the Southern Plains (6) region stand out as having the smallest amounts of (table 16 and figs. 49-57):

- total nitrogen available for crops,
- nitrogen in the crop yield removed at harvest, and
- total nitrogen loss from farm fields.

The average annual amount of total nitrogen available for crops for these two regions was, respectively, 77 pounds per acre per year and 79 pounds per acre per year (table 16 and fig. 49). Figure 55 shows that only one-third of the cropped acres in each of these two regions had total plant-available nitrogen above 85 pounds per acre per year, compared to a range of 70 percent to 97 percent of cropped acres for each of the other regions except the Northwest Non-Coastal (3) region, which had 48 percent of cropped acres with more than 85 pounds per acre per year.

The Northwest Non-Coastal (3) region had the third smallest amount of plant-available nitrogen, averaging 102 pounds per acre per year (table 16 and fig. 49). Nitrogen from both atmospheric deposition and bio-fixation by legumes were minor sources in this region as well as the Northern Plains (5) and the Southern Plains (6) regions (figs. 37 and 48). Manure applications also played a minor role in these three regions, as less than 4 percent of cropped acres received manure applications (fig. 26). The amount of nitrogen applied in the Northwest Non-Coastal (3) region was similar to amounts applied in most of the other regions (fig. 49).

Sources of total nitrogen in the remaining five regions were generally similar, ranging from a low of 116 pounds per acre per year, on average, for cropped acres in the Southeast Coastal Plain (12) to a high of 149 pounds per acre per year in both the North Central and Midwest (7) region and the East Central (11) region (fig. 46). Manure applications were important contributors of nitrogen in each of these two regions (table 16 and fig. 26).

The North Central and Midwest (7) region had the largest average amount of nitrogen taken up by the crop and removed at harvest—110 pounds per acre per year (table 16 and fig. 53). The East Central (11) region had the second-highest average annual amount at 102 pounds per acre per year. Figure 56 shows that 70 percent of the cropped acres in the North Central and Midwest (7) region had more than 100 pounds per acre per year of nitrogen taken up by the crop and removed at harvest, and the East Central (11) region had 50 percent, compared to percentages ranging from 42 percent for the Lower Mississippi and Texas Gulf (9) region to only 7 percent for the Northern Plains (5) region.

Total nitrogen lost from farm fields was lowest for the three westernmost regions (table 27, fig. 54, and fig. 57). As shown previously, these three regions also have:

- the smallest average amounts of precipitation and irrigation water applied (fig. 29),
- the smallest average amounts of surface water runoff (fig. 31),
- the smallest average amounts of loss of water through subsurface flow pathways (fig. 32), and
- the smallest average amounts of sediment loss from farm fields (together with the North Central and Midwest (7) region) (fig. 34).

The relatively high yields in the North Central and Midwest (7) region, which has the most cultivated cropland acres (fig. 2), resulted in a smaller proportion of the amount of nitrogen applied being susceptible to the forces of wind and water. This region was the fourth lowest in average annual total nitrogen loss (table 16 and fig. 54), following the three westernmost regions, with an average annual total nitrogen loss of 36 pounds per acre per year. This represents about 24 percent of the average annual amount of plant-available nitrogen in this region, the lowest proportion among all of the regions except for the Northern Plains (6) region. (The proportion for the Northern Plains (6) region was also about 24 percent.)

The four regions in the south and east have the largest losses of nitrogen from farm fields (table 16, fig. 54, and fig. 57):

- the East Central (11) region, with an average annual total nitrogen loss of 51 pounds per acre per year,
- the Southeast Coastal Plain (12) region, with an average annual loss of 54 pounds per acre per year,
- the Northeast (10) region, with an average annual loss of 56 pounds per acre per year, and
- the Lower Mississippi and Texas Gulf (9) region, with an average annual loss of 58 pounds per acre per year.

Figure 57 shows more effectively the extent to which total nitrogen losses in these four regions is higher than in the remaining four regions. For example, the four regions in the south and east have 20 to 29 percent of cropped acres with total nitrogen loss estimates greater than 70 pounds per acre per year, depending on the region. In contrast, the remaining four regions have 1 to 7 percent of cropped acres with total nitrogen loss estimates greater than 70 pounds per acre per year.

Figure 49. Mean of the average total of all nitrogen sources, by region.

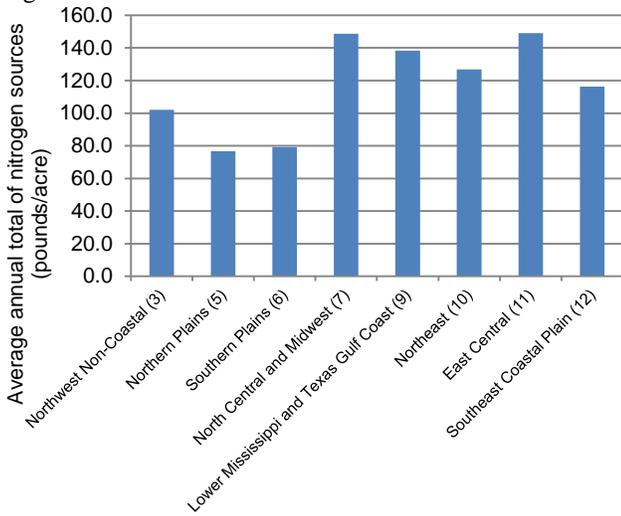


Figure 52. Mean of the average annual nitrogen applied as commercial fertilizer and manure, by region.

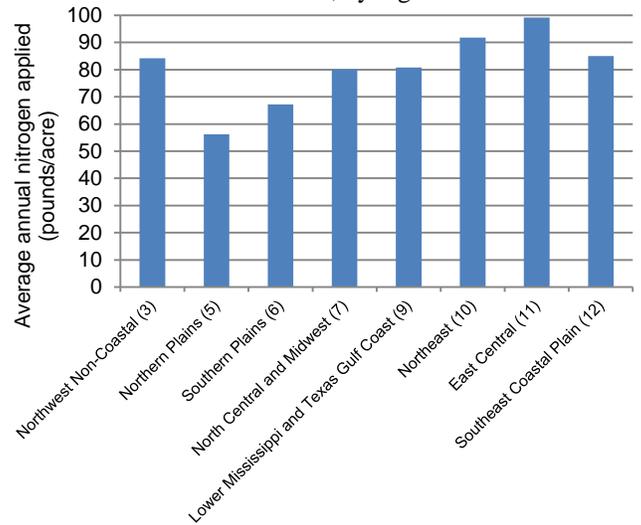


Figure 50. Mean of the average annual atmospheric deposition of nitrogen, by region.

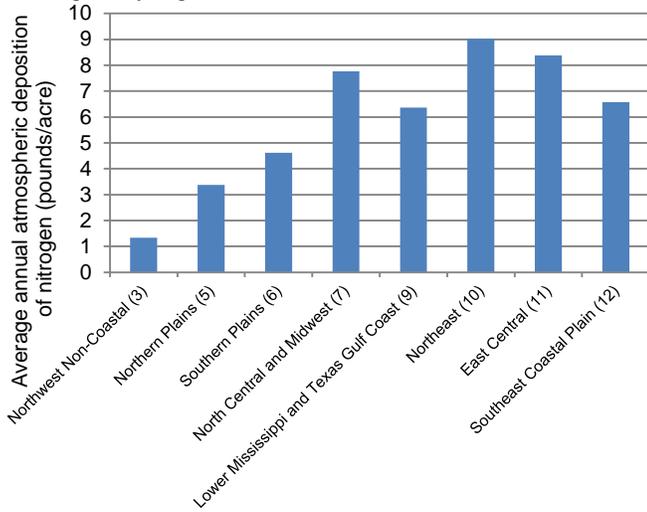


Figure 53. Mean of the average annual amount of nitrogen in the crop yield removed at harvest, by region.

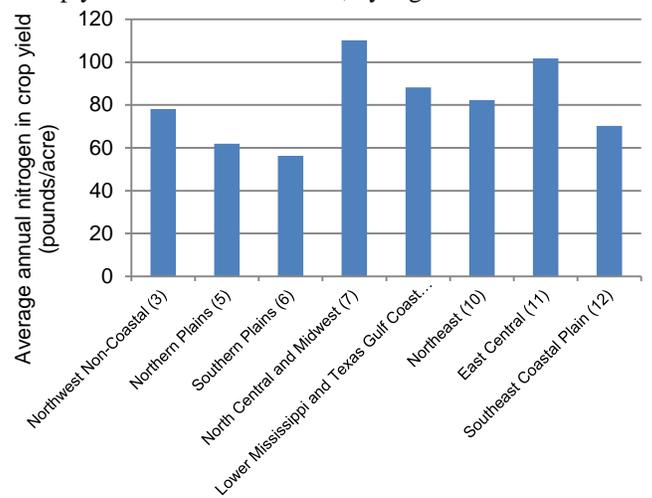


Figure 51. Mean of the average annual amount of nitrogen from bio-fixation by legumes, by region.

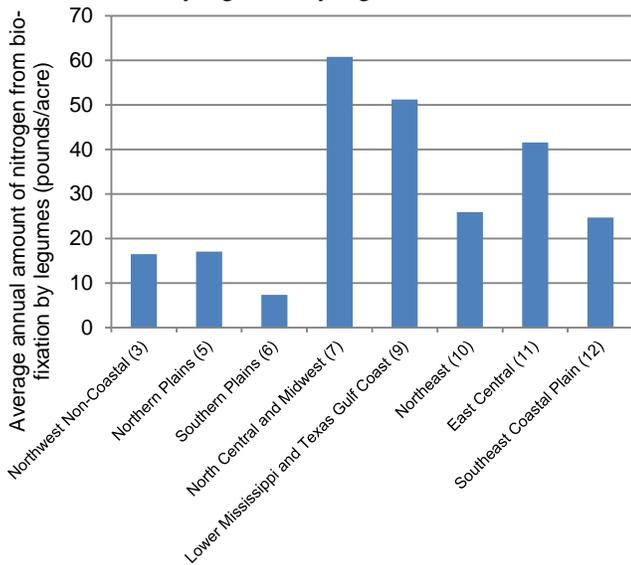


Figure 54. Mean of the average annual total nitrogen loss for all loss pathways, by region.

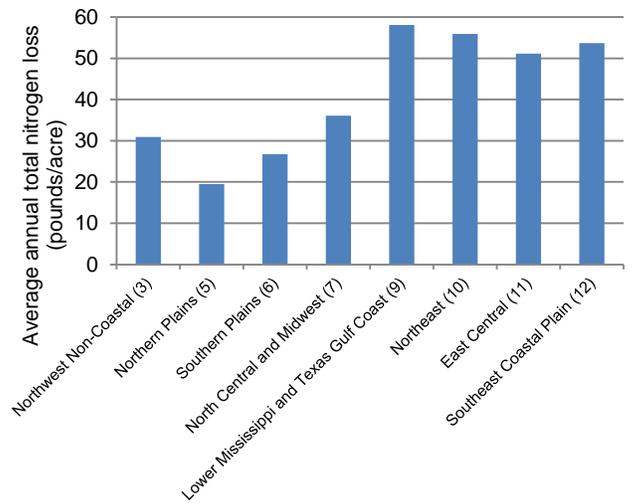


Table 16. Average annual estimates of nitrogen sources and losses from farm fields for cultivated cropland acres, by region combined.

	Northwest Non-Coastal (3)	Northern Plains (5)	Southern Plains (6)	North Central and Midwest (7)
<b>All cultivated cropland acres, mean value (pounds per acre)</b>				
Nitrogen sources				
Atmospheric deposition	1.3	3.4	4.6	7.8
Bio-fixation by legumes	16.5	17.1	7.4	60.8
Nitrogen applied as commercial fertilizer and manure	84.1	56.2	67.2	80.1
Total of all nitrogen sources	102.0	76.6	79.2	148.7
Nitrogen in crop yield removed at harvest	78.1	61.9	56.2	110.2
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.9	5.8	6.7	7.0
Nitrogen loss through denitrification	0.5	1.1	1.0	2.3
Nitrogen lost with windborne sediment	6.0	7.7	7.9	2.8
Nitrogen dissolved in surface water runoff	0.7	0.2	0.3	1.2
Nitrogen loss with waterborne sediment (sediment attached)	3.7	0.5	1.3	6.6
Nitrogen loss in subsurface flow pathways	14.2	4.1	9.7	16.2
Total nitrogen loss for all loss pathways	30.9	19.5	26.8	36.1
Change in soil nitrogen	-7.5	-5.5	-4.4	1.0
<b>Acres without manure applied, mean value (pounds per acre)</b>				
Nitrogen sources				
Atmospheric deposition	1.3	3.4	4.6	7.8
Bio-fixation by legumes	15.8	17.0	7.4	62.8
Nitrogen applied as commercial fertilizer and manure	81.0	55.1	64.1	74.0
Total of all nitrogen sources	98.1	75.5	76.1	144.5
Nitrogen in crop yield removed at harvest	76.2	61.3	55.1	109.1
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.7	5.8	6.5	6.7
Nitrogen loss through denitrification	0.5	1.1	0.9	2.1
Nitrogen lost with windborne sediment	5.7	7.7	7.6	2.6
Nitrogen dissolved in surface water runoff	0.7	0.2	0.3	1.2
Nitrogen loss with waterborne sediment (sediment attached)	3.7	0.5	1.3	6.2
Nitrogen loss in subsurface flow pathways	13.0	3.9	9.0	14.5
Total nitrogen loss for all loss pathways	29.4	19.1	25.5	33.3
Change in soil nitrogen	-8.0	-5.7	-5.1	0.9
<b>Acres with manure applied, mean value (pounds per acre)</b>				
Nitrogen sources				
Atmospheric deposition	1.4	3.8	4.4	7.7
Bio-fixation by legumes	38.7	17.8	7.0	49.3
Nitrogen applied as commercial fertilizer and manure	177.8	87.4	143.4	115.3
Total of all nitrogen sources	218.0	109.0	154.8	172.4
Nitrogen in crop yield removed at harvest	135.1	77.8	83.6	116.9
Nitrogen loss pathways				
Nitrogen loss by volatilization	9.0	8.1	11.6	8.7
Nitrogen loss through denitrification	1.3	1.7	3.5	3.4
Nitrogen lost with windborne sediment	13.5	9.2	13.4	3.6
Nitrogen dissolved in surface water runoff	0.7	0.2	0.4	0.9
Nitrogen loss with waterborne sediment (sediment attached)	2.9	0.4	2.0	9.1
Nitrogen loss in subsurface flow pathways	49.7	9.9	26.2	26.3
Total nitrogen loss for all loss pathways	77.1	29.5	57.1	52.1
Change in soil nitrogen	5.3	1.0	13.4	1.9

Table 19.—continued.

	Lower Mississippi and Texas Gulf Coast (9)	Northeast (10)	East Central (11)	Southeast Coastal Plain (12)
<b>All cultivated cropland acres, mean value (pounds per acre)</b>				
Nitrogen sources				
Atmospheric deposition	6.4	9.0	8.4	6.6
Bio-fixation by legumes	51.2	25.9	41.6	24.7
Nitrogen applied as commercial fertilizer and manure	80.8	91.8	99.1	85.0
Total of all nitrogen sources	138.4	126.8	149.0	116.3
Nitrogen in crop yield removed at harvest	88.2	82.2	101.8	70.2
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.6	5.4	7.6	6.2
Nitrogen loss through denitrification	12.4	1.5	2.2	1.3
Nitrogen lost with windborne sediment	1.3	0.2	0.1	0.3
Nitrogen dissolved in surface water runoff	3.0	1.2	3.4	1.6
Nitrogen loss with waterborne sediment (sediment attached)	10.0	12.9	13.3	4.0
Nitrogen loss in subsurface flow pathways	25.9	34.7	24.5	40.2
Total nitrogen loss for all loss pathways	58.1	55.9	51.2	53.7
Change in soil nitrogen	-8.3	-13.4	-5.1	-8.0
<b>Acres without manure applied, mean value (pounds per acre)</b>				
Nitrogen sources				
Atmospheric deposition	6.4	8.9	8.3	6.6
Bio-fixation by legumes	51.6	28.3	41.9	24.7
Nitrogen applied as commercial fertilizer and manure	79.0	64.9	94.4	81.2
Total of all nitrogen sources	137.0	102.2	144.5	112.6
Nitrogen in crop yield removed at harvest	87.9	72.9	99.2	68.5
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.5	4.6	7.4	6.0
Nitrogen loss through denitrification	12.2	1.3	2.2	1.3
Nitrogen lost with windborne sediment	1.3	0.2	0.1	0.3
Nitrogen dissolved in surface water runoff	3.0	1.4	3.5	1.6
Nitrogen loss with waterborne sediment (sediment attached)	10.0	11.2	12.7	4.1
Nitrogen loss in subsurface flow pathways	25.4	23.4	23.3	38.9
Total nitrogen loss for all loss pathways	57.3	42.1	49.2	52.2
Change in soil nitrogen	-8.6	-14.7	-5.0	-8.5
<b>Acres with manure applied, mean value (pounds per acre)</b>				
Nitrogen sources				
Atmospheric deposition	6.8	9.1	8.9	6.5
Bio-fixation by legumes	31.7	23.1	39.5	24.6
Nitrogen applied as commercial fertilizer and manure	163.9	122.8	126.5	116.0
Total of all nitrogen sources	202.3	155.1	175.0	147.1
Nitrogen in crop yield removed at harvest	103.5	93.0	116.9	84.6
Nitrogen loss pathways				
Nitrogen loss by volatilization	9.7	6.4	8.8	8.3
Nitrogen loss through denitrification	24.8	1.7	2.7	1.1
Nitrogen lost with windborne sediment	0.6	0.1	0.1	0.3
Nitrogen dissolved in surface water runoff	4.1	1.0	2.3	1.3
Nitrogen loss with waterborne sediment (sediment attached)	9.2	14.9	17.0	3.7
Nitrogen loss in subsurface flow pathways	47.3	47.7	31.6	51.6
Total nitrogen loss for all loss pathways	95.7	71.9	62.6	66.2
Change in soil nitrogen	1.9	-11.8	-5.9	-4.1

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

Figure 55. Distributions of average annual amount of nitrogen sources (all sources combined) for sample points in each of the 8 regions.

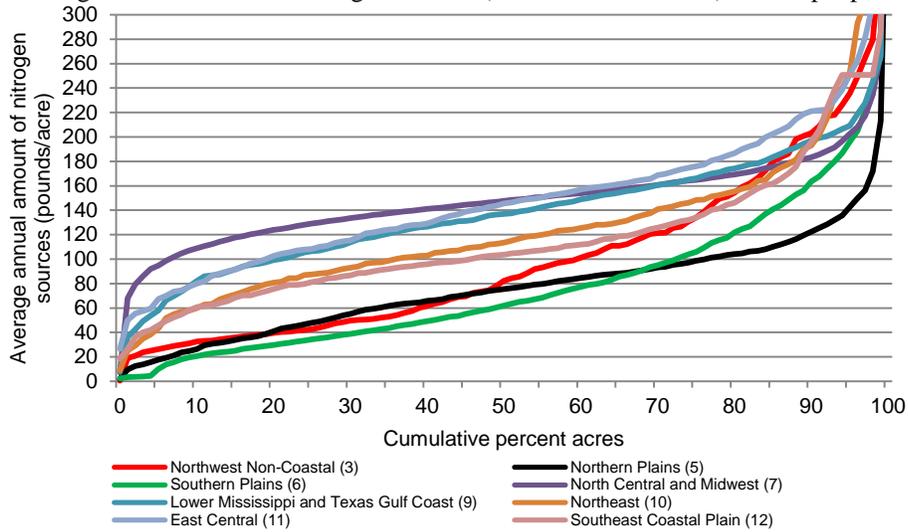


Figure 56. Distributions of average annual amount of nitrogen in the crop yield removed at harvest for sample points in each of the 8 regions.

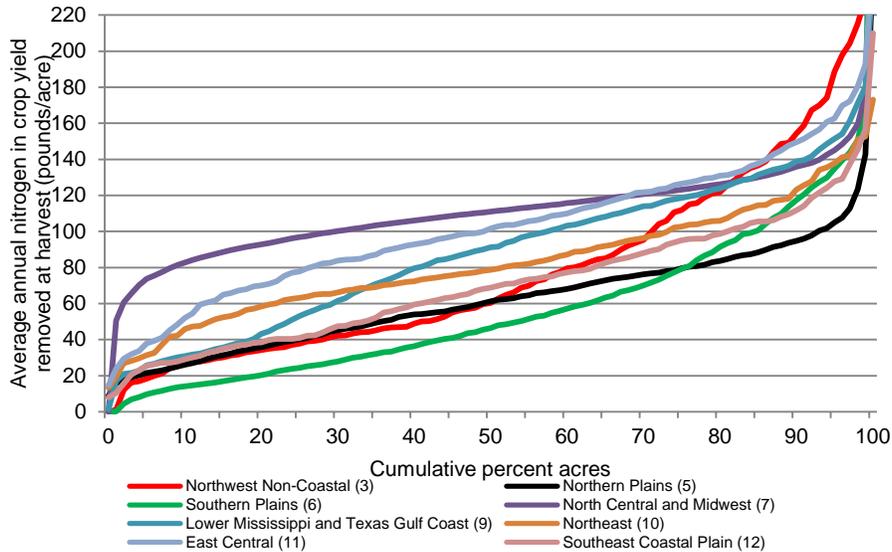
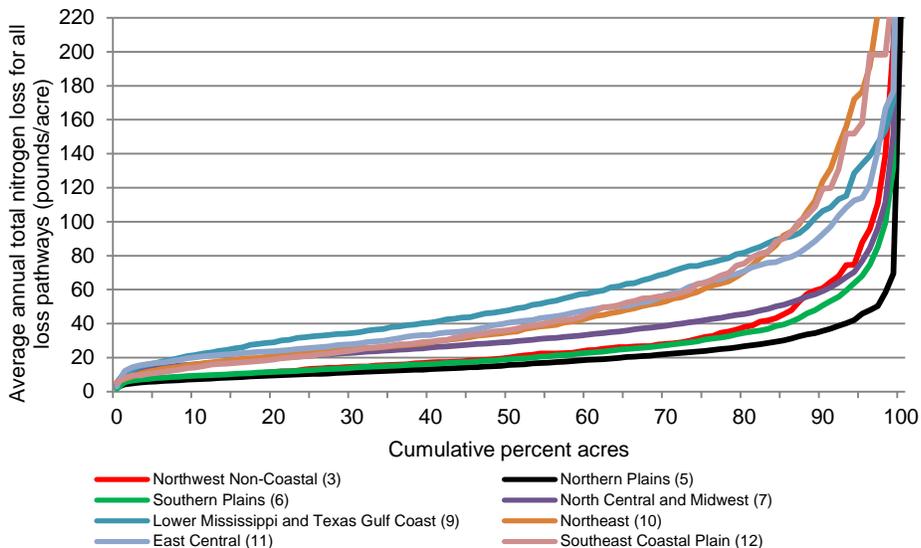


Figure 57. Distributions of average annual amount of total nitrogen lost from farm fields (all loss pathways) for sample points in each of the 8 regions.



The principal nitrogen loss pathways also differed by region, reflecting differences in precipitation and surface water runoff, as shown in figures 58 through 69.

The average annual amount of nitrogen lost by volatilization differed less among the regions than the other loss pathways (table 16 and fig. 64). The average annual amount lost by volatilization ranged from a low of 5.4 pounds per acre per year in the Northeast (10) region to a high of 7.6 pounds per acre per year in the East Central (11) region. Volatilization losses exceeded 15 pounds per acre per year for a small number of acres in every region (fig. 64). In terms of the percent of total nitrogen loss (fig. 58), however, the amount of nitrogen lost by volatilization was one of the three principal loss pathways in the three westernmost regions and was also important within the Midwest and North Central (7) region.

Loss of nitrogen through denitrification was not a principal loss pathway in any region. Amounts lost through this pathway were uniformly low except for in the Lower Mississippi and Texas Gulf (9) region (table 16 and fig. 65), where the average annual amount of nitrogen lost through denitrification was 12.4 pounds per acre per year, representing 21 percent of the total nitrogen loss in that region (fig. 59). In comparison, the average annual amount of nitrogen lost through denitrification ranged from 0.5 pound per acre per year in the Northwest Non-Coastal (3) region to 2.3 pounds per acre per year in the North Central and Midwest (7) region.

Loss of nitrogen with windborne sediment was a principal loss pathway in the three westernmost regions, where wind erosion rates were high (fig. 38), but amounts lost were small in all but a few cropped acres in the other regions (fig. 63). The average annual amount of nitrogen lost with windborne sediment for these three regions was (table 16):

- 7.9 pounds per acre per year in the Southern Plains (6) region, accounting for 29 percent of the total amount of nitrogen lost (fig. 60);
- 7.7 pounds per acre per year in the Northern Plains (5) region, accounting for 40 percent of the total amount of nitrogen lost (fig. 60); and
- 6.0 pounds per acre per year in the Northwest Non-Coastal (3) region, accounting for 19 percent of the total amount of nitrogen lost (fig. 60).

Losses of nitrogen with windborne sediment were much higher for some acres (fig. 66). Nitrogen loss with windborne sediment exceeded 10 pounds per acre per year for 27 percent of the cropped acres in the Southern Plains (6) region, 24 percent of the cropped acres in the Northern Plains (5) region, and 22 percent of the cropped acres in the Northwest Non-Coastal (3) region.

Nitrogen dissolved in surface water runoff is not a principal loss pathway for nitrogen in any of the eight regions. This in part reflects with widespread use of water erosion control practices, especially tillage and residue management. Retaining water on the field reduces the amount of surface water runoff and increases the amount that infiltrates into the

soil. The two regions with the highest amount of nitrogen dissolved in surface water runoff (table 16 and fig. 67) are:

- the East Central (11) region, with an average annual amount of 3.4 pounds per acre per year, representing about 7 percent of the total nitrogen loss in the region (fig. 61), and
- the Lower Mississippi and Texas Gulf (9) region, with an average annual amount of 3.0 pounds per acre per year, representing about 5 percent of the total nitrogen loss in the region (fig. 61).

Nitrogen dissolved in surface water runoff exceeded 5 pounds per acre per year for about 15 percent of cropped acres in each of these two regions (fig. 67). Less than 5 percent of the cropped acres in other regions had amounts of nitrogen dissolved in surface water greater than 5 pounds per acre per year.

Nitrogen loss with waterborne sediment (sediment attached) is a principal loss pathway for nitrogen in four regions (table 16 and fig. 68):

- the East Central (11) region, with an average annual amount of 13.3 pounds per acre per year, representing about 26 percent of the total nitrogen loss in the region (fig. 62);
- the Northeast (10) region, with an average annual amount of 12.9 pounds per acre per year, representing about 23 percent of the total nitrogen loss in the region (fig. 62);
- the Lower Mississippi and Texas Gulf (9) region, with an average annual amount of 10.0 pounds per acre per year, representing about 17 percent of the total nitrogen loss in the region (fig. 62); and
- the North Central and Midwest (7) region, with an average annual amount of 6.6 pounds per acre per year, representing about 18 percent of the total nitrogen loss in the region (fig. 62).

Nitrogen loss in subsurface flows was a principal loss pathway in every region (table 16 and fig. 69). Nitrogen losses to this pathway exceeded losses for each of the other pathways in every region except the Northern Plains (5) region, where nitrogen loss to subsurface flows was less than windborne nitrogen and volatilization. This loss pathway accounts for 75 percent of the total nitrogen loss in the Southeast Coastal Plain (12) region and 62 percent of the total nitrogen loss in the Northeast (10) region (fig. 63).

Nitrogen loss in subsurface water flows were highest for the four regions in the east and south, where the average annual amount lost ranged from 51.2 pounds per acre per year in the East Central (11) region to 58.1 pounds per acre per year in the Lower Mississippi and Texas Gulf (9) region.

Losses of nitrogen are higher for acres receiving manure than for acres without manure applied, but for most loss pathways and in most regions the differences are small (table 16). In the Northeast, however, which had the highest percentage of cropped acres receiving manure, the amount of nitrogen loss in subsurface water flows is twice as high for acres receiving manure, on average.

Figure 58. Nitrogen lost by volatilization as a percent of total nitrogen loss, by region.

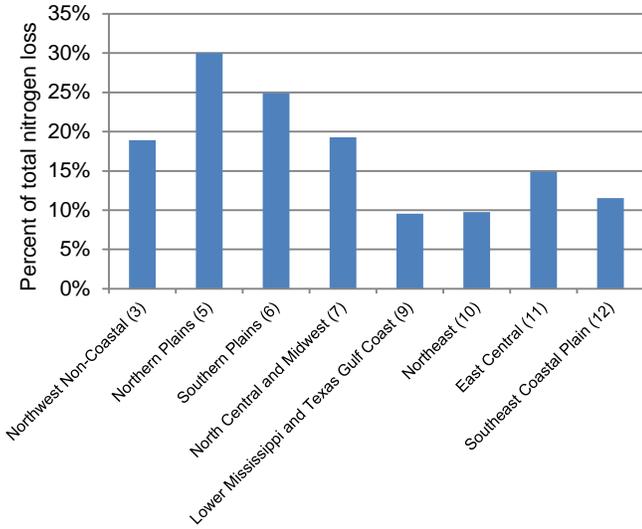


Figure 61. Nitrogen dissolved in surface water runoff as a percent of total nitrogen loss, by region.

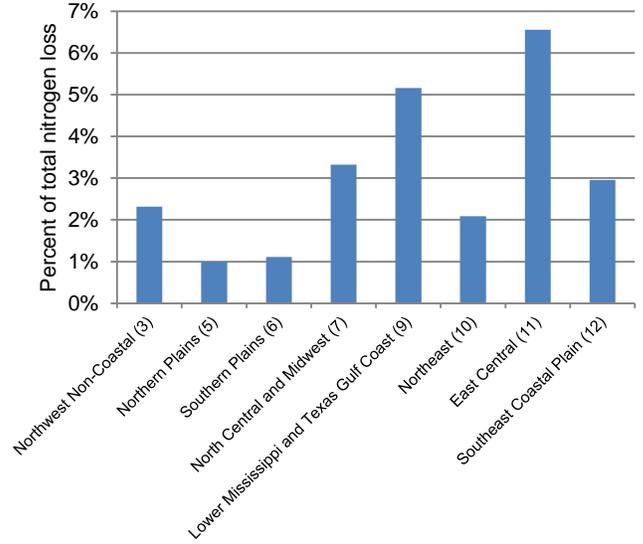


Figure 59. Nitrogen lost through denitrification as a percent of total nitrogen loss, by region.

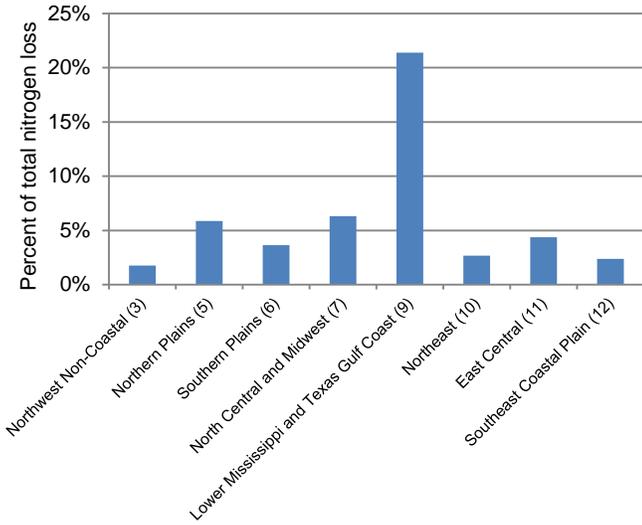


Figure 62. Nitrogen lost with waterborne sediment (sediment attached) as a percent of total nitrogen loss, by region.

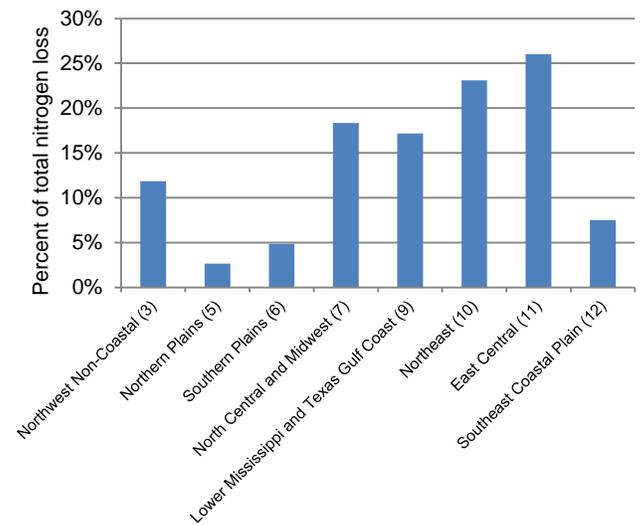


Figure 60. Nitrogen lost with windborne sediment as a percent of total nitrogen loss, by region.

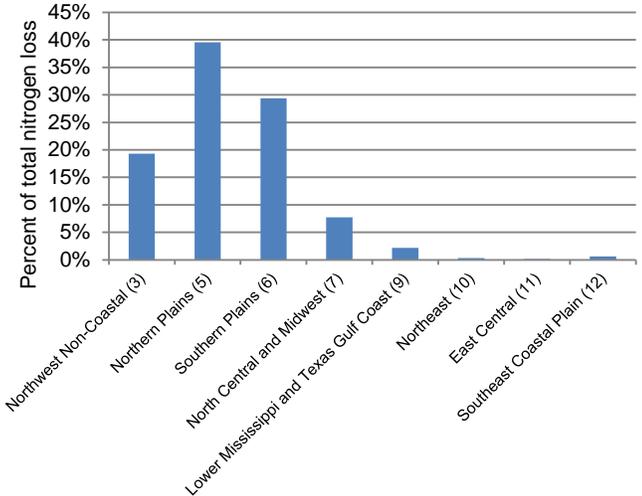


Figure 63. Nitrogen loss in subsurface water flows as a percent of total nitrogen loss, by region.

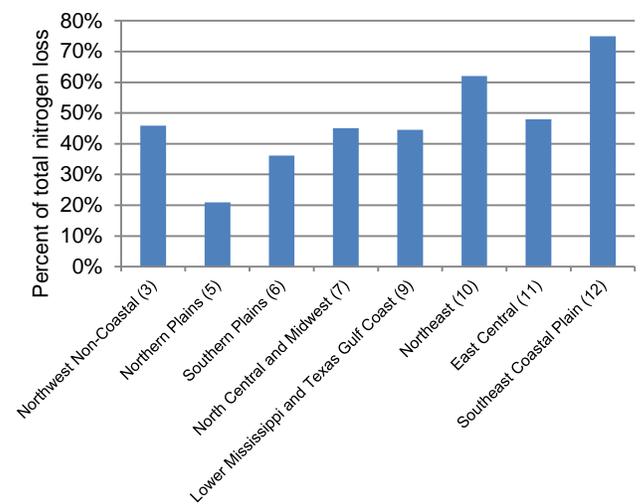


Figure 64. Distributions of average annual amount of nitrogen loss by volatilization for sample points in each of the eight regions.

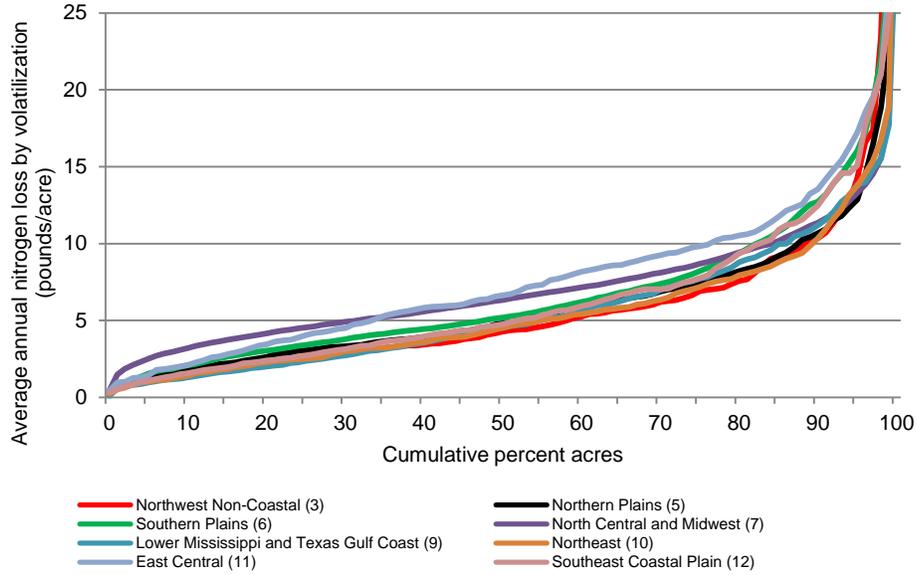


Figure 65. Distributions of average annual amount of nitrogen loss through denitrification for sample points in each of the eight regions.

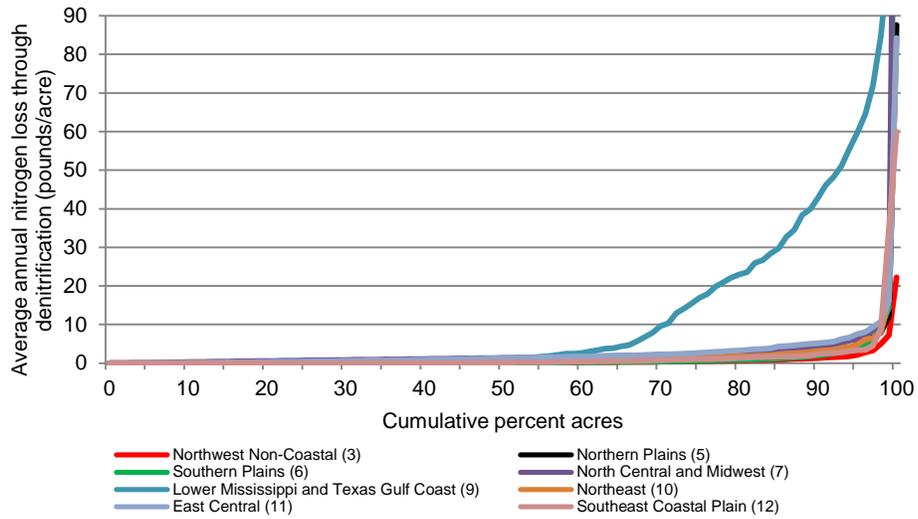


Figure 66. Distributions of average annual amount of nitrogen lost with windborne sediment for sample points in each of the eight regions.

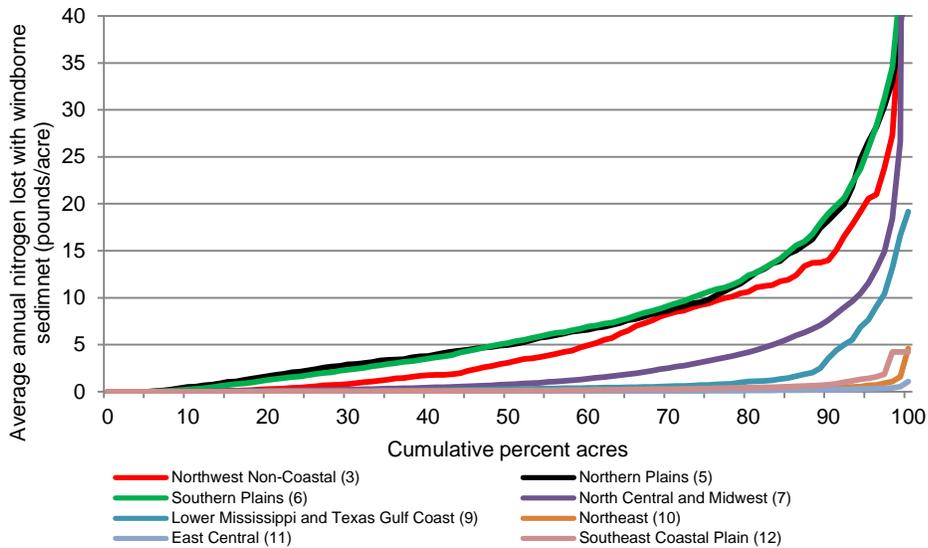


Figure 67. Distributions of average annual amount of nitrogen dissolved in surface water runoff for sample points in each of the eight regions.

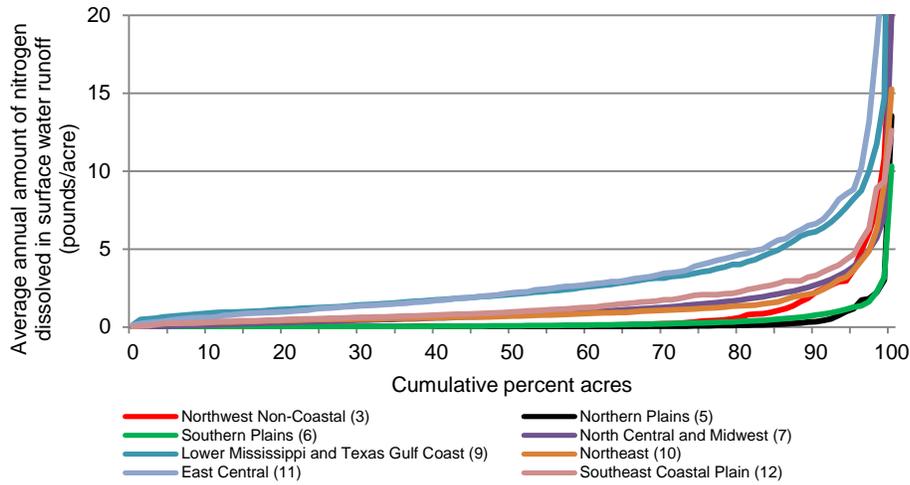


Figure 68. Distributions of average annual amount of nitrogen loss with waterborne sediment (sediment attached) for sample points in each of the eight regions.

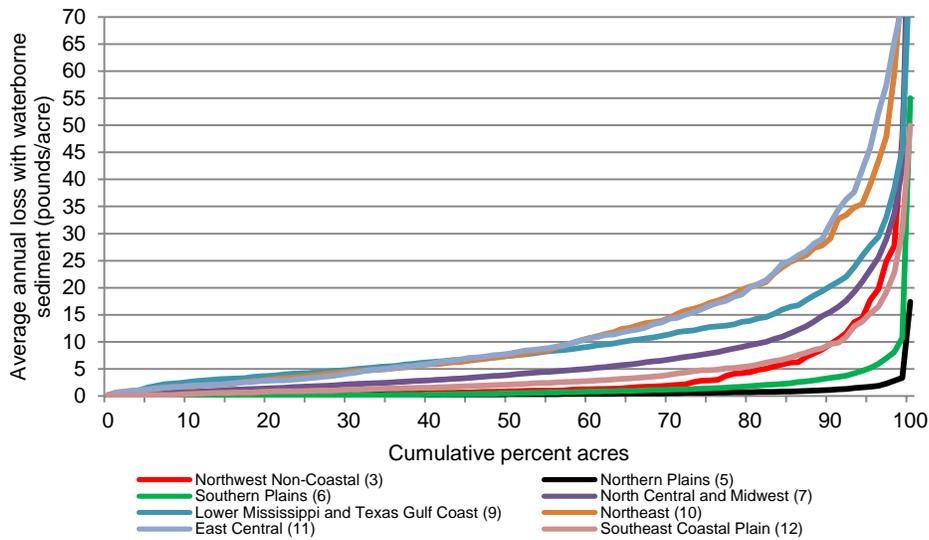
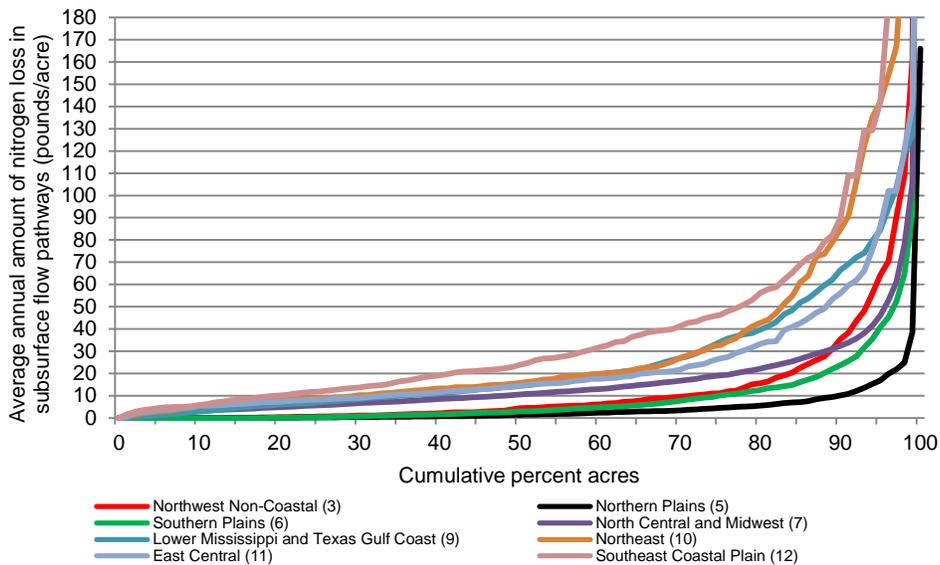


Figure 69. Distributions of average annual amount of nitrogen loss in subsurface flow pathways for sample points in each of the eight regions.



## Breakdown of Estimates of Nitrogen Loss with Surface Water Runoff by Levels of Conservation Treatment

Adequate conservation treatment consists of combinations of conservation practices that treat the specific inherent vulnerability factors associated with each field. Acres with a high level of inherent vulnerability require more treatment than less vulnerable acres to reduce field-level losses to acceptable levels. Acres with characteristics such as steeper slopes and soil types that promote surface water runoff are more vulnerable to sediment and nutrient losses beyond the edge of the field. Acres that are essentially flat with permeable soil types are more prone to soluble nutrient losses through subsurface flow pathways.

The adequacy of conservation practice use in 2003-06 for control of total nitrogen lost to surface water was evaluated. Estimates of “nitrogen loss with surface water runoff” were obtained by adding the amount of waterborne nitrogen (nitrogen attached to sediment) to estimates of soluble nitrogen dissolved in surface water. The evaluation accounts for four levels of soil vulnerability to runoff and four levels of conservation treatment.

Criteria were defined for four “soil runoff potentials” to characterize the inherent vulnerability for water runoff to occur. These criteria are presented in Appendix B. The criteria were then used to define the soil runoff potential at each sample point.<sup>12</sup> For all eight regions combined, about 10 percent of the cultivated cropland acres have a “high” soil runoff potential, most of which are HEL acres (fig. 57). Another 19 percent have a moderately high soil runoff potential, more than half of which are HEL acres. The majority of acres—53 percent—have a “low” soil runoff potential. (A significant proportion of acres with a “low” soil runoff potential are also HEL acres, shown in figure 70. These are primarily HEL acres in the drier regions and are designated as HEL because of a high vulnerability to wind erosion.)

Average annual nitrogen loss estimates were determined for each of four “nitrogen runoff control treatment levels” (presented previously; see figure 27) at each of the four “soil runoff potentials” to provide further insight on what factors were most responsible for the amounts of nitrogen loss with surface water runoff as estimated in the model simulations.

This resulted in a 4-by-4 matrix with 16 cells where each cell consisted of a mean value of the average annual estimates of nitrogen loss with surface water runoff for a specific subset of sample points. Table 17 provides estimates of acres and the average annual amount of nitrogen loss with surface water runoff for each of the 16 cells for all eight regions combined, as well as estimates of the percentage of acres with unacceptably high losses.

The mean of the average annual amount of nitrogen loss with surface water runoff water was 5.8 pounds per acre per year for all cropped acres in all eight regions. As the soil runoff potential increased from “low” to “high,” the mean steadily increased. The mean of the average annual amount of nitrogen loss with surface water runoff water was (table 17):

- 3.0 pounds per acre per year for cropped acres with a “low” soil runoff potential;
- 6.1 pounds per acre per year for cropped acres with a “moderate” soil runoff potential;
- 8.5 pounds per acre per year for cropped acres with a “moderately high” soil runoff potential; and
- 15.9 pounds per acre per year for cropped acres with a “high” soil runoff potential.

Similarly, the mean steadily decreased with increasing levels of conservation treatment for nitrogen runoff control. The mean of the average annual nitrogen loss with surface water runoff water was (table 17):

- 11.1 pounds per acre per year for cropped acres with a “low” level of treatment;
- 6.3 pounds per acre per year for cropped acres with a “moderate” level of treatment;
- 4.2 pounds per acre per year for cropped acres with a “moderately high” level of treatment; and
- 2.8 pounds per acre per year for cropped acres with a “high” level of treatment.

Table 17 also shows that the mean steadily decreased with increasing levels of conservation treatment for groups of acres within each soil runoff potential. The highest estimate of the average annual nitrogen loss with surface water runoff shown in the table 17 matrix—27.5 pounds per acre per year—was for acres with a “low” level of conservation treatment for nitrogen runoff control and a “high” soil runoff potential.

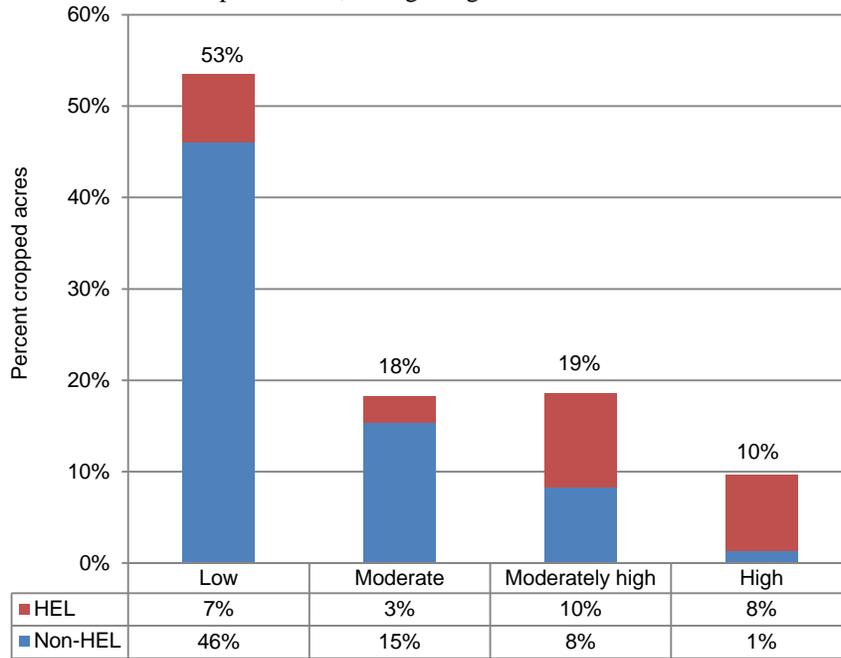
At the “high” level of conservation treatment, estimates of the average annual nitrogen loss with surface water runoff were low at all soil runoff potentials, ranging from 1.4 to 5.1 pounds per acre per year. The increasing trend in nitrogen loss with increasing levels of soil runoff potentials breaks down for the “high” level of conservation treatment because at that level all the acres would be expected to be adequately treated.

Estimates of the average annual nitrogen loss with surface water runoff were more substantial at all soil runoff potentials for the “moderate” and the “low” conservation treatment levels, steadily increasing as the soil runoff potential increased.

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<sup>12</sup> Soil runoff potentials were used with conservation treatment levels to estimate conservation treatment needs in the previously published CEAP reports for each water resource region.

Figure 70. Soil runoff potential for cultivated cropland acres, all eight regions combined.



Note: Criteria for defining the soil runoff potentials are presented in Appendix B.

Table 17. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, all eight regions combined.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	11,060,768	74,868,586	61,723,221	7,526,590	155,179,165
Moderate	5,066,862	25,857,755	19,531,319	2,538,600	52,994,537
Moderately high	6,179,122	30,263,587	16,198,978	1,147,256	53,788,943
High	4,048,327	16,740,137	7,219,619	117,268	28,125,352
All	26,355,080	147,730,066	104,673,137	11,329,714	290,087,997
Percent of cropped acres					
Low	4%	26%	21%	3%	53%
Moderate	2%	9%	7%	1%	18%
Moderately high	2%	10%	6%	<1%	19%
High	1%	6%	2%	<1%	10%
All	9%	51%	36%	4%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	4.5	3.2	2.7	1.8	3.0
Moderate	6.7	6.2	5.8	5.1	6.1
Moderately high	15.9	8.6	5.8	4.1	8.5
High	27.5	16.0	9.3	1.4	15.9
All	11.1	6.3	4.2	2.8	5.8
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	7%	4%	1%	1%	3%
Moderate	8%	9%	5%	3%	7%
Moderately high	45%	20%	7%	0%	19%
High	61%	43%	20%	0%	39%
All	25%	12%	4%	1%	10%

Table 17 also presents the percentage of acres in each of the 16 cells of the 4-by-4 matrix that exceed 15 pounds per acre per year of total nitrogen loss with surface water runoff as a guide to determining the extent of cropped acres with excessive nitrogen loss. Estimates of total nitrogen loss with surface water runoff greater than 15 pounds per acre per year are generally considered to be unacceptable and require additional conservation treatment.<sup>13</sup>

About 10 percent of all cultivated cropland acres in the eight regions—totaling 29 million acres—have average annual estimates of total nitrogen loss with surface water runoff greater than 15 pounds per acre per year (table 17). Most of these acres (18.6 million acres) are concentrated in the four groups of acres with “low” or “moderate” levels of conservation treatment and “high” or “moderately high” soil runoff potentials. For example, 61 percent of the acres with a “low” conservation treatment level and a “high” soil runoff potential have estimates of average annual total nitrogen loss with surface water runoff greater than 15 pounds per acre per year (table 17).

Overall, 25 percent of cropped acres with a “low” level of conservation treatment for runoff control had estimates of average annual total nitrogen loss with surface water runoff greater than 15 pounds per acre per year (table 17). About 12 percent of cropped acres with a “moderate” level of conservation treatment for runoff control had estimates of average annual total nitrogen loss with surface water runoff greater than 15 pounds per acre per year. Only 4 percent of the cropped acres with a “moderately high” level of conservation treatment and 1 percent of cropped acres with a “high” level of conservation treatment had estimates of average total nitrogen loss with surface water runoff greater than 15 pounds per acre per year.

The four matrixes in table 17 are repeated in tables 18-25 for each of the regions. The decreasing trend in nitrogen loss with increasing levels of conservation treatment and the increasing trend in nitrogen loss with increasing levels of soil runoff potentials shown in table 17 for all eight regions combined remained strong in four regions (except for a few combinations where the number of samples was very small)—the Southern Plains (6) region, the North Central and Midwest (7) region, the Northeast (10) region, and the East Central (11) region.

In other regions, the trends are evident but generally weaker because, in part, one or more of the soil runoff potentials or conservation treatment levels are represented by too few acres to make reliable comparisons among all of the 16 cells.

Nevertheless, these matrixes clearly show that for each region the lowest rates of total nitrogen loss with surface water runoff are for acres with the higher levels of conservation treatment for nitrogen runoff control when the inherent soil runoff vulnerability is taken into account.

About three-fourths of the 29 million acres with estimates of average total nitrogen loss with surface water runoff greater than 15 pounds per acre per year are concentrated in two regions:

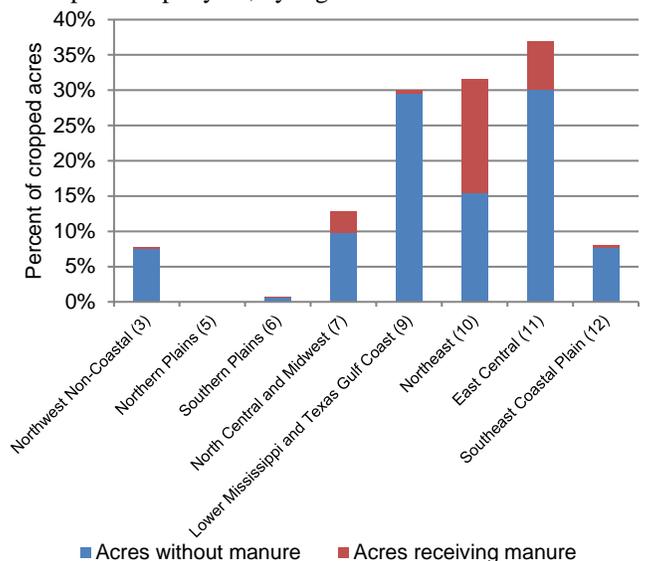
- the North Central and Midwest (7) region, where 13 percent of cropped acres (15.0 million acres) had estimates of average annual total nitrogen loss with surface water runoff greater than 15 pounds per acre per year, and
- the Lower Mississippi and Texas Gulf Coast (9) region, where 30 percent of cropped acres (6.3 million acres) had estimates of average total nitrogen loss with surface water runoff greater than 15 pounds per acre per year.

Two other regions had a high percentage of cropped acres with excessive nitrogen loss rates:

- the Northeast (10) region, with 32 percent of cropped acres, and
- the East Central (11) region, with 37 percent.

Together, these two regions account for 18 percent of the cropped acres with excessive levels of total nitrogen loss with surface water runoff. The remaining four regions each accounted for less than 4 percent.

Figure 71. Percent of cultivated cropland acres with estimates of total nitrogen loss with surface water runoff greater than 15 pounds per acre per year, by region.



<sup>13</sup> In previous CEAP reports, acceptable levels for edge-of-field sediment loss, nitrogen loss, and phosphorus loss were used to estimate conservation treatment needs. Losses above these levels were treated as unacceptable levels

of loss based on what could be realistically achieved with today’s crop production and conservation technologies.

Table 18. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Northwest Non-Coastal (3) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	652,692	2,355,900	1,331,592	234,551	4,574,735
Moderate	69,625	114,166	100,132	0	283,923
Moderately high	509,219	1,780,303	588,010	58,876	2,936,408
High	486,925	2,205,705	954,771	34,545	3,681,946
All	1,718,462	6,456,073	2,974,505	327,972	11,477,012
Percent of cropped acres					
Low	6%	21%	12%	2%	40%
Moderate	1%	1%	1%	0%	2%
Moderately high	4%	16%	5%	1%	26%
High	4%	19%	8%	<1%	32%
All	15%	56%	26%	3%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	2.3	1.7	1.0	3.1	1.7
Moderate	2.3	1.2	1.1	NA	1.4
Moderately high	5.2	3.4	1.2	0.7	3.2
High	11.2	10.6	4.1	0.8	8.9
All	5.7	5.2	2.1	2.4	4.4
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	2%	3%	1%	0%	2%
Moderate	5%	1%	0%	0%	2%
Moderately high	6%	6%	0%	0%	5%
High	23%	23%	4%	0%	18%
All	9%	11%	2%	0%	8%

Table 19. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Northern Plains (5) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	1,038,736	10,392,772	10,103,932	2,232,860	23,768,299
Moderate	725,223	5,523,077	2,856,196	324,397	9,428,893
Moderately high	864,262	7,035,162	2,953,089	391,162	11,243,675
High	484,827	2,412,336	350,869	0	3,248,032
All	3,113,048	25,363,347	16,264,086	2,948,419	47,688,900
Percent of cropped acres					
Low	2%	22%	21%	5%	50%
Moderate	2%	12%	6%	1%	20%
Moderately high	2%	15%	6%	1%	24%
High	1%	5%	1%	0%	7%
All	7%	53%	34%	6%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	0.6	0.4	0.3	0.2	0.4
Moderate	1.1	0.9	0.9	0.4	0.9
Moderately high	1.6	1.0	0.6	0.5	0.9
High	2.1	2.2	1.1	NA	2.1
All	1.2	0.8	0.5	0.3	0.7
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	0%	0%	0%	0%	0%
Moderate	0%	0%	0%	0%	0%
Moderately high	0%	0%	0%	0%	0%
High	0%	0%	0%	0%	0%
All	0%	0%	0%	0%	0%

Table 20. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Southern Plains (6) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	3,334,853	26,144,169	16,365,380	1,650,063	47,494,465
Moderate	993,089	4,348,538	1,742,334	177,875	7,261,836
Moderately high	540,877	4,690,986	2,113,461	85,550	7,430,874
High	230,844	915,213	230,453	0	1,376,509
All	5,099,663	36,098,907	20,451,628	1,913,487	63,563,684
Percent of cropped acres					
Low	5%	41%	26%	3%	75%
Moderate	2%	7%	3%	<1%	11%
Moderately high	1%	7%	3%	<1%	12%
High	<1%	1%	<1%	0%	2%
All	8%	57%	32%	3%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	1.0	1.0	0.9	0.7	0.9
Moderate	3.3	3.0	1.8	1.2	2.7
Moderately high	6.0	4.4	3.4	0.6	4.2
High	14.3	2.9	2.4	NA	4.7
All	2.6	1.7	1.2	0.8	1.6
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	0%	<1%	0%	0%	0%
Moderate	0%	0%	0%	0%	0%
Moderately high	11%	5%	1%	0%	4%
High	30%	6%	0%	0%	9%
All	2%	1%	0%	0%	1%

Table 21. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, North Central and Midwest (7) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	2,656,087	23,274,423	27,378,071	2,941,482	56,250,063
Moderate	1,435,123	8,264,974	10,101,209	944,456	20,745,761
Moderately high	2,821,161	12,071,890	9,401,233	559,617	24,853,901
High	1,914,808	8,307,195	5,268,748	82,723	15,573,475
All	8,827,178	51,918,482	52,149,262	4,528,278	117,423,200
Percent of cropped acres					
Low	2%	20%	23%	3%	48%
Moderate	1%	7%	9%	1%	18%
Moderately high	2%	10%	8%	<1%	21%
High	2%	7%	4%	<1%	13%
All	8%	44%	44%	4%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	5.2	4.7	3.8	2.8	4.2
Moderate	8.1	7.5	5.7	3.8	6.5
Moderately high	19.1	11.6	7.4	7.5	10.7
High	31.5	19.7	10.8	1.7	18.0
All	15.8	9.2	5.5	3.6	7.8
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	7%	3%	1%	0%	2%
Moderate	8%	8%	<1%	0%	4%
Moderately high	56%	29%	8%	0%	23%
High	76%	56%	24%	0%	47%
All	38%	18%	4%	0%	13%

Table 22. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Lower Mississippi and Texas Gulf (9) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	798,954	3,630,166	2,609,934	263,625	7,302,679
Moderate	1,169,685	5,152,483	3,897,240	1,018,016	11,237,424
Moderately high	413,556	1,491,341	338,219	0	2,243,116
High	67,871	271,034	40,376	0	379,281
All	2,450,066	10,545,024	6,885,769	1,281,641	21,162,500
Percent of cropped acres					
Low	4%	17%	12%	1%	35%
Moderate	6%	24%	18%	5%	53%
Moderately high	2%	7%	2%	0%	11%
High	<1%	1%	<1%	0%	2%
All	12%	50%	33%	6%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	14.7	12.7	8.6	8.0	11.3
Moderate	9.2	11.2	11.2	8.5	10.7
Moderately high	30.0	24.6	18.2	NA	24.7
High	52.9	42.5	16.8	NA	41.6
All	15.7	14.4	10.6	8.4	13.0
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	50%	34%	11%	14%	27%
Moderate	16%	22%	22%	7%	20%
Moderately high	88%	78%	79%	0%	80%
High	100%	94%	42%	0%	90%
All	41%	36%	21%	8%	30%

Table 23. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Northeast (10) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	399,385	1,346,316	421,319	31,826	2,198,846
Moderate	169,670	411,458	202,214	23,852	807,195
Moderately high	453,820	1,080,783	174,675	5,896	1,715,173
High	410,414	1,336,744	79,128	0	1,826,286
All	1,433,289	4,175,301	877,336	61,574	6,547,500
Percent of cropped acres					
Low	6%	21%	6%	<1%	34%
Moderate	3%	6%	3%	<1%	12%
Moderately high	7%	17%	3%	<1%	26%
High	6%	20%	1%	0%	28%
All	22%	64%	13%	1%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	13.1	5.3	3.5	4.5	6.3
Moderate	12.8	9.3	8.7	4.4	9.7
Moderately high	21.0	13.3	5.1	4.3	14.5
High	40.7	21.3	7.1	NA	25.0
All	23.5	12.9	5.3	4.4	14.1
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	21%	4%	0%	0%	6%
Moderate	39%	11%	7%	0%	15%
Moderately high	54%	28%	0%	0%	32%
High	86%	66%	10%	0%	69%
All	52%	31%	3%	0%	32%

Table 24. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, East Central (11) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	169,071	1,548,083	1,269,946	95,759	3,082,859
Moderate	183,088	818,361	299,617	31,195	1,332,261
Moderately high	329,610	1,597,415	484,533	40,507	2,452,065
High	428,714	1,155,679	271,622	0	1,856,015
All	1,110,482	5,119,538	2,325,718	167,462	8,723,200
Percent of cropped acres					
Low	2%	18%	15%	1%	35%
Moderate	2%	9%	3%	<1%	15%
Moderately high	4%	18%	6%	<1%	28%
High	5%	13%	3%	0%	21%
All	13%	59%	27%	2%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	12.8	10.4	8.6	5.2	9.6
Moderate	14.6	9.9	7.6	6.9	10.0
Moderately high	27.8	19.1	11.9	3.3	18.6
High	48.4	27.9	14.6	NA	30.7
All	31.3	17.0	9.9	5.0	16.7
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	24%	22%	12%	0%	17%
Moderate	12%	20%	8%	0%	16%
Moderately high	88%	49%	26%	0%	49%
High	100%	65%	37%	0%	69%
All	70%	40%	17%	0%	37%

Table 25. Breakdown of cultivated cropland acres and estimates of total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Southeast Coastal Plain (12) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	2,010,990	6,176,757	2,243,048	76,423	10,507,218
Moderate	321,359	1,224,697	332,377	18,810	1,897,243
Moderately high	246,617	515,708	145,757	5,648	913,731
High	23,925	136,231	23,652	0	183,808
All	2,602,891	8,053,394	2,744,834	100,881	13,502,000
Percent of cropped acres					
Low	15%	46%	17%	1%	78%
Moderate	2%	9%	2%	<1%	14%
Moderately high	2%	4%	1%	<1%	7%
High	<1%	1%	<1%	0%	1%
All	19%	60%	20%	1%	100%
Estimates of total nitrogen loss with surface water runoff for the baseline scenario (average annual pounds/acre)					
Low	5.4	4.1	3.4	1.8	4.2
Moderate	7.5	9.1	7.7	6.7	8.5
Moderately high	25.3	12.5	12.1	2.3	15.8
High	10.4	8.0	5.1	NA	8.0
All	7.6	5.4	4.4	2.8	5.6
Percent of acres in baseline scenario with average annual total nitrogen loss with surface water runoff more than 15 pounds/acre					
Low	5%	4%	3%	0%	4%
Moderate	5%	17%	9%	0%	13%
Moderately high	87%	25%	18%	0%	40%
High	7%	19%	0%	0%	15%
All	13%	8%	5%	0%	8%

## Breakdown of Nitrogen Loss in Subsurface Flows by Levels of Conservation Treatment

The adequacy of conservation practice use in 2003-06 for control of nitrogen loss in subsurface flow pathways was evaluated in the same manner as was done in the previous section. A series of 4-by-4 matrixes, each with 16 cells, were constructed using four levels of soil vulnerability and four levels of conservation treatment. For this analysis, the four soil vulnerability levels are represented by the intrinsic vulnerability of the soil for water infiltration, and the four levels of conservation treatment are represented by the four nitrogen management levels previously presented in figure 25.

Criteria for four “soil leaching potentials,” which characterize the inherent vulnerability for water infiltration to occur, are presented in Appendix C. The criteria were used to define the soil leaching potential at each sample point. For all eight regions combined, about 8 percent of the cultivated cropland acres have a “high” soil leaching potential (fig. 72). Another 6 percent have a moderately high soil leaching potential. The bulk of the cropped acres—68 percent—has a “moderate” soil leaching potential. About 18 percent of cropped acres have a “low” soil leaching potential.

Table 26 provides estimates of acres and the average annual amount of nitrogen loss in subsurface flow pathways for each of the 16 cells, as well as estimates of the percentage of acres with unacceptably high losses.

The mean of the average annual amount of nitrogen loss in subsurface flow pathways was 15.2 pounds per acre per year for all cropped acres in all eight regions. As the soil leaching potential increased from “low” to “high,” the mean steadily increased. The mean of the average annual amount of nitrogen loss in subsurface flow pathways was (table 26)—

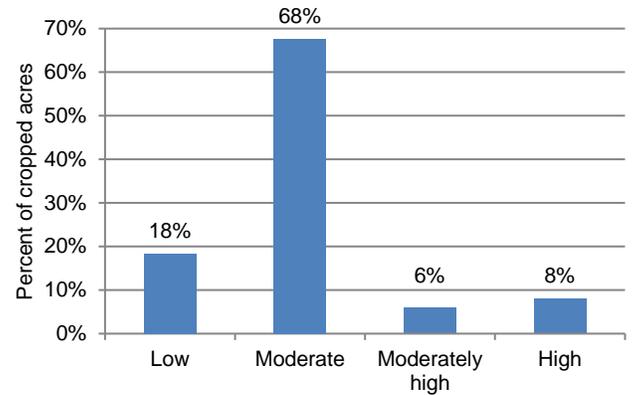
- 12.3 pounds per acre per year for cropped acres with a “low” soil leaching potential;
- 13.4 pounds per acre per year for cropped acres with a “moderate” soil leaching potential;
- 20.1 pounds per acre per year for cropped acres with a “moderately high” soil leaching potential; and
- 33.4 pounds per acre per year for cropped acres with a “high” soil leaching potential.

Similarly, the mean steadily decreased with increasing levels of nitrogen management. The mean of the average annual nitrogen loss in subsurface flow pathways was (table 26)—

- 29.0 pounds per acre per year for cropped acres with a “low” level of treatment;
- 22.7 pounds per acre per year for cropped acres with a “moderate” level of treatment;
- 8.5 pounds per acre per year for cropped acres with a “moderately high” level of treatment; and
- 5.9 pounds per acre per year for cropped acres with a “high” level of treatment.

Table 26 also shows that the mean steadily decreased with increasing levels of conservation treatment for groups of acres within each soil leaching potential.

Figure 72. Soil leaching potential for cultivated cropland acres, all eight regions combined.



Note: Criteria for defining the soil leaching potentials are presented in Appendix C.

The highest estimate of the average annual nitrogen loss in subsurface flow pathways shown in the table 26 matrix—56.9 pounds per acre per year—was for acres with a “low” level of nitrogen management and a “high” soil leaching potential.

At the “high” level of conservation treatment, estimates of the average annual nitrogen loss in subsurface flow pathways were relatively low at all soil leaching potentials, ranging from 5.3 to 10.7 pounds per acre per year. The increasing trend in nitrogen loss with increasing levels of soil leaching potentials breaks down for the “high” level of conservation treatment because at that level all the acres would be expected to be adequately treated. Estimates of the average annual nitrogen loss in subsurface flow pathways for the “moderately high” treatment level were larger, but also relatively low, ranging from 6.6 to 17.0 pounds per acre per year over the four soil leaching potentials.

Estimates of the average annual nitrogen loss in subsurface flow pathways were much more substantial at all soil leaching potentials for the “moderate” and the “low” conservation treatment levels, steadily increasing as the soil leaching potential increased.

Table 26 also presents the percentage of acres in each of the 16 cells of the 4-by-4 matrix that exceed 25 pounds per acre per year of nitrogen loss in subsurface flow pathways as a guide to determining the extent of cropped acres with excessive nitrogen loss. Estimates of nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year are generally considered to be unacceptable and require additional conservation treatment. About 16 percent of all cultivated cropland acres in the eight regions—totaling 45.6 million acres—have average annual estimates of nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year (table 26). About half of these acres (23.7 million acres) are concentrated in two groups of acres with “low” or “moderate” level of conservation treatment and a “moderate” soil leaching potential.

Table 26. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, all eight regions combined.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	5,158,955	19,683,491	16,440,631	11,808,963	53,092,040
Moderate	21,628,005	69,830,176	59,567,972	44,916,807	195,942,960
Moderately high	2,067,181	5,660,462	5,584,337	4,462,167	17,774,146
High	2,342,136	8,852,107	7,117,051	4,967,558	23,278,852
All	31,196,276	104,026,236	88,709,991	66,155,494	290,087,997
Percent of cropped acres					
Low	2%	7%	6%	4%	18%
Moderate	7%	24%	21%	15%	68%
Moderately high	1%	2%	2%	2%	6%
High	1%	3%	2%	2%	8%
All	11%	36%	31%	23%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	19.4	18.8	6.6	6.1	12.3
Moderate	27.0	19.2	7.7	5.3	13.4
Moderately high	42.7	30.9	12.2	5.9	20.1
High	56.9	53.1	17.0	10.7	33.4
All	29.0	22.7	8.5	5.9	15.2
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	23%	19%	3%	3%	11%
Moderate	33%	24%	4%	2%	14%
Moderately high	44%	45%	11%	2%	23%
High	71%	62%	15%	8%	37%
All	35%	27%	5%	3%	16%

Overall, 35 percent of cropped acres with a “low” level of nitrogen management had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year (table 26). About 27 percent of cropped acres with a “moderate” level of nitrogen management had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year. Only 5 percent of the cropped acres with a “moderately high” level of nitrogen management and 3 percent of cropped acres with a “high” level of nitrogen management had estimates of average nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year.

The four matrixes in table 26 are repeated in tables 27-34 for each of the regions. The decreasing trend in nitrogen loss with increasing levels of conservation treatment remained strong in all but one region (the Southeast Coastal Plain (12) region), when averaging over the four soil leaching potentials. The trend was sometimes weaker within each soil leaching potential because some soil leaching potentials were not well represented in the sample.

The increasing trend of nitrogen loss with increasing levels of soil leaching potentials was strong in four of the regions when averaging over the four conservation treatment levels: 1) the North Central and Midwest (7) region, 2) the Lower Mississippi and Texas Gulf (9) region, 3) the Northeast (10) region, and 4) the East Central (11) region. The trend was weaker but still evident in the other four regions.

About 43 percent of the 45.6 million acres with estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year are in the North Central and Midwest (7) region, where 17 percent of cropped acres (19.5 million acres) had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year.

Four other regions had a high percentage of cropped acres with excessive nitrogen loss rates (tables 31-34):

- the Southeast Coastal Plain (12) region, where 49 percent of cropped acres had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year;
- the Lower Mississippi and Texas Gulf (9) region, where 32 percent of cropped acres had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year;
- the Northeast (10) region, where 31 percent of cropped acres had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year; and
- the East Central (11) region, where 27 percent of cropped acres had estimates of average annual nitrogen loss in subsurface flow pathways greater than 25 pounds per acre per year.

Table 27. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Northwest Non-Coastal (3) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	3,278	77,292	79,468	101,116	261,154
Moderate	672,476	2,217,609	2,957,711	4,390,052	10,237,848
Moderately high	22,361	36,599	115,153	268,399	442,512
High	80,272	260,036	73,988	121,203	535,499
All	778,388	2,591,536	3,226,319	4,880,769	11,477,012
Percent of cropped acres					
Low	<1%	1%	1%	1%	2%
Moderate	6%	19%	26%	38%	89%
Moderately high	<1%	<1%	1%	2%	4%
High	1%	2%	1%	1%	5%
All	7%	23%	28%	43%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	22.1	36.1	6.5	4.1	17.0
Moderate	31.0	25.4	6.7	5.0	11.6
Moderately high	15.3	68.7	8.6	7.3	13.1
High	69.1	103.7	4.3	8.6	63.3
All	35.3	34.2	6.7	5.2	14.2
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	0%	45%	0%	0%	15%
Moderate	36%	31%	5%	2%	11%
Moderately high	24%	93%	6%	0%	11%
High	47%	91%	0%	9%	53%
All	37%	38%	5%	2%	13%

Table 28. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Northern Plains (5) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	454,260	2,146,217	2,499,505	2,389,831	7,489,813
Moderate	1,640,423	9,133,083	9,116,907	13,023,990	32,914,404
Moderately high	102,831	485,229	1,163,550	2,396,970	4,148,580
High	237,161	845,365	767,076	1,286,502	3,136,104
All	2,434,675	12,609,894	13,547,038	19,097,293	47,688,900
Percent of cropped acres					
Low	1%	5%	5%	5%	16%
Moderate	3%	19%	19%	27%	69%
Moderately high	<1%	1%	2%	5%	9%
High	<1%	2%	2%	3%	7%
All	5%	26%	28%	40%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	3.5	5.3	3.7	3.2	4.0
Moderate	7.5	6.1	3.0	2.3	3.8
Moderately high	10.9	3.6	2.9	2.1	2.7
High	8.7	16.8	7.9	4.3	8.9
All	7.0	6.6	3.4	2.5	4.1
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	0%	1%	1%	2%	1%
Moderate	5%	5%	<1%	0%	2%
Moderately high	14%	1%	0%	0%	0%
High	12%	16%	7%	0%	7%
All	5%	5%	1%	<1%	2%

Table 29. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Southern Plains (6) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	611,686	1,907,419	2,907,334	2,455,232	7,881,670
Moderate	2,458,831	15,969,495	14,815,738	15,067,820	48,311,884
Moderately high	192,397	761,343	335,117	461,849	1,750,707
High	330,100	1,853,418	1,948,878	1,487,028	5,619,424
All	3,593,014	20,491,675	20,007,067	19,471,929	63,563,684
Percent of cropped acres					
Low	1%	3%	5%	4%	12%
Moderate	4%	25%	23%	24%	76%
Moderately high	<1%	1%	1%	1%	3%
High	1%	3%	3%	2%	9%
All	6%	32%	31%	31%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	15.2	27.6	5.3	3.1	10.8
Moderate	18.1	11.1	7.3	5.1	8.4
Moderately high	12.7	14.3	13.3	9.9	12.8
High	58.4	28.0	9.1	7.4	17.8
All	21.0	14.3	7.3	5.1	9.7
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	33%	24%	1%	3%	10%
Moderate	13%	13%	7%	3%	8%
Moderately high	23%	24%	17%	6%	18%
High	75%	35%	6%	4%	19%
All	23%	16%	6%	3%	9%

Table 30. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, North Central and Midwest (7) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	3,163,900	8,296,599	8,348,394	2,803,244	22,612,136
Moderate	14,170,800	31,939,478	27,068,835	8,910,988	82,090,099
Moderately high	1,022,281	2,422,261	2,016,904	724,642	6,186,087
High	614,004	2,624,252	2,320,342	976,280	6,534,877
All	18,970,985	45,282,589	39,754,474	13,415,153	117,423,200
Percent of cropped acres					
Low	3%	7%	7%	2%	19%
Moderate	12%	27%	23%	8%	70%
Moderately high	1%	2%	2%	1%	5%
High	1%	2%	2%	1%	6%
All	16%	39%	34%	11%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	16.8	12.3	6.0	5.3	9.7
Moderate	26.3	20.2	8.4	6.7	15.9
Moderately high	40.7	32.3	13.5	9.0	24.8
High	50.4	50.5	22.2	15.0	35.2
All	26.3	21.1	8.9	7.1	16.2
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	15%	9%	1%	1%	6%
Moderate	33%	26%	2%	1%	16%
Moderately high	46%	51%	13%	<1%	32%
High	73%	71%	16%	7%	42%
All	32%	27%	3%	1%	17%

Table 31. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Lower Mississippi and Texas Gulf (9).

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	592,445	6,256,201	1,667,807	3,372,414	11,888,866
Moderate	708,877	4,896,553	1,404,446	1,731,867	8,741,743
Moderately high	0	17,120	0	8,203	25,324
High	6,117	257,276	107,553	135,621	506,568
All	1,307,439	11,427,149	3,179,806	5,248,106	21,162,500
Percent of cropped acres					
Low	3%	30%	8%	16%	56%
Moderate	3%	23%	7%	8%	41%
Moderately high	0%	<1%	0%	<1%	0%
High	<1%	1%	1%	1%	2%
All	6%	54%	15%	25%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	41.5	23.3	13.7	10.8	19.3
Moderate	51.0	43.4	18.4	13.8	34.1
Moderately high	NA	36.1	NA	37.2	36.5
High	8.3	51.4	20.0	24.3	37.0
All	46.5	32.6	16.0	12.1	25.9
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	57%	31%	15%	6%	23%
Moderate	77%	56%	27%	7%	43%
Moderately high	0%	100%	0%	100%	100%
High	0%	59%	25%	53%	49%
All	68%	42%	20%	7%	32%

Table 32. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Northeast (10) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	85,944	91,015	194,570	167,887	539,416
Moderate	509,334	1,025,092	887,516	483,855	2,905,797
Moderately high	384,865	669,311	859,771	206,463	2,120,410
High	209,154	426,721	258,308	87,694	981,877
All	1,189,297	2,212,139	2,200,164	945,900	6,547,500
Percent of cropped acres					
Low	1%	1%	3%	3%	8%
Moderate	8%	16%	14%	7%	44%
Moderately high	6%	10%	13%	3%	32%
High	3%	7%	4%	1%	15%
All	18%	34%	34%	14%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	49.9	54.4	10.5	6.8	23.0
Moderate	72.9	38.3	11.5	10.8	31.6
Moderately high	78.7	39.4	12.3	11.0	32.8
High	97.2	65.3	14.6	16.9	54.4
All	77.4	44.5	12.1	10.7	34.7
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	54%	66%	9%	0%	23%
Moderate	66%	43%	6%	<1%	29%
Moderately high	51%	49%	6%	0%	27%
High	95%	67%	10%	10%	53%
All	66%	50%	7%	1%	31%

Table 33. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, East Central (11) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	52,128	129,070	134,118	132,871	448,187
Moderate	916,155	2,946,327	2,088,609	592,310	6,543,401
Moderately high	147,057	395,004	474,130	236,843	1,253,034
High	62,922	258,226	120,122	37,308	478,578
All	1,178,262	3,728,628	2,816,978	999,332	8,723,200
Percent of cropped acres					
Low	1%	1%	2%	2%	5%
Moderate	11%	34%	24%	7%	75%
Moderately high	2%	5%	5%	3%	14%
High	1%	3%	1%	<1%	5%
All	14%	43%	32%	11%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	21.4	20.6	9.7	6.7	13.3
Moderate	37.5	31.5	11.4	9.6	23.9
Moderately high	32.3	46.8	15.7	9.6	26.3
High	33.7	55.0	14.8	13.2	38.9
All	35.9	34.3	12.2	9.3	24.5
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	26%	34%	0%	0%	13%
Moderate	47%	39%	6%	2%	26%
Moderately high	40%	50%	11%	1%	25%
High	28%	80%	2%	0%	47%
All	44%	43%	7%	1%	27%

Table 34. Breakdown of cultivated cropland acres and estimates of nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Southeast Coastal Plain (12) region.

Soil runoff potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Estimated cropped acres					
Low	195,315	779,679	609,435	386,368	1,970,798
Moderate	551,109	1,702,540	1,228,211	715,924	4,197,784
Moderately high	195,388	873,594	619,713	158,798	1,847,493
High	802,404	2,326,813	1,520,786	835,922	5,485,925
All	1,744,216	5,682,626	3,978,145	2,097,013	13,502,000
Percent of cropped acres					
Low	1%	6%	5%	3%	15%
Moderate	4%	13%	9%	5%	31%
Moderately high	1%	6%	5%	1%	14%
High	6%	17%	11%	6%	41%
All	13%	42%	29%	16%	100%
Estimates of nitrogen loss in subsurface flow pathways for the baseline scenario (average annual pounds/acre)					
Low	28.8	62.3	12.5	7.6	32.9
Moderate	46.7	37.3	15.4	19.7	29.1
Moderately high	40.2	41.5	22.8	19.7	33.2
High	65.9	81.2	24.6	18.8	53.8
All	52.8	59.4	19.6	17.1	40.2
Percent of acres in baseline scenario with average annual nitrogen loss in subsurface flow pathways more than 25 pounds/acre					
Low	50%	55%	11%	3%	31%
Moderate	70%	55%	18%	30%	42%
Moderately high	67%	63%	34%	19%	50%
High	84%	85%	31%	21%	60%
All	74%	68%	25%	21%	49%

## Effects of Conservation Practices— Preliminaries

### The No-Practice Scenario

The baseline results presented in previous sections include the benefits and effects of conservation practices in use in 2003-06. Program routines and parameter settings within the APEX model allow for simulation of the presence of structural erosion control practices, and tillage practices are represented by daily field operations simulated in the model. The presence or absence of nutrient management practices was based on information on the timing, rate, and method of application for manure and commercial fertilizer as reported by the producer in the NRI-CEAP Cropland Survey.

To estimate the effects of these practices already represented in the baseline scenario, an alternative simulation was created by removing the practices or reversing their effects, called the “no-practice” 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 scenario. For example, to simulate “no practices” for sample points where some type of residue management is used, model simulations were conducted as if continuous conventional tillage had been used instead. Similarly, for sample points with structural conservation practices (buffers, terraces, grassed waterways, etc.), the no-practice scenario was simulated as if the practices were not present.

The effects of conservation practices are obtained by taking the difference in model results between the two scenarios at each sample point, and then aggregating over the points for national and regional estimates. The reduction in nitrogen loss, for example, is the nitrogen loss estimate for the no-practice scenario minus the nitrogen loss estimate for the baseline scenario. This calculation is made using the average annual values at each sample point. National level results are then obtained by calculating the acres-weighted mean of the average annual reduction over all the sample points in the eight production regions. The percent reduction is calculated by dividing the difference by the no-practice scenario estimate.

The no-practice scenario also included specific features to remove or reverse the effects of other practices not targeted specifically at reducing nutrient loss, but which could have some effect on nutrient loss:<sup>14</sup>

- Cover crops, which could also affect soil erosion and nutrient loss, but were not in common use in 2003-06.
- Irrigation management, which could increase nutrient losses in the no-practice scenario where less efficient irrigation systems are simulated.

**No-practice representation of structural practices.** The no-practice field condition for structural practices is simply the

removal of the structural practices from the modeling process. In addition, the soil condition is changed from “good” to “poor” for the determination of the runoff curve number for erosion prediction.

For overland flow practices such as terraces and contouring, which slow the flow of water across the field, the P factor of the USLE-based equation was increased to 1. Slope length was also changed to reflect the absence of these slope-interrupting practices.

For concentrated flow practices such as grassed waterways and grade stabilization structures, which are designed to prevent areas of concentrated flow from developing gullies, or to stabilize gullies that have developed, the no-practice protocol removes the structure or waterway and replaces it with a “ditch” as a separate subarea. This ditch, or channel, represents a gully. Sediment contributions from the gully will come from downcutting. (Headcutting and sloughing of the sides are not simulated in APEX.)

For edge-of-field practices such as buffers and filters, which occur outside the primary production area, the no-practice protocol removes these areas from the model representation as well as their management. The slope length is also restored to the undisturbed length that it would have been had the practices not been in place. (When simulating a buffer in APEX, the slope length reported in the NRI is adjusted.)

Windbreaks or shelterbelts, cross wind ridges, stripcropping or trap strips, and hedgerows are examples of practices used for wind control. In the baseline scenario, the unsheltered distance was reduced to represent the presence of these wind control practices. The unsheltered distance reflects the dimensions of the field as modeled, 400 meters or 1,312 feet. Wind control practices represented in the baseline scenario were removed in the no-practice scenario and the unsheltered distance returned to 400 meters.

**No-practice representation of conservation tillage.** The no-practice tillage protocols are designed to remove the benefits of conservation tillage. For all crops grown with some kind of reduced tillage, the no-practice scenario simulates conventional tillage based on the STIR (Soil Tillage Intensity Rating) value. Conventional tillage for the purpose of estimating conservation benefits is defined as any crop grown with a STIR value above 100. Those crops grown with a STIR value of less than 100 in the baseline scenario had tillage operations added in the no-practice scenario. Two consecutive tandem disk operations were added prior to planting.<sup>15</sup> The tandem disk has a STIR value of 39 for a single use. Two consecutive disking operations will add 78 to the existing tillage intensity, which allows for more than 90 percent of the crops to exceed a STIR of 100 and yet maintain the unique suite and timing of operations for each crop in the rotation.

<sup>14</sup> For more information on the representation of the no-practice scenario in the APEX model simulation, see the collection of previously published regional CEAP reports based on the 2003-06 survey database.

<sup>15</sup> The most common type of tillage operation in the survey was disking, and the most common disk used was a tandem disk for nearly all crops, in all regions, and for both dryland and irrigated agriculture.

These additional two tillage operations were inserted in the simulation one week prior to planting, one of the least vulnerable times for tillage operations because it is close to the time when vegetation will begin to provide cover and protection. In addition to adding tillage, the hydrologic condition for assignment of the runoff curve number was changed from “good” to “poor” on all points receiving additional tillage. Points that are conventionally tilled for all crops in the baseline condition scenario are also modeled with a “poor” hydrologic condition curve number.

**No-practice representation of nutrient management practices.** The no-practice nutrient management protocols are designed to remove the benefits of proper nutrient management techniques. Three of the four basic aspects of nutrient application—rate, timing, and method—were altered to represent nutrient applications that would be expected if there was no regard to the levels of nutrient losses from farm fields. The form of application was not addressed because of the inability based on survey responses to determine if proper form was being applied.

**Commercial nitrogen fertilizer rate and manure applications.** For the no-practice scenario, the amount of nitrogen applied was increased for crops that met the following criteria, indicating that appropriate application rates were in use as represented in the modeling of the baseline scenario.

- The total of all applications of nitrogen (commercial fertilizer and manure applications) was less than or equal to 1.4 times the amount of nitrogen removed at harvest in the baseline scenario for non-legume crops except cotton and small grain crops.
- The total of all applications of nitrogen (commercial fertilizer and manure applications) was less than or equal to 1.6 times the amount of nitrogen removed at harvest in the baseline scenario for small grain crops.
- The total of all applications of nitrogen (commercial fertilizer and manure applications) for cotton was less than or equal to 60 pounds per bale.

The assessment was made on an average annual basis for each crop in the rotation using average annual model output on nitrogen removed with the yield at harvest in the model results for the baseline scenario. For sites receiving manure, the appropriate manure application rate in tons per acre was identified on the basis of the total nitrogen application rate, including both manure and commercial nitrogen fertilizer.

For cotton, the amount of nitrogen applied in the no-practice scenario was increased to 90 pounds per acre for cotton crops that met the above criterion.

For other crops that met the above criteria, the amount of nitrogen applied in the no-practice scenario was increased sufficiently to raise the ratio of the application rate to harvest

removal to a higher value. For small grain crops, the application rate was increased to bring the application rate up to 2.0 times the amount of nitrogen removed at harvest. For other non-legume crops, the application rate was increased to bring the application rate up to a level that depended on the Water Resource Region where the sample point was located in order to account for yield potential differences from region to region. These application rate levels ranged from a low of 1.64 times the amount of nitrogen removed at harvest in the Upper Mississippi River Basin to a high of 2.0 times the amount of nitrogen removed at harvest in the Pacific Northwest Water Resource Region (table 35). (These rate-to-yield-removal ratios were determined by the average rate-to-yield-removal ratio for crops exceeding the application-removal ratio of 1.4 in each Water Resource Region.)

All nitrogen applications, including manure applications, were increased proportionately so that the total application rate equaled the no-practice rate of application described above.

Nitrogen application rates were not adjusted for legume crops in the no-practice scenario, remaining the same as in the baseline scenario.

**Commercial phosphorus fertilizer rate.** Phosphorus application rates in the no-practice scenario were adjusted to higher levels based on the total amount of phosphorus applied to all of the crops in the crop rotation, rather on a crop-by-crop basis as was done for nitrogen.

The threshold for identifying proper commercial phosphorus application rates as represented in the modeling of the baseline scenario was 1.1 times the amount of phosphorus taken up by all the crops in rotation and removed at harvest. Phosphorus application rates for sample points with phosphorus applications at or below this threshold were increased for the no-practice scenario.<sup>16</sup> Any increase in phosphorus from manure added to meet the nitrogen criteria for the no-practice scenario was taken into account in setting the no-practice commercial phosphorus fertilizer application rate.

For the no-practice scenario, the amount of commercial phosphorus fertilizer applied was increased sufficiently to raise the ratio of the application rate to harvest removal for the full crop rotation to a higher value. As was done for nitrogen, the higher level depended on the Water Resource Region where the sample point was located in order to account for yield potential differences from region to region. These commercial phosphorus application rates ranged from a low of 1.57 times the amount of phosphorus removed at harvest in the Missouri River Basin to a high of 2.7 times the amount of phosphorus removed at harvest in the South Atlantic Gulf Water Resource Region (table 35). (These rate-to-yield-removal ratios were determined by the average rate-to-yield-removal ratio for sample points where the amount of phosphorus applied to all crops in the rotation exceeded 1.1

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<sup>16</sup> The threshold is lower for phosphorus than for nitrogen because phosphorus is not lost through volatilization to the atmosphere and much less is lost

through other pathways owing to strong bonding of phosphorus to soil particles.

times the amount of phosphorus taken up by all the crops in rotation and removed at harvest in each Water Resource Region.)

Commercial phosphorus application rates were increased proportionately for all crops in the rotation. No adjustment was made to manure applied at rates below the P threshold of 1.1 in the no-practice scenario because the manure application rate was based on the nitrogen level in the manure.

**Timing of application.** Nutrients applied closest to the time when a plant needs them are the most efficiently utilized and least likely to be lost to the surrounding environment.

All commercial fertilizer applications occurring within 3 weeks prior to planting, at planting, or within 60 days after planting were moved back to 3 weeks prior to planting for the no-practice scenario. For example, split applications that occur within 60 days after planting are moved to a single application 3 weeks before planting for the no-practice scenario.

Timing of manure applications was not adjusted in the no-practice scenario.

**Method of application.** Commercial fertilizer applications and manure applications that were incorporated or banded in the baseline scenario were changed to a surface broadcast application method for the no-practice scenario.

Table 35. Levels to which nutrient application rates were increased to represent the no-practice scenario in model simulations.

Water Resource Regions	Increase in nitrogen application rates for each non-legume crop other than small grain crops and cotton.	Increase in commercial phosphorus application rates for all crops in the rotation
Upper Mississippi River Basin	to 1.64 times amount removed at harvest by crop	to 1.60 times amount removed at harvest from all crops in rotation
Ohio and Tennessee River Basins and Great Lakes Basin	to 1.70 times amount removed at harvest by crop	to 1.80 times amount removed at harvest from all crops in rotation
Souris-Red-Rainy River Basins	to 1.83 times amount removed at harvest by crop	to 1.71 times amount removed at harvest from all crops in rotation
Chesapeake Bay and Delaware River Basins	to 1.98 times amount removed at harvest by crop	to 2.20 times amount removed at harvest from all crops in rotation
South Atlantic Gulf Region	to 1.85 times amount removed at harvest by crop	to 2.70 times amount removed at harvest from all crops in rotation
Lower Mississippi River Basin	to 1.90 times amount removed at harvest by crop	to 2.30 times amount removed at harvest from all crops in rotation
Pacific Northwest Region	to 2.00 times amount removed at harvest by crop	to 2.05 times amount removed at harvest from all crops in rotation
Missouri River Basin	to 1.68 times amount removed at harvest by crop	to 1.57 times amount removed at harvest from all crops in rotation
Texas Gulf Region and Arkansas-White-Red River Basins	to 1.90 times amount removed at harvest by crop	to 2.00 times amount removed at harvest from all crops in rotation

## Effects of Conservation Practices on Water Loss

Water loss from farm fields is a principle determinant of sediment and nutrient losses. The effect of conservation practices on water loss is summarized in this section to provide a perspective on the results presented for nitrogen loss in the next chapter.

Model simulations indicate that conservation practices have reduced surface water runoff by an average of about 0.64 inch per year averaged over all acres, representing a 14-percent reduction nationally (table 36). The distributions of the average annual estimates of surface water runoff in the baseline scenario and the no-practice scenario are contrasted in figure 73. The distribution for the no-practice scenario shows what surface water runoff would be if there were no conservation practices in use—more surface water runoff and thus less subsurface flow and thus less soil moisture available for crop growth.

The average annual reductions in surface water runoff due to conservation practices range among the sample points from less than zero to above 5 or more inches per year (fig. 74). The variability in reductions due to practices reflects different levels of conservation treatment as well as differences in precipitation and inherent differences among acres for water to run off or infiltrate. Figure 74 shows that, for about 45 percent of the cultivated cropland acres in the eight regions, the effects of conservation practices on surface water runoff were very small—average annual reductions less than 0.2 inch per year. In contrast, the effects of practices were high for the top 15 percent, where surface water runoff was reduced by 1 inch or more per year due to the use of conservation practices.

About 10 percent of the acres had less surface water runoff in the no-practice scenario than in the baseline scenario resulting in the negative reductions shown in figure 74. In general, these gains in surface water runoff due to practices are small, and occur on soils with low to moderate potential for surface water runoff together with: (1) higher nutrient application rates in the no-practice scenario that result in more biomass production, which can reduce surface water runoff (typically rotations with hay or continuous corn); or (2) the additional tillage simulated in the no-practice scenario provided increased random roughness of the surface reducing runoff on nearly level landscapes with low crop residue rotations.

Most of the reductions in surface water runoff are re-routed to subsurface flow loss pathways, resulting in gains in subsurface flows for many acres due to the use of conservation practices. Model simulations indicate that conservation practices have increased the volume of water lost through subsurface flow pathways by an average annual amount of 0.5 inch per year, representing a 9-percent increase nationally (table 36). The re-routing of surface water to subsurface flows is shown graphically in figures 75 and 76. The baseline scenario curve in figure 75 shows higher subsurface flows than the no-practice curve. Figure 76 shows that the gain in subsurface flows due to conservation practices ranges among the sample points from an average of less than zero to 5 or more inches per year.

Figure 73. Distributions of average annual surface water runoff for the baseline and no-practice scenarios, all eight regions combined.

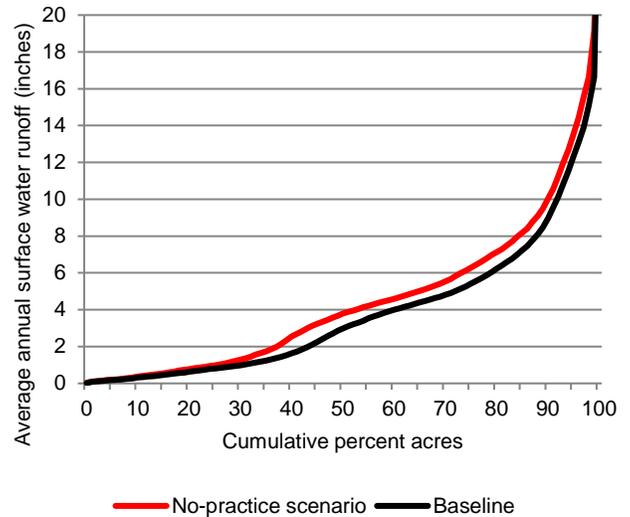
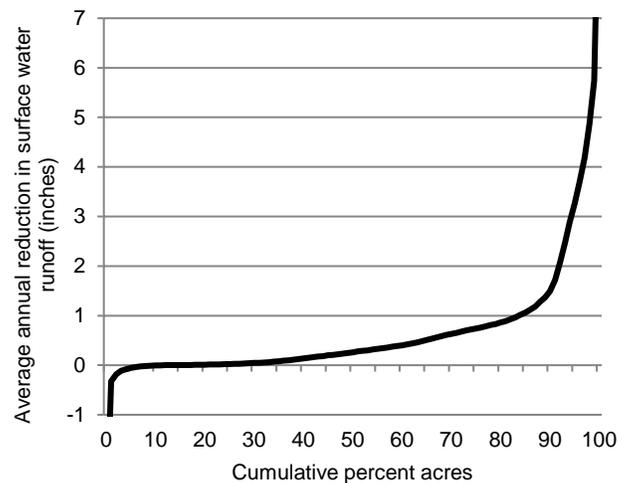


Figure 74. Distribution of average annual reductions in surface water runoff due to the use of conservation practices, all eight regions combined.



For about 30 percent of the cultivated cropland acres the effects of conservation practices on subsurface water flows were near zero. Conservation practice use resulted in gains ranging from 0.1 to 1.0 inch per year for about 45 percent of cultivated cropland acres. Gains were greater than 1 inch per year for only about 15 percent (fig. 76).

Model simulations showed that reductions in subsurface water flows (shown as negative gains in figure 76) occur on up to about 10 percent of cultivated cropland acres. These were mostly irrigated acres in areas where weather during the growing season was often hot and dry. In some of these situations, a significant portion of the surface water runoff that is re-routed through infiltration into the soil is taken up by the crop and thus does not contribute to any of the subsurface flow loss pathways. In addition, any ponding of irrigation water applied on nearly level landscapes would also be susceptible to greater rates of evaporation, further reducing the volume of water available for loss through subsurface flow pathways.

Table 36. Effects of conservation practices on water loss from farm fields.

	Baseline scenario	No-practice scenario	Reduction due to practices	Percent reduction
<b>Northwest Non-Coastal (3) region</b>				
Average annual surface water runoff (inches)	1.71	2.56	0.86	33%
Average annual subsurface water flow (inches)	2.94	2.89	-0.06*	-2%
<b>Northern Plains (5) region</b>				
Average annual surface water runoff (inches)	0.66	0.77	0.11	14%
Average annual subsurface water flow (inches)	1.19	1.03	-0.15*	-15%
<b>Southern Plains (6) region</b>				
Average annual surface water runoff (inches)	1.38	2.33	0.94	41%
Average annual subsurface water flow (inches)	2.19	2.12	-0.08*	-4%
<b>North Central and Midwest (7) region</b>				
Average annual surface water runoff (inches)	4.32	4.78	0.46	10%
Average annual subsurface water flow (inches)	6.42	5.74	-0.68*	-12%
<b>Lower Mississippi and Texas Gulf Coast (9) region</b>				
Average annual surface water runoff (inches)	13.07	14.63	1.56	11%
Average annual subsurface water flow (inches)	9.95	8.84	-1.11*	-13%
<b>Northeast (10) region</b>				
Average annual surface water runoff (inches)	6.11	6.59	0.48	7%
Average annual subsurface water flow (inches)	9.42	8.83	-0.60*	-7%
<b>East Central (11) region</b>				
Average annual surface water runoff (inches)	8.22	8.99	0.77	9%
Average annual subsurface water flow (inches)	10.82	10.00	-0.82*	-8%
<b>Southeast Coastal Plain (12) region</b>				
Average annual surface water runoff (inches)	6.02	6.98	0.95	14%
Average annual subsurface water flow (inches)	16.28	15.85	-0.44*	-3%
<b>All eight regions combined</b>				
Average annual surface water runoff (inches)	3.85	4.49	0.64	14%
Average annual subsurface water flow (inches)	5.41	4.96	-0.46*	-9%

\* Represents gains in water lost in subsurface flow pathways because of re-routing of surface water runoff due to conservation practice use.

Figure 75. Distributions of average annual subsurface water flow for the baseline and no-practice scenarios, all eight regions combined.

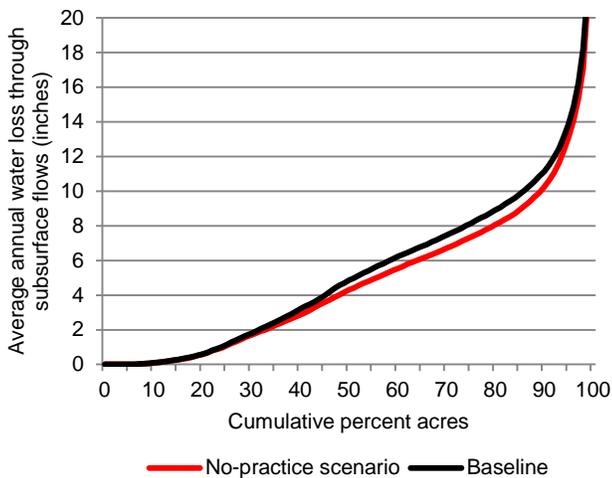
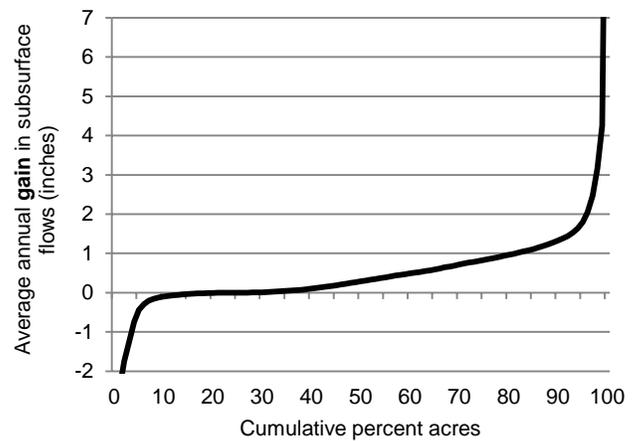


Figure 76. Distribution of average annual gain in subsurface water flows due to the use of conservation practices, all eight regions combined.



The effects of conservation practices on water loss from farm fields vary substantially across the eight production regions (table 36, figs. 77-80).

Conservation practices have been the most effective in reducing surface water runoff in the Lower Mississippi and Texas Gulf Coast (9) region. The mean of the average annual reductions in surface water runoff due to conservation practices was 1.56 inches per year, representing an 11 percent reduction relative to the no-practice scenario (table 36 and fig. 77). This region also had the largest amount of surface water runoff in the baseline scenario. Figure 79 shows that about 60 percent of cropped acres in the Lower Mississippi and Texas Gulf Coast (9) region had average annual reductions in surface water runoff of 1 inch or more due to the use of conservation practices.

Reductions in surface water runoff were also significant in three other regions (table 36, fig. 77, and fig. 79):

- the Southeast Coastal Plain (12) region, where conservation practice use reduced surface water runoff by an average of 0.95 inches per year, representing a 14-percent reduction,
- the Southern Plains (6) region, where conservation practice use reduced surface water runoff by an average of 0.94 inches per year, representing a 41-percent reduction, and
- the Northwest Non-Coastal (3) region, where conservation practice use reduced surface water runoff by an average of 0.86 inches per year, representing a 33-percent reduction.

A significant portion of the reductions in surface water runoff for the Southern Plains (5) region, the Northwest Non-Coastal (3) region, and the Lower Mississippi and Texas Gulf Coast (9) region results from improvements in irrigation efficiency in those regions—the three regions with the highest proportions of irrigated acres (i.e., lower efficiency irrigation systems simulated in the no-practice scenario).

Conservation practices have been the least effective in reducing surface water runoff in the Northern Plains (5) region, where conservation practice use reduced surface water runoff only by an average of 0.11 inch per year. This region also had the smallest amount of surface water runoff in the baseline scenario. Figure 79 shows that, for this region, 95 percent of the cultivated cropland acres had reductions in surface water runoff less than 0.25 inch per year due to conservation practice use.

Conservation practices generally have been less effective on water lost through subsurface loss pathways (table 36, fig. 78, and fig. 70). On average, all eight regions had gains in subsurface flows from the re-routing of surface water runoff by conservation practice use, although some gains were very small.

The region with the largest gains in subsurface flows was the Lower Mississippi and Texas Gulf Coast (9) region, which also had the largest average reductions in surface water runoff and the most volume of water in subsurface flows in the baseline scenario. The mean of the average annual gains in subsurface water flows due to conservation practice use was 1.11 inches per year, representing a 13-percent reduction relative to the no-practice scenario (table 36 and fig. 68).

Three regions were the least effective in attaining gains in subsurface water flows due to conservation practice use (table 36, fig. 68, and fig. 70):

- the Northwest Non-Coastal (3) region, where conservation practice use increased subsurface water flows by an average of only 0.06 inch per year, representing a 2-percent increase relative to the no-practice scenario,
- the Southern Plains (6) region, where conservation practice use increased subsurface water flows by an average of only 0.08 inch per year, representing a 4-percent increase, and
- the Northern Plains (5) region, where conservation practice use increased subsurface water flows by an average of only 0.15 inch per year, representing a 15-percent increase—the highest percent increase among all the regions only because both the baseline and no-practice scenario values were so small.

Figure 77. Mean of the average annual reduction in surface water runoff due to the use of conservation practices, by region.

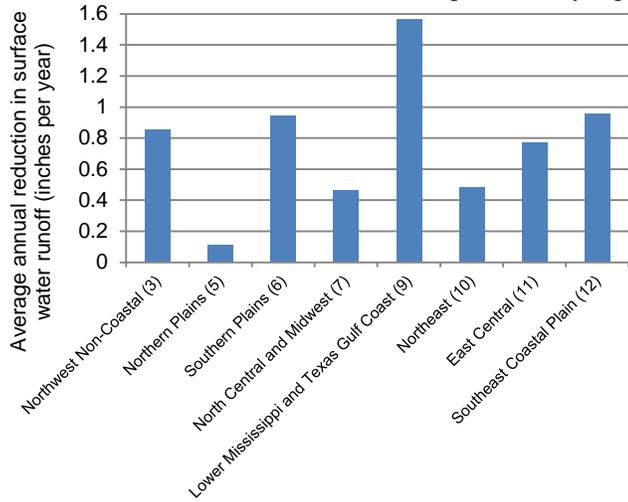


Figure 78. Mean of the average annual gains in subsurface water flows due to the use of conservation practices, by region.

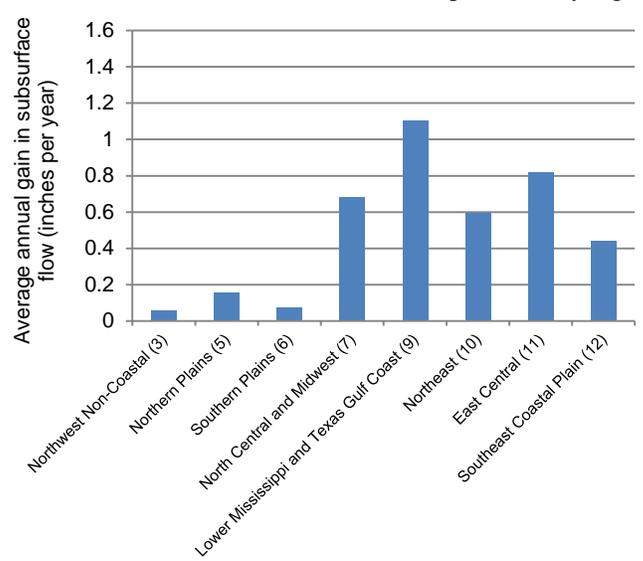


Figure 79. Distributions of average annual reductions in surface water runoff due to the use of conservation practices, representing CEAP sample points in eight production regions.

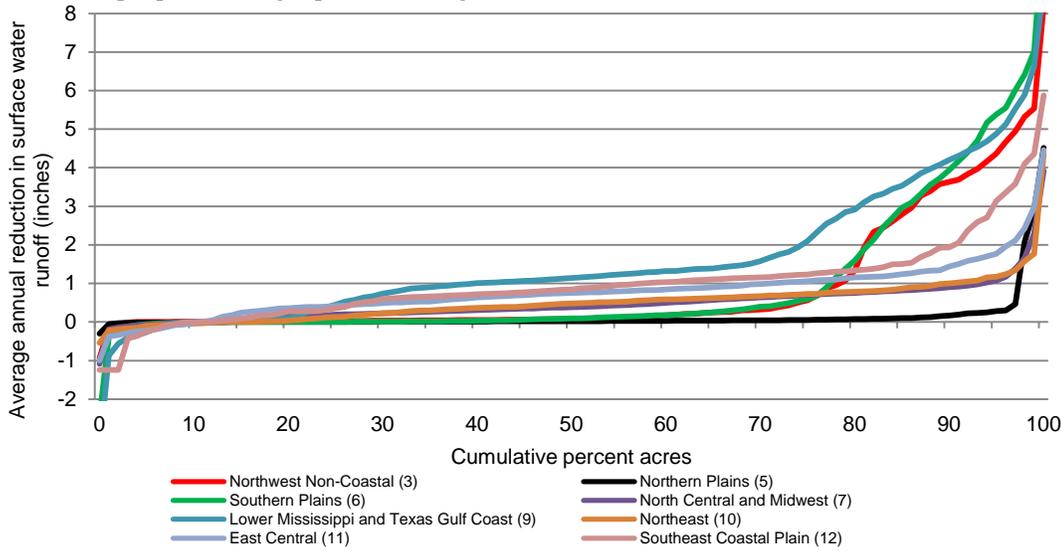
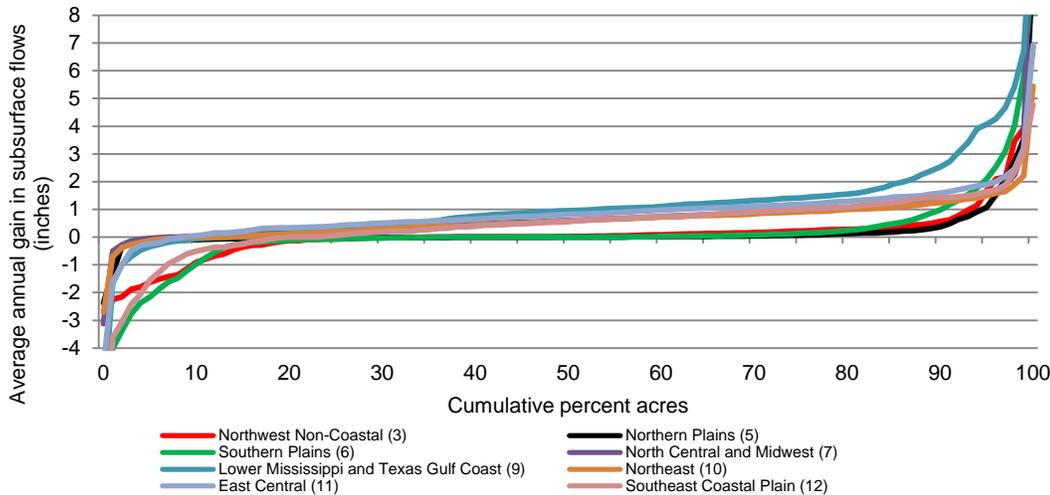


Figure 80. Distributions of average annual gains in subsurface flows due to the use of conservation practices, representing CEAP sample points in eight production regions.



## Effects of Conservation Practices on Sediment Loss from Water Erosion

Sediment loss from farm fields is a principle determinant of nutrient losses. The effect of conservation practices on sediment loss is summarized in this section to provide a perspective on the results presented for nitrogen loss in the next chapter.

Model simulations indicate that the use of conservation practices has reduced average annual sediment loss from water erosion by 54 percent for cultivated cropland acres in all eight regions, including both treated and untreated acres (table 37). Without conservation practices, the average annual sediment loss for these acres would have been 1.74 tons per acre per year compared to 0.79 ton per acre average for the baseline scenario. The reduction in sediment loss due to the use of conservation practices averaged about 0.95 ton per acre per year.

Reductions in edge-of-field sediment loss due to conservation practices are much higher for HEL acres than for non-HEL acres, although the percent reduction is about the same (table 37). For HEL acres, the average annual reduction was 1.79 tons per acre per year, representing a 56-percent reduction. For non-HEL acres, the average annual reduction was 0.61 ton per acre per year, representing a 53-percent reduction.

The distributions of the average annual estimates of sediment loss in the baseline scenario and the no-practice scenario are contrasted in figure 81. Figure 81 shows that about 25 percent of the acres would have more than 2 tons per acre per year sediment loss without practices, on average, compared to 10 percent with conservation practices.

Reductions in sediment loss due to conservation practices are much higher for some acres than others, reflecting both the level of treatment and the inherent erodibility of the soil. For about half of the cultivated cropland acres in the eight regions, the average annual sediment loss reduction due to practices was less than 0.2 ton per acre per year (fig. 82). In contrast, about 25 percent had average annual reductions in sediment loss greater than 1 ton per acre per year and the top 10 percent had reductions greater than 2.7 tons per acre per year.

For 2 percent of the cultivated cropland acres, sediment loss estimates were higher in the baseline scenario than in the no-practice scenario, resulting in negative reductions due to use of conservation practices (fig. 82). These negative reductions in sediment loss are the result of tradeoffs in benefits of conservation practices previously discussed with respect to figure 74, where a small number of acres had negative reductions in surface water runoff due to use of conservation practices.

Figure 81. Distributions of average annual edge-of-field sediment loss from water erosion for the baseline and no-practice scenarios, all eight regions combined.

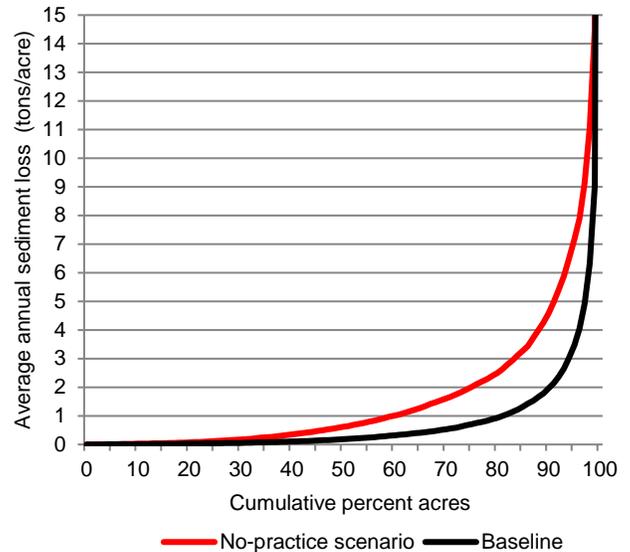


Figure 82. Distribution of average annual reduction in edge-of-field sediment loss from water erosion due to the use of conservation practices, all eight regions combined.

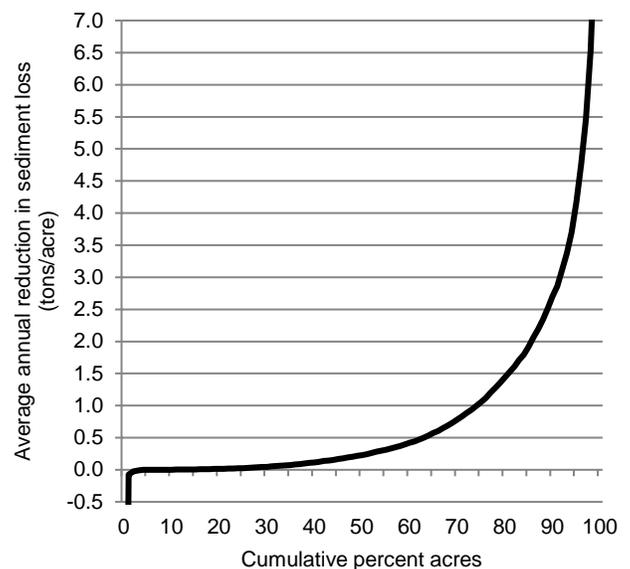


Table 37. Effects of conservation practices on sediment loss from water erosion.

	Baseline scenario (tons/acre)	No-practice scenario (tons/acre)	Reduction due to practices (tons/acre)	Percent reduction
<b>All cultivated cropland acres</b>				
Production region				
Northwest Non-Coastal (3)	0.901	1.740	0.839	48%
Northern Plains (5)	0.063	0.135	0.072	53%
Southern Plains (6)	0.260	0.917	0.657	72%
North Central and Midwest (7)	0.797	2.044	1.248	61%
Lower Mississippi and Texas Gulf Coast (9)	2.663	3.797	1.135	30%
Northeast (10)	2.360	4.095	1.735	42%
East Central (11)	2.523	5.355	2.832	53%
Southeast Coastal Plain (12)	0.960	1.983	1.024	52%
All eight regions	0.793	1.742	0.949	54%
<b>HEL acres</b>				
Production region				
Northwest Non-Coastal (3)	1.385	2.496	1.111	45%
Northern Plains (5)	0.089	0.191	0.103	54%
Southern Plains (6)	0.274	1.098	0.824	75%
North Central and Midwest (7)	1.921	4.923	3.002	61%
Lower Mississippi and Texas Gulf Coast (9)	6.500	10.933	4.433	41%
Northeast (10)	3.505	6.280	2.775	44%
East Central (11)	3.675	7.828	4.153	53%
Southeast Coastal Plain (12)	3.503	6.516	3.013	46%
All eight regions	1.399	3.191	1.792	56%
<b>Non-HEL acres</b>				
Production region				
Northwest Non-Coastal (3)	0.354	0.886	0.532	60%
Northern Plains (5)	0.048	0.103	0.055	53%
Southern Plains (6)	0.253	0.823	0.570	69%
North Central and Midwest (7)	0.467	1.200	0.733	61%
Lower Mississippi and Texas Gulf Coast (9)	2.115	2.779	0.664	24%
Northeast (10)	1.147	1.782	0.635	36%
East Central (11)	1.320	2.771	1.451	52%
Southeast Coastal Plain (12)	0.659	1.448	0.789	54%
All eight regions	0.547	1.152	0.606	53%

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

Conservation practices were most effective in reducing sediment loss from water erosion in the East Central (11) region (table 37 and fig. 83). In this region, the mean of the average annual reductions in sediment loss was 2.83 tons per acre per year. Conservation practices reduced average sediment loss from 5.36 tons per acre per year in the no-practice scenario to an average of 2.52 tons per acre per year in the baseline scenario—a 53-percent reduction. The average annual reduction in sediment loss averaged 4.15 tons per acre per year for HEL acres in this region and 1.45 tons per acre for non-HEL acres, representing a 53-percent and a 52-percent reduction, respectively (table 37, figs. 84 and 85).

The region with the smallest reductions in sediment loss due to conservation practice use was the Northern Plains (5) region, where the mean of the average annual reductions in sediment loss was only 0.07 ton per acre per year, which nevertheless represented a 53-percent reduction because of the very low sediment loss in both the baseline and the no-practice scenarios.

The remaining regions had mean average annual reductions in sediment loss ranging from 0.66 ton per acre per year for the Southern Plains (6) region to 1.74 tons per acre per year in the Northeast (10) region (table 37 and fig. 83).

In terms of the percent reduction, the Southern Plains (6) region and North Central and Midwest (7) region had the largest—72 percent and 61 percent reduction, respectively, in sediment loss rates for all cultivated cropland acres due to conservation practices. Percent reduction for the Southern Plains (6) region was slightly higher for HEL acres and slightly lower for non-HEL acres. Percent reductions for HEL acres and non-HEL acres in the North Central and Midwest (7) region were the same as for all cropped acres.

The Lower Mississippi and Texas Gulf Coast (9) region had the smallest percent reduction in sediment loss rates due to conservation practices—24 percent for non-HEL acres and 41 percent for HEL acres (table 37).

Figure 86 contrasts the distributions of the average annual reductions for all eight regions. Again, the East Central (11) region stands out as having the most benefit from use of conservation practices. About 62 percent of the cropped acres in this region had reductions in edge-of-field sediment loss of 1 or more ton per acre per year due to conservation practice use. About 45 percent of the cropped acres had reductions of 2 or more tons per acre per year and 22 percent of the cropped acres had reductions of 4 or more tons per acre per year.

In contrast, the Northern Plains (5) region stands out as having the least benefit from the use of conservation practices for control of sediment loss from water erosion, primarily because of the generally low potential for surface water runoff in the region (fig. 31). In this region, 95 percent of the cropped acres had reductions of less than 0.2 tons per acre per year due to the use of conservation practices (fig. 86).

Figure 83. Mean of the average annual reduction in edge-of-field sediment loss from water erosion due to conservation practices for all cultivated cropland acres, by region.

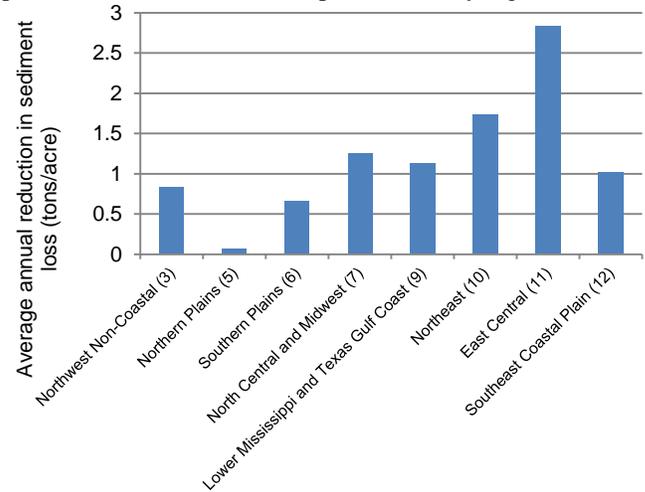


Figure 84. Mean of the average annual reduction in edge-of-field sediment loss from water erosion due to conservation practices for HEL acres, by region.

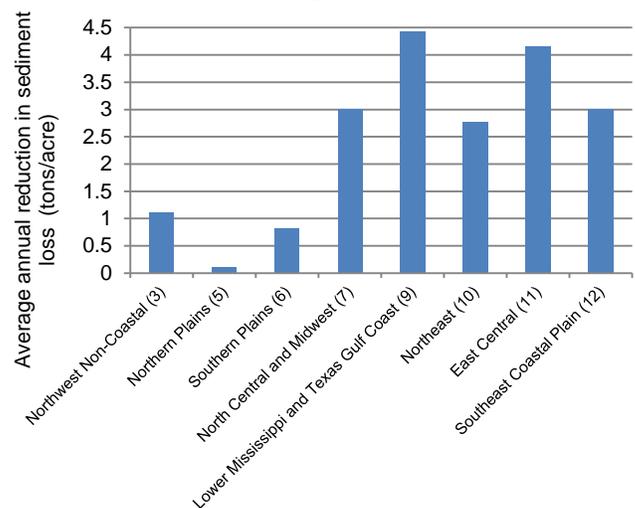
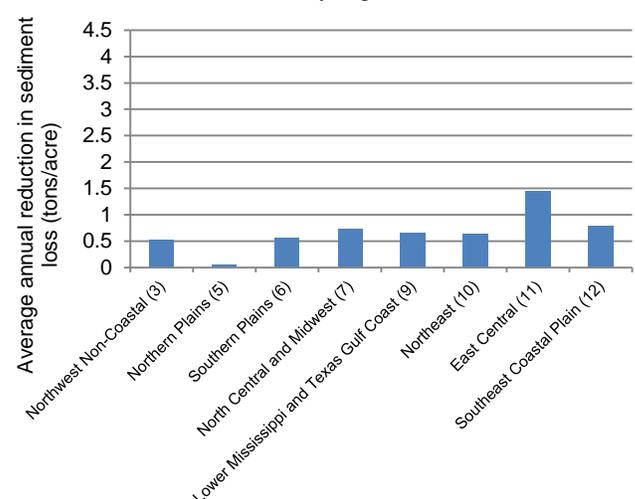


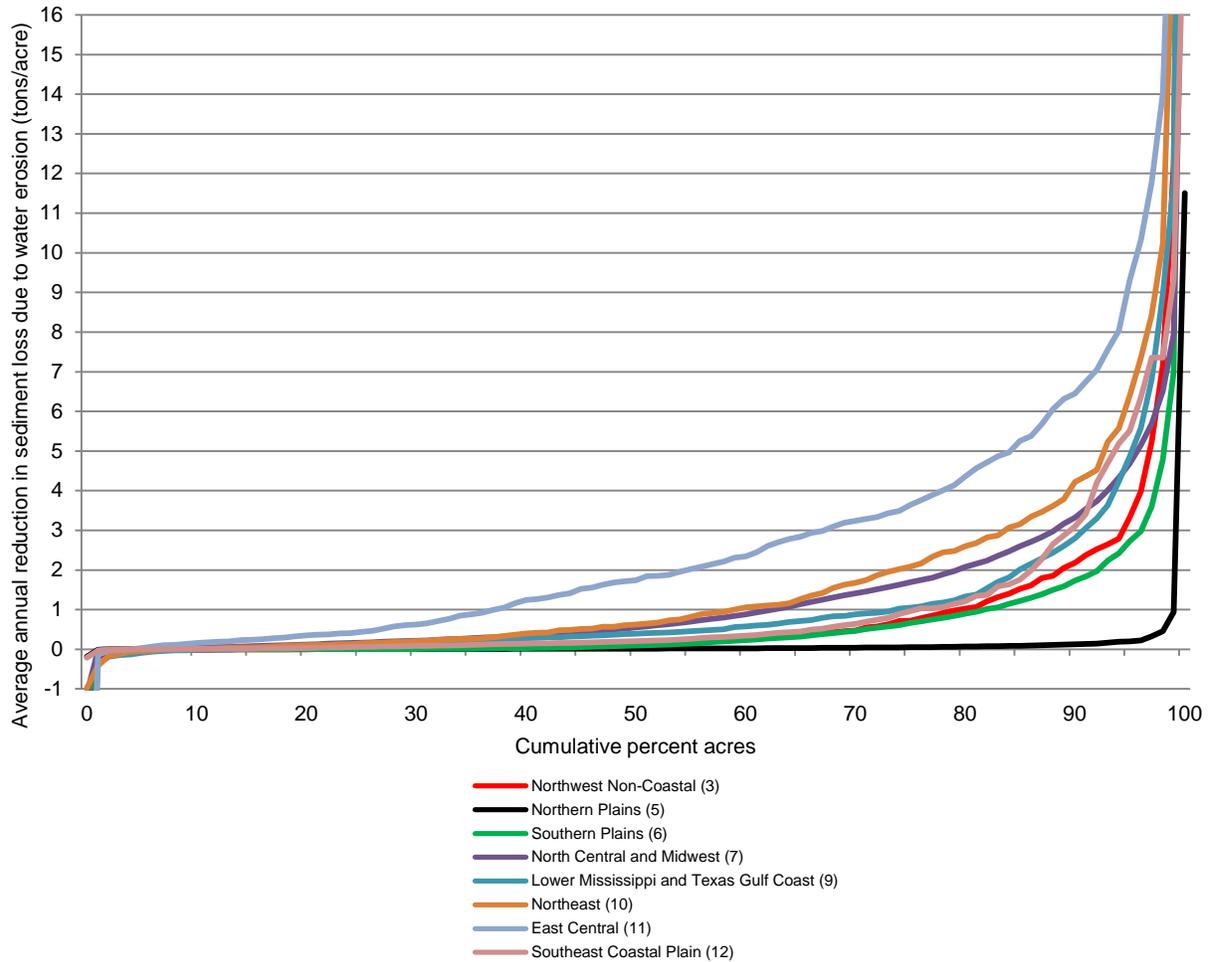
Figure 85. Mean of the average annual reduction in edge-of-field sediment loss from water erosion due to conservation practices for non-HEL acres, by region.



The remaining six regions had little or no benefit from the use of conservation practices for over half of the acres but had significant benefits for some acres (fig. 86). Reductions in sediment loss for acres with the highest reductions—those

acres that were treated the most for erosion control—ranged to above 5 tons per acre per year for at least some acres in all 6 regions.

Figure 86. Distributions of average annual reductions in sediment loss from water erosion due to the use of conservation practices, representing CEAP sample points in eight production regions.



## Effects of Conservation Practices on Wind Erosion

Windborne nitrogen loss from farm fields is a principal loss pathway for nitrogen in some regions, as shown previously. The effect of conservation practices on reducing wind erosion is summarized in this section to provide a perspective on the results presented for nitrogen loss in the next chapter.

Farmers address wind erosion using conservation practices designed to enhance the soil's ability to resist and reduce the wind velocity near the soil surface. Physical barriers such as windbreaks or shelterbelts, herbaceous wind barriers or windbreaks, cross wind trap strips, or ridges constructed perpendicular to the prevailing wind direction reduce the intensity of wind energy at the surface. As shown in table 4, these structural practices for wind erosion control are in use on only 6 percent of the cropped acres in the eight regions. However, other practices in common use in all regions, such as residue and tillage management, reduced tillage, and various water erosion control practices, are also effective in reducing wind erosion. Properly planned and applied residue management reduces wind erosion by leaving more organic material on the soil surface, which in turn helps preserve soil aggregate stability and promotes further aggregation. Row direction or arrangement, surface roughening, and stripcropping also lessen the wind's energy.

Model simulations indicate that conservation practices have reduced the average wind erosion rate by 37 percent for cultivated cropland acres in all eight regions combined, on average (table 38). The distributions of the average annual estimates of wind erosion in the baseline scenario and the no-practice scenario are contrasted in figure 87. Figure 87 shows that about 28 percent of the acres would have wind erosion rates greater than 2 tons per acre per year without conservation practices, compared to 15 percent with conservation practices.

On average, conservation practices have reduced wind erosion by 0.8 ton per acre. Reductions in wind erosion due to conservation practices are much higher for some acres than others, reflecting both the level of treatment and the inherent erodibility of the soil (fig. 88).

For about 5 percent of cropped acres, average annual wind erosion rates were higher in the baseline scenario than in the no-practice scenario, resulting in the negative reductions shown in figure 88. This condition occurs in areas with relatively low precipitation because the higher fertilization rates used to simulate the no-practice scenario produce significantly more vegetative cover, which in turn provides better protection for the soil from the forces of the wind than in the baseline scenario, where biomass production is less and crop residue losses are higher.

Figure 87. Distributions of average annual wind erosion for the baseline and no-practice scenarios, all eight regions combined.

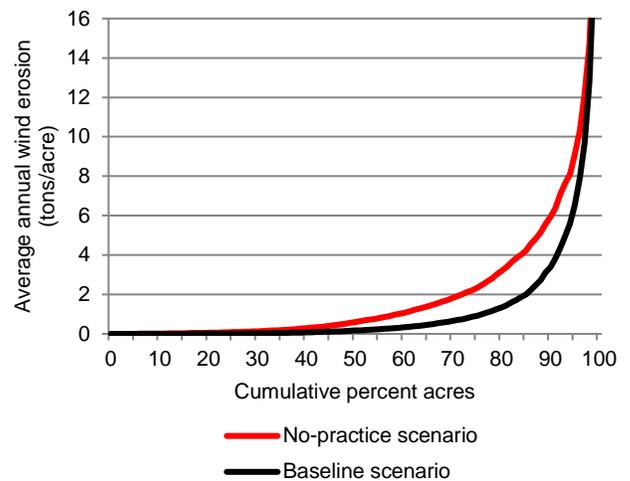
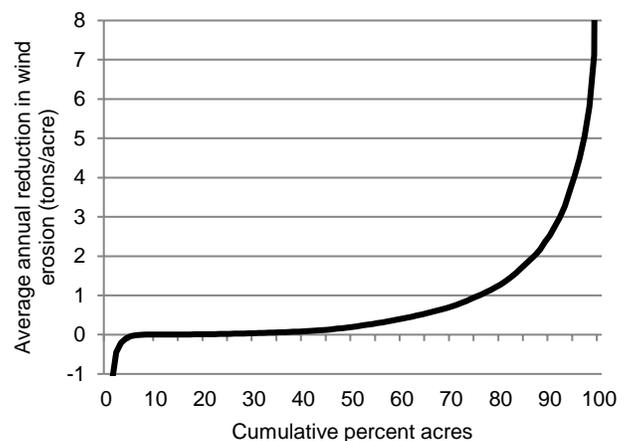


Figure 88. Distribution of average annual reduction in wind erosion due to the use of conservation practices, all eight regions combined.



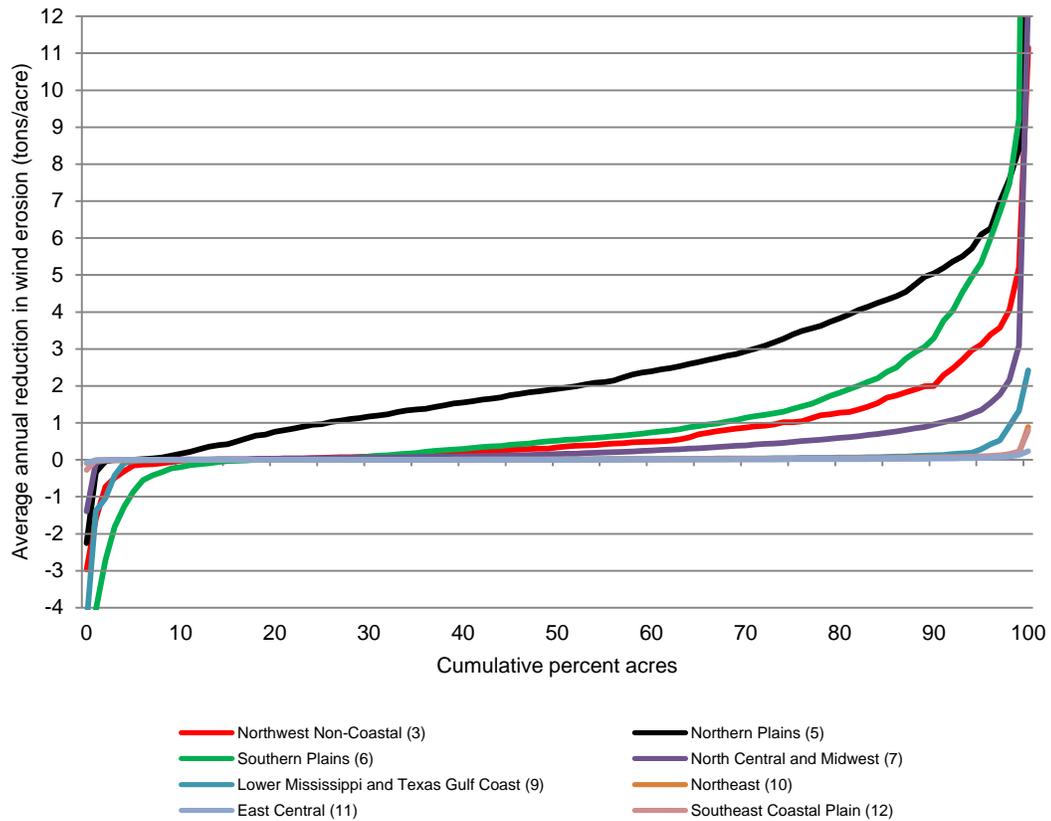
The largest reductions in wind erosion due to conservation practices are in the three westernmost regions, where wind erosion rates are sometimes extremely high (table 38 and fig. 89).

- In the Northern Plains (5) region, conservation practices have reduced wind erosion by 2.36 tons per acre per year, on average, representing a 61-percent reduction; reductions exceed 2 tons per acre per year for 47 percent of the cropped acres.
- In the Southern Plains (6) region, conservation practices have reduced wind erosion by 1.03 tons per acre per year, on average, representing a 22-percent reduction; reductions exceed 2 tons per acre per year for 18 percent of the cropped acres.
- In the Northwest Non-Coastal (3) region, conservation practices have reduced wind erosion by 0.73 ton per acre per year, on average, representing a 26-percent reduction; reductions exceed 2 tons per acre per year for 9 percent of the cropped acres.

Table 38. Effects of conservation practices on wind erosion, all cultivated cropland acres.

Production region	Baseline scenario (tons/acre)	No-practice scenario (tons/acre)	Reduction due to practices (tons/acre)	Percent reduction
Northwest Non-Coastal (3)	2.067	2.800	0.733	26%
Northern Plains (5)	1.514	3.878	2.364	61%
Southern Plains (6)	3.709	4.742	1.033	22%
North Central and Midwest (7)	0.386	0.763	0.377	49%
Lower Mississippi and Texas Gulf Coast (9)	0.638	0.666	0.028	4%
Northeast (10)	0.036	0.056	0.020	35%
East Central (11)	0.017	0.030	0.013	44%
Southeast Coastal Plain (12)	0.086	0.112	0.026	23%
All eight regions	1.351	2.152	0.801	37%

Figure 89. Distributions of average annual reductions in wind erosion due to the use of conservation practices, representing CEAP sample points in eight production regions.



## Effects of Conservation Practices on Nitrogen Loss

The NRCS Nutrient Management standard (590) allows a variety of methods to reduce nutrient losses while supplying a sufficient amount of nutrients to meet realistic yield goals. The standard addresses nutrient loss in two primary ways: (1) by altering rates, form, timing, and methods of application, and (2) by installing buffers, filters, or erosion or use of other runoff control practices to reduce the wind and water erosion mechanisms of loss. The reduction in nitrogen loss due to the effects of conservation practices is estimated here as the difference between the model simulation results for the no-practice and the baseline scenario, which represents the use of a combination of structural practices, tillage and residue management practices, and nitrogen management practices.

### Effects of Practice Use for All Regions Combined

Overall for all eight regions combined, model simulation results show that conservation practices have reduced total nitrogen loss (all loss pathways) by an average annual amount of 14.9 pounds per acre per year, representing a 30-percent reduction relative to the no-practice scenario. Without conservation practices, the average annual amount of total nitrogen loss would have been 49.3 pounds per acre per year as represented by the no-practice scenario, compared to an average of 34.4 pounds per acre per year for the baseline scenario, which includes a mix of fully treated, partially treated, and untreated acres. Reductions in total nitrogen loss due to conservation practices are much higher for some acres than others, reflecting both the level of treatment and the inherent erodibility of the soil.

Distributions of the average annual estimates of total nitrogen loss in the baseline scenario and the no-practice scenario are contrasted in figure 90, which shows that about 48 percent of the acres would have more than 40 pounds per acre per year of total nitrogen loss without practices (no-practice scenario) compared to 25 percent with conservation practices (baseline scenario), on average. The average annual reductions in total nitrogen loss are shown in figure 91. About 65 percent of the cropped acres had reductions in losses of more than 5 pounds per acre per year due to conservation practices. Moreover, about 25 percent of the cropped acres had reductions in losses of more than 20 pounds per acre per year; these are the acres that were treated the most.

In contrast, about 13 percent of cropped acres had negative reductions, indicating that nitrogen losses increased slightly for those acres resulting from tradeoffs in the benefits of conservation practice use for wind and water erosion.

As presented in the previous chapter, nitrogen application rates were increased above the rates reported in the farmer survey as part of the representation of the no-practice scenario. On average, the amount of nitrogen added for the no-practice simulation was 24.9 pounds per acre per year, which is represented in table 39 as a reduction of 25 percent due to the use of nitrogen management practices. As a consequence of the increased application rates, the no-practice scenario also had an increase, on average, of 9.3 pounds per acre per year of nitrogen in the crop yield removed at harvest compared to the baseline scenario, which is also represented in table 39 as a reduction in yield of 10 percent due to the use of conservation practices.

Figure 90. Distributions of average annual total nitrogen loss (all loss pathways) for the baseline and no-practice scenarios, all eight regions combined.

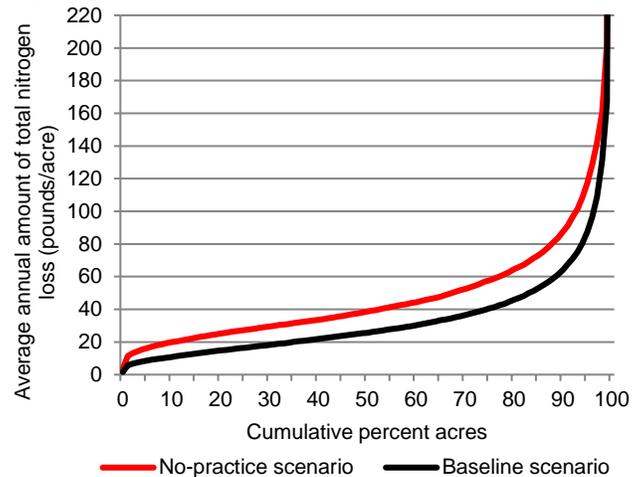


Figure 91. Distribution of average annual reduction in total nitrogen loss (all loss pathways) due to the use of conservation practices, all eight regions combined.

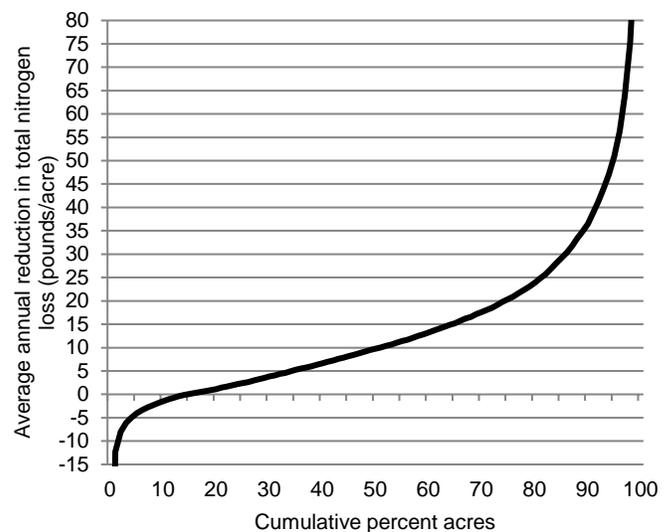


Table 39. Effects of conservation practices on nitrogen loss from farm fields, all eight regions combined.

	Baseline scenario (pounds/acre)	No-practice scenario (pounds/acre)	Reduction due to practices (pounds/acre)	Percent reduction
Nitrogen sources				
Atmospheric deposition	6.0	6.0	0.0	0%
Bio-fixation by legumes	36.4	34.5	-1.9	-6%
Nitrogen applied as commercial fertilizer and manure	74.6	99.5	24.9	25%
Total of all nitrogen sources	117.0	140.0	23.0	16%
Nitrogen in crop yield removed at harvest	84.8	94.1	9.3	10%
Nitrogen loss pathways				
Nitrogen loss by volatilization	6.5	7.1	0.6	9%
Nitrogen loss through denitrification	2.4	2.4	<0.1	<1%
Nitrogen lost with windborne sediment	4.5	7.1	2.6	37%
Nitrogen dissolved in surface water runoff	1.0	3.1	2.1	67%
Nitrogen loss with waterborne sediment (sediment attached)	4.8	7.3	2.5	34%
Nitrogen loss in subsurface flow pathways	15.2	22.4	7.2	32%
Total nitrogen loss for all loss pathways	34.4	49.3	14.9	30%
Change in soil nitrogen	-3.2	-4.2	-1.0	--

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

The extent to which conservation practices reduced losses in each of the six nitrogen loss pathways tracked by the APEX model varies (table 39 and figs. 92-95). The mean of the average annual reduction for all cropped acres in all eight regions combined was (table 39):

- 0.6 pounds per acre per year for nitrogen loss by volatilization, a 9-percent reduction relative to the results for the no-practice scenario;
- close to 0 pounds per acre per year for nitrogen loss through denitrification, on average;
- 2.6 pounds per acre per year for nitrogen lost with windborne sediment, a 37-percent reduction relative to the results for the no-practice scenario;
- 2.1 pounds per acre per year for nitrogen dissolved in surface water runoff, a 67-percent reduction;
- 2.5 pounds per acre per year for nitrogen lost with waterborne sediment, a 34-percent reduction; and
- 7.2 pounds per acre per year for nitrogen loss in subsurface flow pathways, a 32-percent reduction.

Reductions were highest for acres with the most conservation practice use, especially when erosion control practices were used in combination with appropriate nutrient management (rate, timing, and method of application). For the top 10 percent of cropped acres for each loss pathway:

- the average annual reduction in nitrogen loss by volatilization was 4.1 pounds per acre per year or greater (fig. 93);
- the average annual reduction in nitrogen loss through denitrification was 1.0 pound per acre per year or greater (fig. 95);
- the average annual reduction in nitrogen lost with windborne sediment was 8.4 pounds per acre per year or greater (fig. 97);

- the average annual reduction in nitrogen dissolved in surface water runoff was 5.7 pounds per acre per year or greater (fig. 99);
- the average annual reduction in nitrogen lost with waterborne sediment was 7.1 pounds per acre per year or greater (fig. 101); and
- the average annual reduction in nitrogen loss in subsurface flow pathways was 23.7 pounds per acre per year or greater (fig. 103).

Reductions were negative for some acres in each loss pathway, indicating that the representation of the no-practice scenario had less nitrogen loss than in the baseline scenario, which represented losses with conservation practice use. These instances represent tradeoffs in the effectiveness of conservation practices in terms of the transport of water and sediment from farm fields, as discussed in the previous chapter. For example, use of erosion control practices reduces surface water runoff, and thus nitrogen loss through this pathway, but enhances infiltration, which can increase nitrogen loss in subsurface flow pathways. For each loss pathway, the percentage of cropped acres with negative reductions was:

- 38 percent for nitrogen loss by volatilization (fig. 93);
- 34 percent for nitrogen loss through denitrification (fig. 95);
- 7 percent for nitrogen lost with windborne sediment (fig. 97);
- 2 percent for nitrogen dissolved in surface water runoff (fig. 99);
- 9 percent for nitrogen lost with waterborne sediment (fig. 101); and
- 26 percent for nitrogen loss in subsurface flow pathways (fig. 103).

Figure 92. Distributions of average annual nitrogen loss by volatilization for the baseline and no-practice scenarios, all eight regions combined.

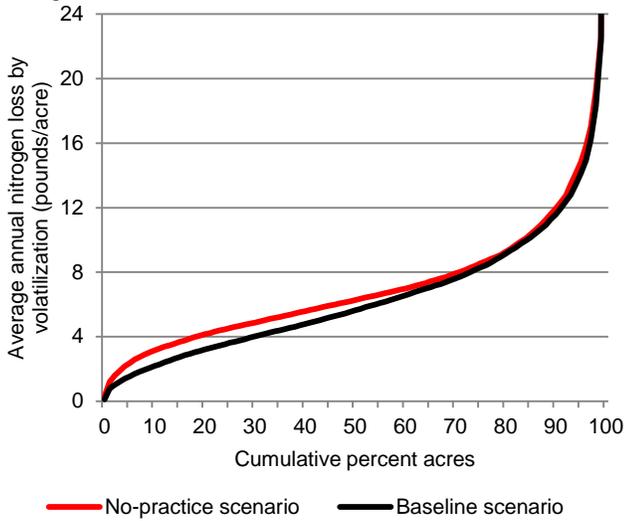


Figure 94. Distributions of average annual nitrogen loss through denitrification for the baseline and no-practice scenarios, all eight regions combined.

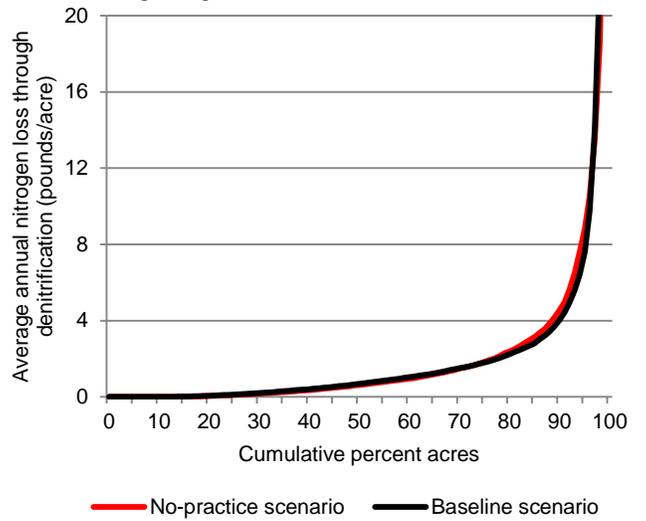


Figure 93. Distribution of average annual reductions in nitrogen loss by volatilization due to the use of conservation practices, all eight regions combined.

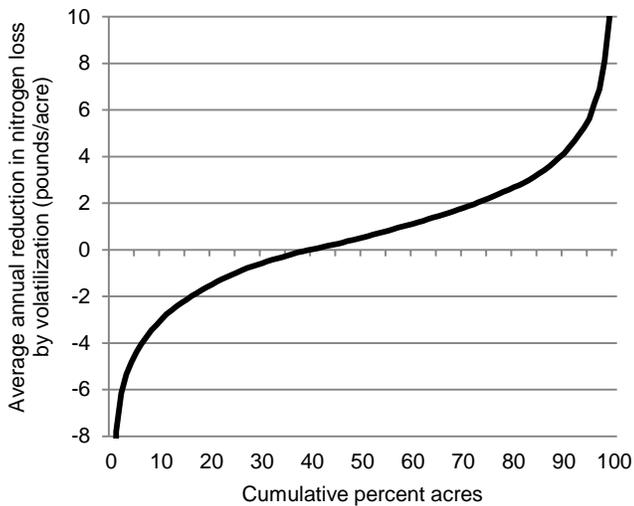


Figure 95. Distribution of average annual reductions in nitrogen loss through denitrification due to the use of conservation practices, all eight regions combined.

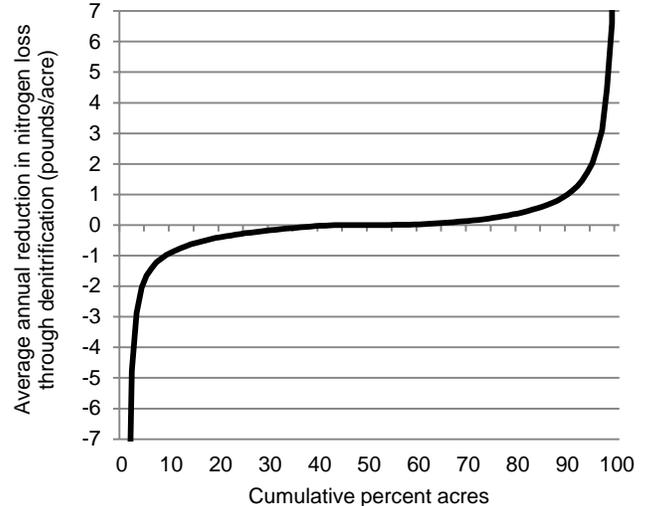


Figure 96. Distributions of average annual nitrogen lost with windborne sediment for the baseline and no-practice scenarios, all eight regions combined.

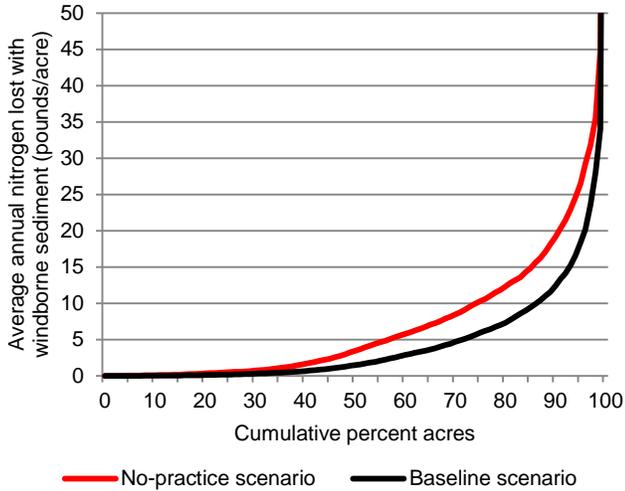


Figure 98. Distributions of average annual nitrogen dissolved in surface water runoff for the baseline and no-practice scenarios, all eight regions combined.

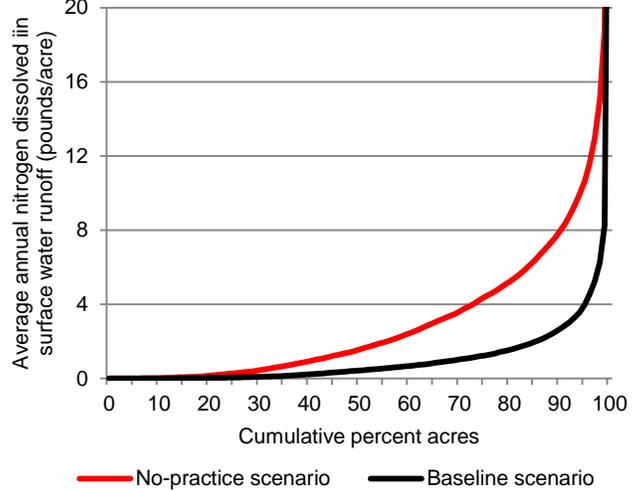


Figure 97. Distribution of average annual reductions in nitrogen lost with windborne sediment due to the use of conservation practices, all eight regions combined.

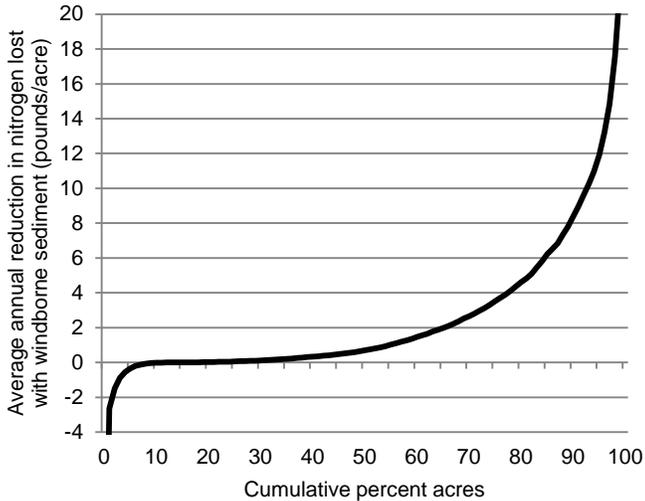


Figure 99. Distribution of average annual reduction in annual nitrogen dissolved in surface water runoff due to the use of conservation practices, all eight regions combined.

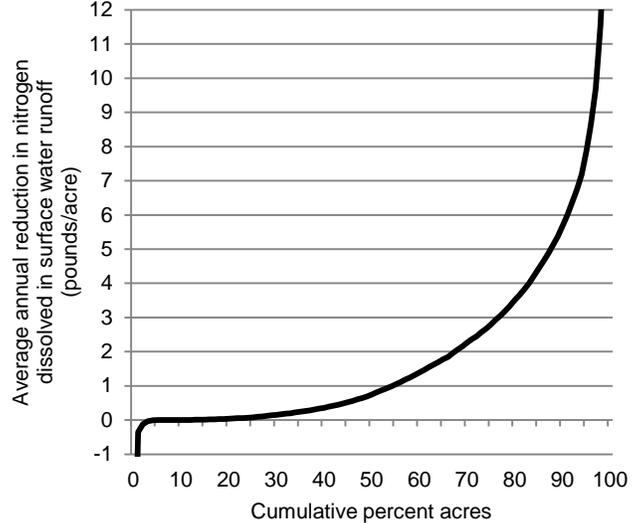


Figure 100. Distributions of average annual nitrogen lost with waterborne sediment for the baseline and no-practice scenarios, all eight regions combined.

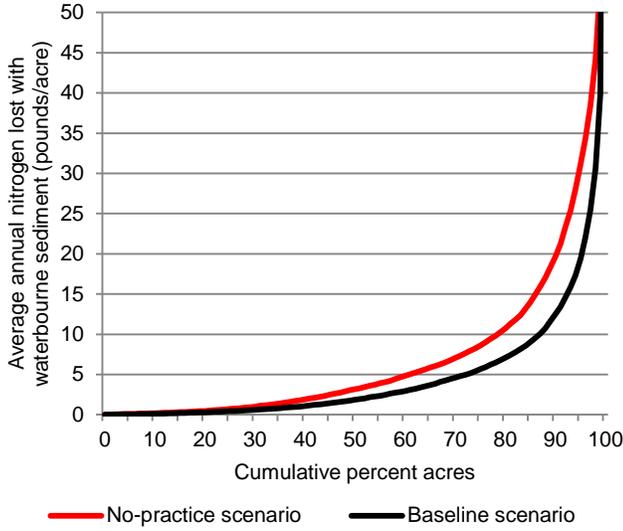


Figure 102. Distributions of average annual nitrogen loss in subsurface flow pathways for the baseline and no-practice scenarios, all eight regions combined.

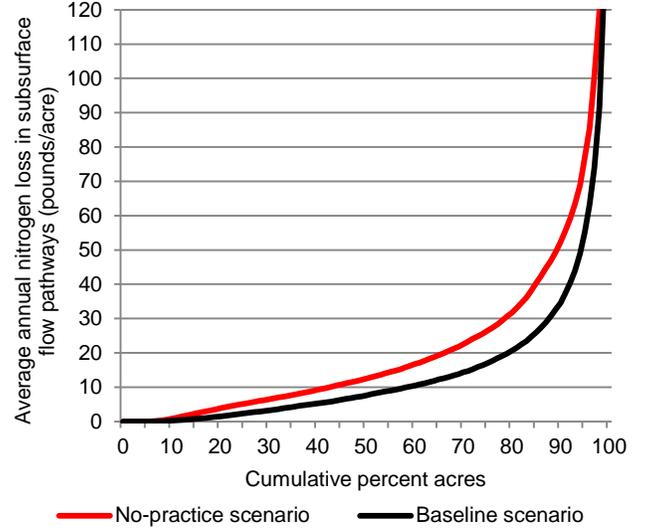


Figure 101. Distribution of average annual reductions in nitrogen lost with waterborne sediment due to the use of conservation practices, all eight regions combined.

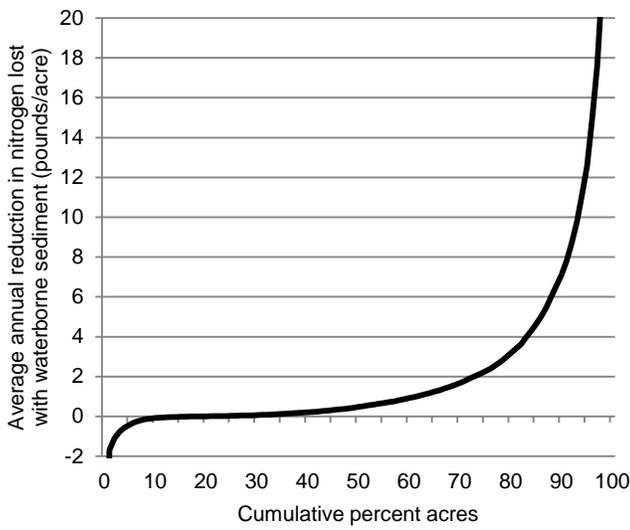
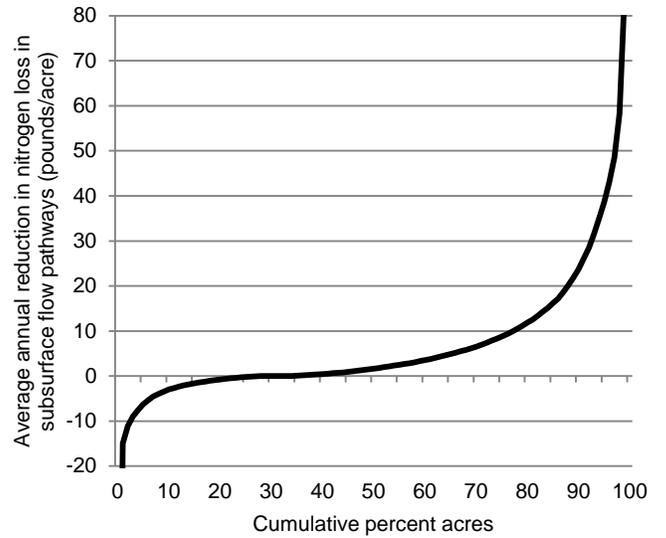


Figure 103. Distribution of average annual reductions in nitrogen loss in subsurface flow pathways due to the use of conservation practices, all eight regions combined.



## Effects of Practice Use by Production Region

Conservation practices were most effective in reducing nitrogen losses in different regions depending on the loss pathway (figs. 104 through 115 and table 40).

The reduction in the amount of nitrogen loss by volatilization due to conservation practices is relatively low in most regions (table 40, figs. 104 and 110). Conservation practices were the most effective in the three westernmost regions. In the Northwest Non-Coastal (3) region, for example, reductions due to conservation practices were greater than 5 pounds per acre per year for 30 percent of the cropped acres (fig. 110). Conservation practices had little or no effect on nitrogen loss by volatilization in the central and eastern regions, however, where losses for the majority of cropped acres ranged from -1.5 to 1.5 pound per acre per year (fig. 110). As shown previously in figure 93, 38 percent of cropped acres had increases in nitrogen loss by volatilization due to conservation practices; most of these acres were in the five easternmost regions, resulting in small negative mean estimates of losses for four of the regions (table 40 and fig. 104).

The smallest reductions in nitrogen loss due to conservation practices were for nitrogen losses through denitrification (table 40, figs. 105 and 111). In all but one region, reductions in nitrogen loss through denitrification ranged from -1.5 to 1.5 pound per acre per year for over 80 percent of the cropped acres (fig. 111). The exception was in the Lower Mississippi and Texas Gulf Coast (9) region, where 29 percent of cropped acres had negative reductions in nitrogen loss through denitrification of 5 pounds per acre or more (fig. 111) and the mean of the average annual reductions was -3.7 pounds per acre per year (table 40).

For nitrogen lost with windborne sediment, conservation practices were most effective in the three westernmost regions and the North Central and Midwest (7) region, where wind erosion is an important pathway for nitrogen loss (table 40, figs. 106 and 112). The largest reductions were in the Northern Plains (5) region, where the mean of the average annual reduction in nitrogen lost with windborne sediment was 8.0 pounds per acre per year, representing a 51-percent reduction (table 40, fig. 106). Figure 112 shows that, in this region, average annual reductions in nitrogen lost with windborne sediment were greater than 5 pounds per acre per year for 63 percent of the cropped acres, and greater than 15 pounds per acre per year for 11 percent of the cropped acres, far more than any other region. The effect of conservation practices for most cropped acres in the remaining four regions was slight because wind erosion is generally not a major concern.

Figure 104. Mean of the average annual reduction in nitrogen loss by volatilization due to the use of conservation practices, by region.

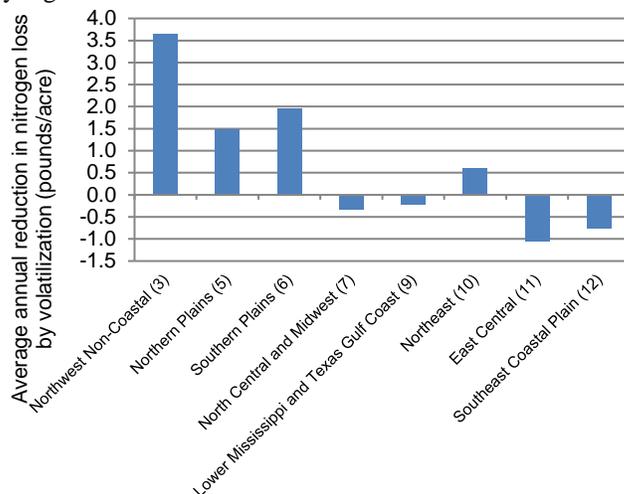


Figure 105. Mean of the average annual reduction in nitrogen loss through denitrification due to the use of conservation practices, by region.

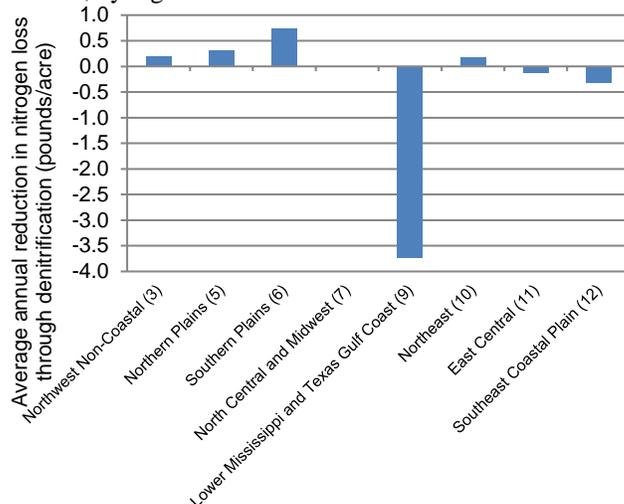
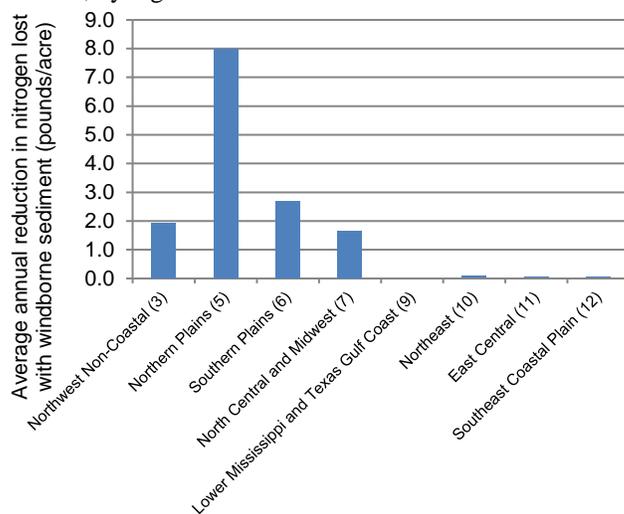


Figure 106. Mean of the average annual reduction in nitrogen lost with windborne sediment due to the use of conservation practices, by region.



Conservation practices were effective in controlling nitrogen dissolved in surface water runoff in regions where this was a significant loss pathway in the absence of conservation practices (as represented by the no-practice scenario) (table 40, figs. 107 and 113). The largest reductions—averaging over 3.5 pounds per acre per year—were in the two regions with the largest losses: 1) the Lower Mississippi and Texas Gulf Coast (9) region, and 2) the East Central (11) region (figs. 107 and 113). In terms of percent reductions, practices were effective in all regions, including the Northern Plains (5) region and the Southern Plains (6) region where this loss pathway was relatively unimportant. Percent reductions ranged from a low of 50 percent in the Southeast Coastal Plain (12) region to a high of 80 percent in the Northwest Non-Coastal (3) region (table 40).

The effectiveness of conservation practices in controlling nitrogen lost with waterborne sediment varied considerably among the regions (table 40, figs. 108 and 114). Reductions were largest in the Northeast (10) region and the East Central (11) region, where the mean of the average annual reduction in nitrogen lost with waterborne sediment averaged about 5.5 pounds per acre per year (fig. 108). In contrast, reductions in the Northern Plains (5) region, where surface water runoff is very small, were negligible for nearly all cropped acres (fig. 114). Percent reductions for this loss pathway, however, were modest in all regions. Percent reductions ranged from a low of 14 percent in the Lower Mississippi and Texas Gulf Coast (9) region to a high of 60 percent in the Southern Plains (6) region.

The largest reductions due to conservation practices were for nitrogen loss in subsurface flow pathways, which is a principal loss pathway in every region (table 40, figs. 109 and 115). The largest reductions were in two regions:

- the Northeast (10) region, where the mean of the average annual reduction was 19.1 pounds per acre per year (fig. 109), representing a 35-percent reduction, and 17 percent of cropped acres had average annual reductions greater than 40 pounds per acre per year (fig. 115); and
- the Northwest Non-Coastal (3) region, where the mean of the average annual reduction was 17.2 pounds per acre per year (fig. 109), representing a 55-percent reduction, and 16 percent of cropped acres had average annual reductions greater than 40 pounds per acre per year (fig. 115).

Conservation practices were the least effective in controlling nitrogen loss in subsurface flow pathways in two regions:

- the North Central and Midwest (7) region, where the mean of the average annual reduction was only 3.1 pounds per acre per year (fig. 109), representing a 16-percent reduction; and
- the Lower Mississippi and Texas Gulf Coast (9) region, where the mean of the average annual reduction was only 2.9 pounds per acre per year (fig. 109), representing a 10-percent reduction.

Figure 107. Mean of the average annual reduction in nitrogen dissolved in surface water runoff due to the use of conservation practices, by region.

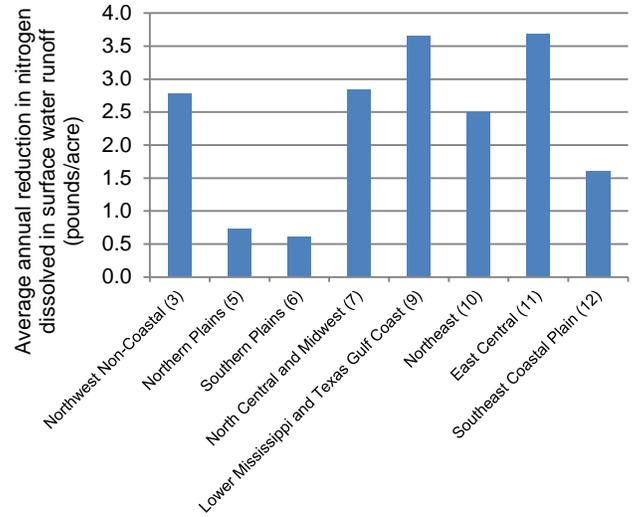


Figure 108. Mean of the average annual reduction in nitrogen lost with waterborne sediment due to the use of conservation practices, by region.

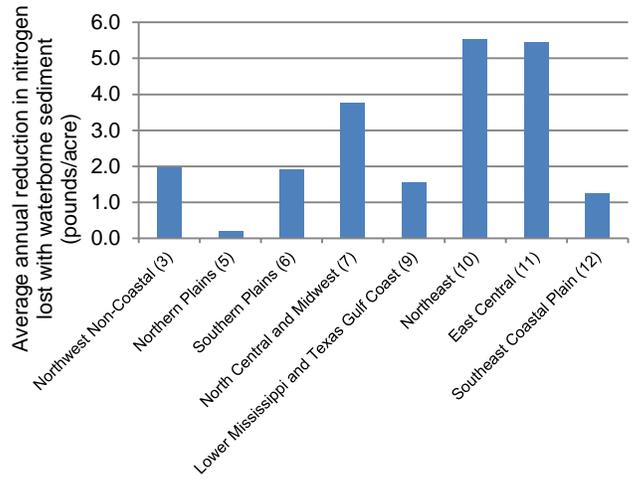


Figure 109. Mean of the average annual reduction in nitrogen loss in subsurface flow pathways due to the use of conservation practices, by region.

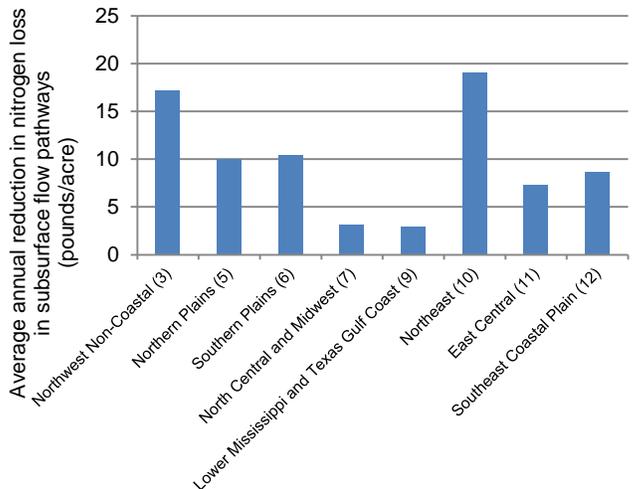


Table 40. Effects of conservation practices on nitrogen loss from farm fields, by region.

	Baseline scenario (pounds/acre)	No-practice scenario (pounds/acre)	Reduction due to practices (pounds/acre)	Percent reduction
<b>Northwest Non-Coastal (3) region</b>				
Nitrogen sources				
Atmospheric deposition	1.3	1.3	0.0	0%
Bio-fixation by legumes	16.5	15.7	-0.8	-5%
Nitrogen applied as commercial fertilizer and manure	84.1	132.1	48.0	36%
Total of all nitrogen sources	102.0	149.2	47.2	32%
Nitrogen in crop yield removed at harvest	78.1	96.1	18.0	19%
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.9	9.5	3.7	38%
Nitrogen loss through denitrification	0.5	0.7	0.2	27%
Nitrogen lost with windborne sediment	6.0	7.9	1.9	25%
Nitrogen dissolved in surface water runoff	0.7	3.5	2.8	80%
Nitrogen loss with waterborne sediment (sediment attached)	3.7	5.6	2.0	35%
Nitrogen loss in subsurface flow pathways	14.2	31.4	17.2	55%
Total nitrogen loss for all loss pathways	30.9	58.7	27.8	47%
Change in soil nitrogen	-7.5	-6.1	1.4	--
<b>Northern Plains (5) region</b>				
Nitrogen sources				
Atmospheric deposition	3.4	3.4	0.0	0%
Bio-fixation by legumes	17.1	12.8	-4.2	-33%
Nitrogen applied as commercial fertilizer and manure	56.2	92.0	35.9	39%
Total of all nitrogen sources	76.6	108.2	31.6	29%
Nitrogen in crop yield removed at harvest	61.9	71.6	9.7	14%
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.8	7.3	1.5	20%
Nitrogen loss through denitrification	1.1	1.5	0.3	21%
Nitrogen lost with windborne sediment	7.7	15.7	8.0	51%
Nitrogen dissolved in surface water runoff	0.2	0.9	0.7	79%
Nitrogen loss with waterborne sediment (sediment attached)	0.5	0.7	0.2	28%
Nitrogen loss in subsurface flow pathways	4.1	14.1	10.0	71%
Total nitrogen loss for all loss pathways	19.5	40.2	20.7	52%
Change in soil nitrogen	-5.5	-4.3	1.2	--
<b>Southern Plains (6) region</b>				
Nitrogen sources				
Atmospheric deposition	4.6	4.6	0.0	0%
Bio-fixation by legumes	7.4	6.8	-0.5	-7%
Nitrogen applied as commercial fertilizer and manure	67.2	99.2	32.0	32%
Total of all nitrogen sources	79.2	110.6	31.4	28%
Nitrogen in crop yield removed at harvest	56.2	67.2	10.9	16%
Nitrogen loss pathways				
Nitrogen loss by volatilization	6.7	8.6	1.9	23%
Nitrogen loss through denitrification	1.0	1.7	0.7	43%
Nitrogen lost with windborne sediment	7.9	10.6	2.7	25%
Nitrogen dissolved in surface water runoff	0.3	0.9	0.6	67%
Nitrogen loss with waterborne sediment (sediment attached)	1.3	3.2	1.9	60%
Nitrogen loss in subsurface flow pathways	9.7	20.1	10.5	52%
Total nitrogen loss for all loss pathways	26.8	45.1	18.4	41%
Change in soil nitrogen	-4.4	-2.2	2.1	--

Table 43.—continued.

	Baseline scenario (pounds/acre)	No-practice scenario (pounds/acre)	Reduction due to practices (pounds/acre)	Percent reduction
<b>North Central and Midwest (7) region</b>				
Nitrogen sources				
Atmospheric deposition	7.8	7.8	0.0	0%
Bio-fixation by legumes	60.8	58.7	-2.1	-4%
Nitrogen applied as commercial fertilizer and manure	80.1	97.3	17.2	18%
Total of all nitrogen sources	148.7	163.8	15.1	9%
Nitrogen in crop yield removed at harvest	110.2	118.2	8.0	7%
Nitrogen loss pathways				
Nitrogen loss by volatilization	7.0	6.6	-0.3	-5%
Nitrogen loss through denitrification	2.3	2.3	0.0	0%
Nitrogen lost with windborne sediment	2.8	4.4	1.6	37%
Nitrogen dissolved in surface water runoff	1.2	4.0	2.8	70%
Nitrogen loss with waterborne sediment (sediment attached)	6.6	10.4	3.8	36%
Nitrogen loss in subsurface flow pathways	16.2	19.4	3.1	16%
Total nitrogen loss for all loss pathways	36.1	47.1	11.0	23%
Change in soil nitrogen	1.0	-2.6	-3.7	--
<b>Lower Mississippi and Texas Gulf Coast (9) region</b>				
Nitrogen sources				
Atmospheric deposition	6.4	6.4	0.0	0%
Bio-fixation by legumes	51.2	49.8	-1.4	-3%
Nitrogen applied as commercial fertilizer and manure	80.8	91.6	10.8	12%
Total of all nitrogen sources	138.4	147.7	9.4	6%
Nitrogen in crop yield removed at harvest	88.2	93.8	5.6	6%
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.6	5.3	-0.2	-4%
Nitrogen loss through denitrification	12.4	8.7	-3.7	-43%
Nitrogen lost with windborne sediment	1.3	1.3	0.0	0%
Nitrogen dissolved in surface water runoff	3.0	6.7	3.7	55%
Nitrogen loss with waterborne sediment (sediment attached)	10.0	11.5	1.6	14%
Nitrogen loss in subsurface flow pathways	25.9	28.8	2.9	10%
Total nitrogen loss for all loss pathways	58.1	62.3	4.2	7%
Change in soil nitrogen	-8.3	-8.7	-0.3	--
<b>Northeast (10) region</b>				
Nitrogen sources				
Atmospheric deposition	9.0	9.0	0.0	0%
Bio-fixation by legumes	25.9	23.6	-2.3	-10%
Nitrogen applied as commercial fertilizer and manure	91.8	129.2	37.4	29%
Total of all nitrogen sources	126.8	161.8	35.1	22%
Nitrogen in crop yield removed at harvest	82.2	93.0	10.8	12%
Nitrogen loss pathways				
Nitrogen loss by volatilization	5.4	6.1	0.6	10%
Nitrogen loss through denitrification	1.5	1.7	0.2	10%
Nitrogen lost with windborne sediment	0.2	0.3	0.1	30%
Nitrogen dissolved in surface water runoff	1.2	3.7	2.5	68%
Nitrogen loss with waterborne sediment (sediment attached)	12.9	18.5	5.5	30%
Nitrogen loss in subsurface flow pathways	34.7	53.8	19.1	35%
Total nitrogen loss for all loss pathways	55.9	83.9	28.0	33%
Change in soil nitrogen	-13.4	-16.7	-3.4	--

Table 43.—continued.

	Baseline scenario (pounds/acre)	No-practice scenario (pounds/acre)	Reduction due to practices (pounds/acre)	Percent reduction
<b>East Central (11) region</b>				
Nitrogen sources				
Atmospheric deposition	8.4	8.4	0.0	0%
Bio-fixation by legumes	41.6	39.8	-1.8	-4%
Nitrogen applied as commercial fertilizer and manure	99.1	122.0	22.9	19%
Total of all nitrogen sources	149.0	170.2	21.1	12%
Nitrogen in crop yield removed at harvest	101.8	111.4	9.7	9%
Nitrogen loss pathways				
Nitrogen loss by volatilization	7.6	6.6	-1.1	-16%
Nitrogen loss through denitrification	2.2	2.1	-0.1	-6%
Nitrogen lost with windborne sediment	0.1	0.1	0.0	34%
Nitrogen dissolved in surface water runoff	3.4	7.0	3.7	52%
Nitrogen loss with waterborne sediment (sediment attached)	13.3	18.8	5.4	29%
Nitrogen loss in subsurface flow pathways	24.5	31.9	7.3	23%
Total nitrogen loss for all loss pathways	51.2	66.5	15.3	23%
Change in soil nitrogen	-5.1	-8.4	-3.3	--
<b>Southeast Coastal Plain (12) region</b>				
Nitrogen sources				
Atmospheric deposition	6.6	6.6	0.0	0%
Bio-fixation by legumes	24.7	23.9	-0.9	-4%
Nitrogen applied as commercial fertilizer and manure	85.0	102.7	17.8	17%
Total of all nitrogen sources	116.3	133.2	16.9	13%
Nitrogen in crop yield removed at harvest	70.2	77.9	7.6	10%
Nitrogen loss pathways				
Nitrogen loss by volatilization	6.2	5.4	-0.8	-14%
Nitrogen loss through denitrification	1.3	0.9	-0.3	-35%
Nitrogen lost with windborne sediment	0.3	0.4	0.0	11%
Nitrogen dissolved in surface water runoff	1.6	3.2	1.6	50%
Nitrogen loss with waterborne sediment (sediment attached)	4.0	5.3	1.3	24%
Nitrogen loss in subsurface flow pathways	40.2	49.0	8.7	18%
Total nitrogen loss for all loss pathways	53.7	64.2	10.5	16%
Change in soil nitrogen	-8.0	-9.2	-1.2	--

Source: APEX simulation modeling results based on 2003-06 CEAP survey information on farming practices.

Figure 110. Distributions of average annual reduction in nitrogen loss by volatilization due to the use of conservation practices, CEAP sample points in eight production regions.

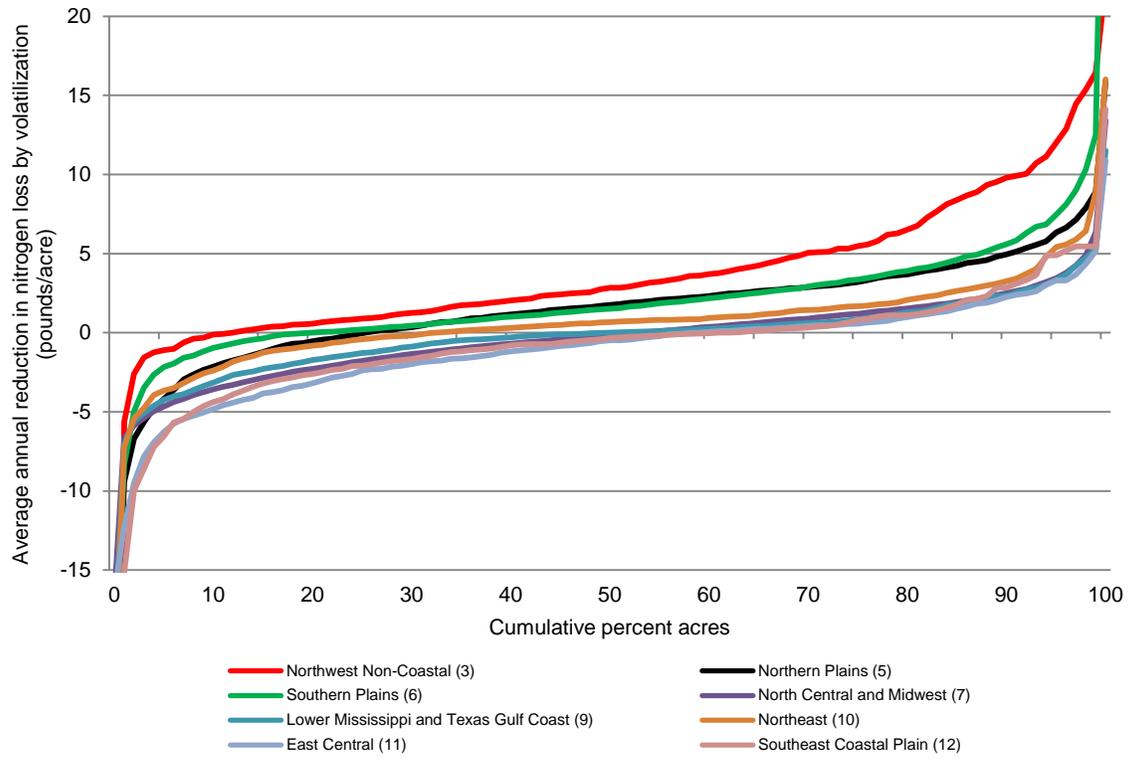


Figure 111. Distributions of average annual reduction in nitrogen loss through denitrification due to the use of conservation practices, CEAP sample points in eight production regions.

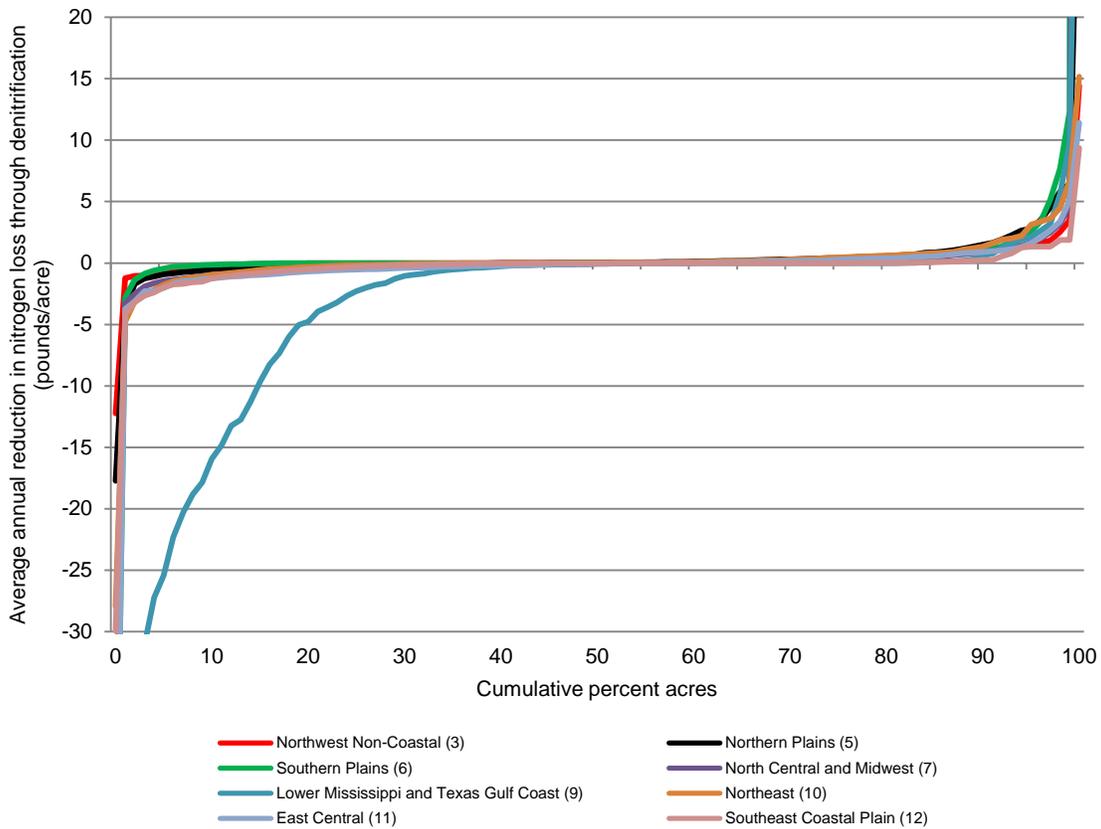


Figure 112. Distributions of average annual reduction in nitrogen lost with windborne sediment due to the use of conservation practices, CEAP sample points in eight production regions.

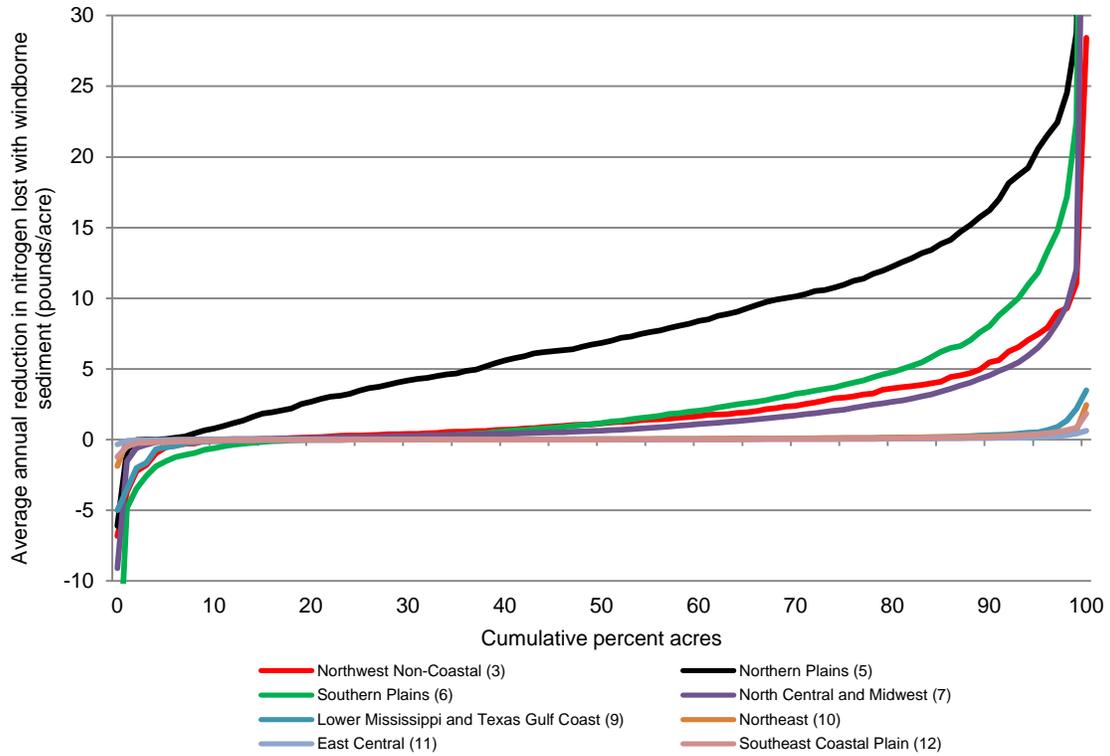


Figure 113. Distributions of average annual reduction in nitrogen dissolved in surface water runoff due to the use of conservation practices, CEAP sample points in eight production regions.

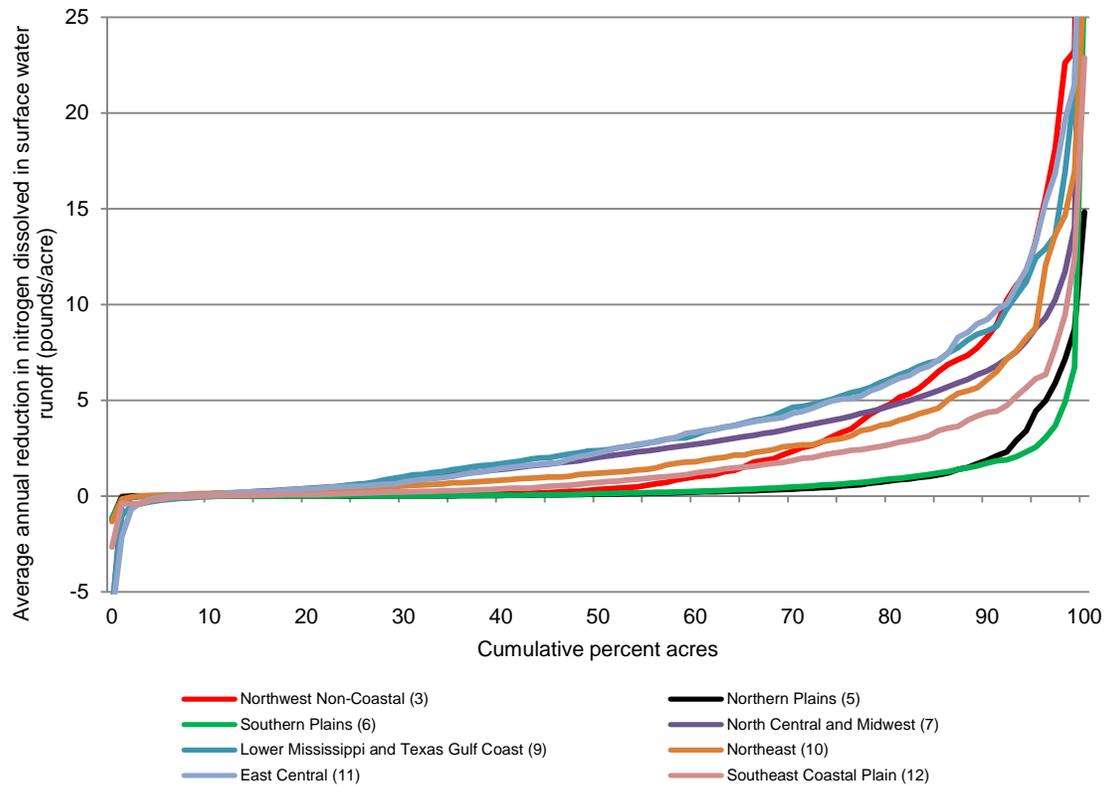


Figure 114. Distributions of average annual reduction in nitrogen lost with waterborne sediment due to the use of conservation practices, CEAP sample points in eight production regions.

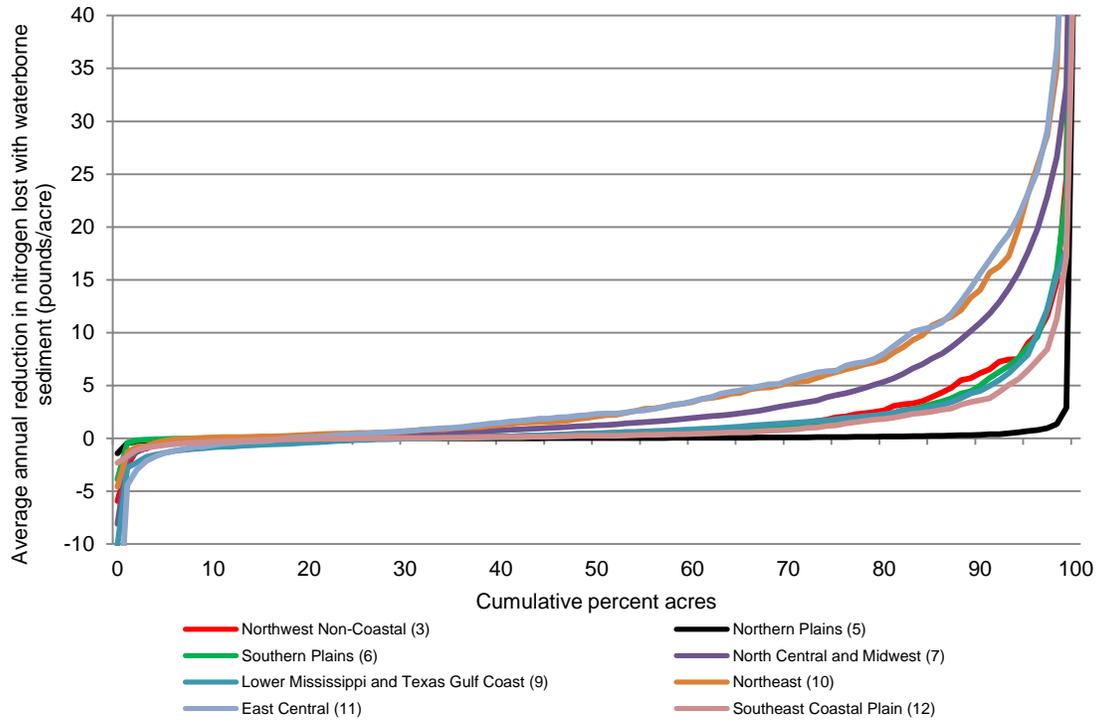
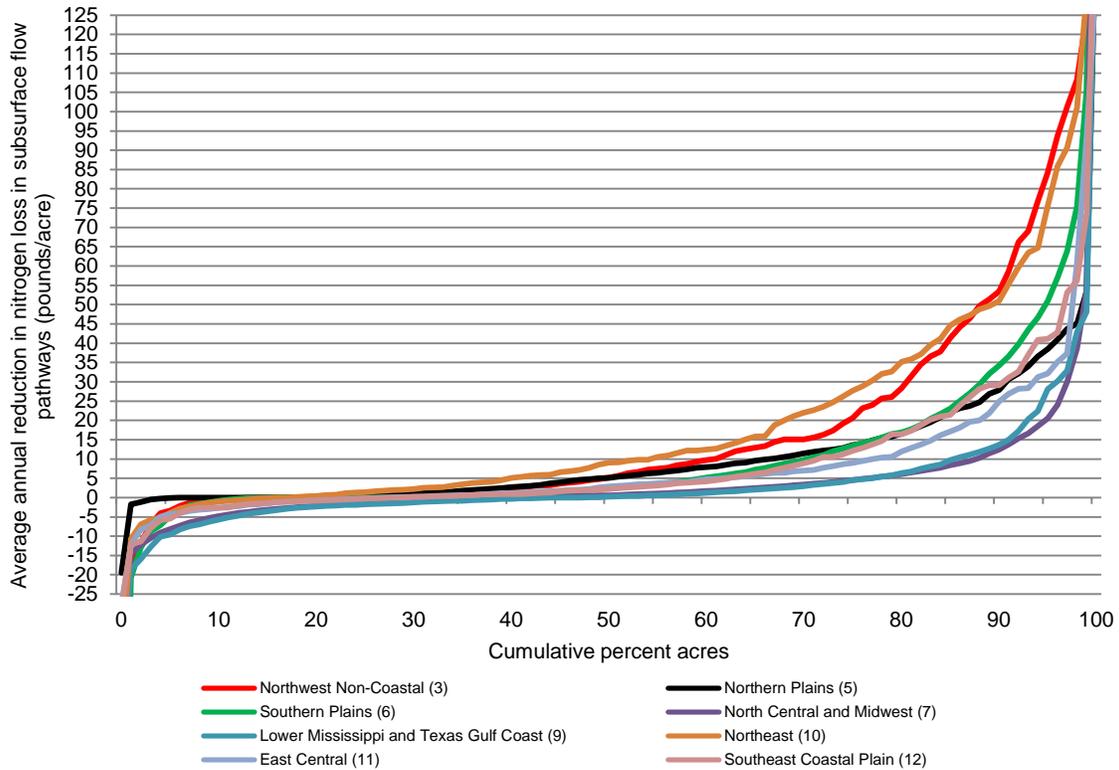


Figure 115. Distributions of average annual reduction in nitrogen loss in subsurface flow pathways due to the use of conservation practices, CEAP sample points in eight production regions.



For all loss pathways combined, the Lower Mississippi and Texas Gulf Coast (9) region had the smallest reductions in total nitrogen loss due to conservation practices (table 40 and figs. 116 and 117). For this region, the mean of the average annual reduction in total nitrogen loss was only 4.2 pounds per acre per year, representing a 7-percent reduction due to the use of conservation practices (table 40). All other regions had an average annual reduction of 10 pounds per acre per year or more.

Conservation practices were the most effective in controlling total nitrogen loss two regions (table 40, figs. 116 and 117):

- the Northeast (10) region, where the mean of the average annual reduction was 28.0 pounds per acre per year (fig. 116), representing a 33-percent reduction;
- the Northwest Non-Coastal (3) region, where the mean of the average annual reduction was 27.8 pounds per acre per year (fig. 116), representing a 47-percent reduction.

Figure 116. Mean of the average annual reduction in total nitrogen loss for all loss pathways due to the use of conservation practices, by region.

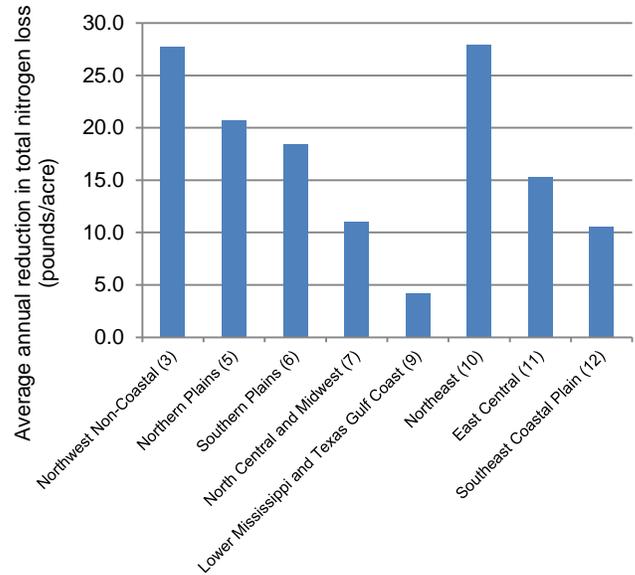
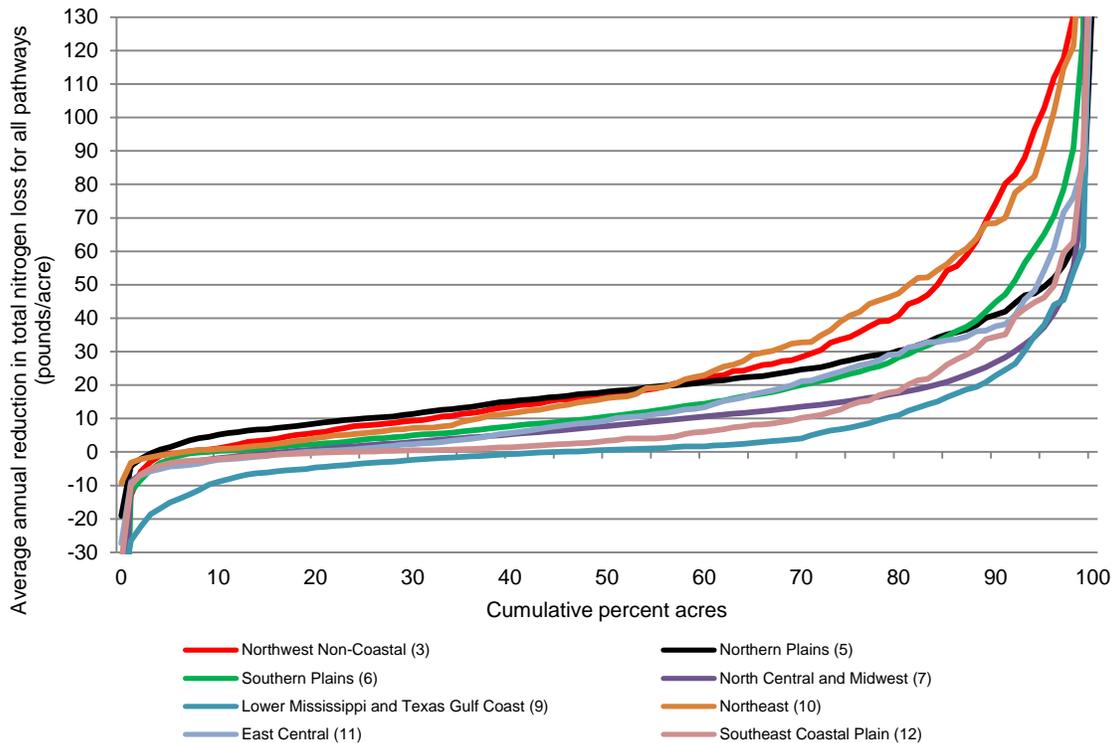


Figure 117. Distributions of average annual reduction in total nitrogen loss (all loss pathways) due to the use of conservation practices, CEAP sample points in eight production regions.



## Breakdown of the Effects of Practice Use by Levels of Conservation Treatment

The assessment of the effects of conservation practices is extended further by presenting the estimates of the average annual **reductions due to conservation practices** for each of the 16-cell matrixes presented previously for:

- total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) (see table 17 and relevant text), and
- nitrogen loss in subsurface flow pathways (see table 26 and relevant text).

**Total nitrogen loss with surface water runoff.** The average annual reductions in total nitrogen loss with surface water runoff were estimated for the four soil runoff potentials and the four treatment levels of nitrogen runoff control. Table 41 presents estimates for the no-practice scenario and estimates of reductions in total nitrogen loss with surface water runoff due to conservation practices for all eight regions combined.

As shown previously in table 17 for the baseline scenario, the amounts of total nitrogen loss with surface water runoff are highest for soils with the highest soil runoff potential. Table 41 shows that nitrogen losses for the no-practice scenario also increase as the soil runoff potential increases.

With respect to increases in the nitrogen runoff control treatment levels, the matrix for nitrogen losses in the no-practice scenario exhibit decreasing trends in nitrogen loss estimates as conservation treatment levels increase, in spite of modeling efforts to remove or reverse the effects of conservation practices. These trends may be due to the benefits of practices other than nitrogen runoff control that may be correlated with the nitrogen runoff control treatment levels.

Table 41 shows that **reductions** in nitrogen losses follow the trend of increasing amounts with increasing soil runoff potentials. Overall losses are highest for soils with the higher soil runoff potentials, and so reductions due to conservation practices also tend to be higher for these sample points as well. The mean average annual reduction due to conservation practice use in all eight regions, averaged over the four treatment levels, was:

- 2.8 pounds per acre per year for acres with a “low” soil runoff potential,
- 4.2 pounds per acre per year for acres with a “moderate” soil runoff potential,
- 6.2 pounds per acre per year for acres with a “moderately high” soil runoff potential, and
- 11.4 pounds per acre per year for acres with a “high” soil runoff potential.

Average annual reductions in total nitrogen loss with surface water runoff did not, however, consistently increase as treatment levels increased (table 41). The mean average

annual reduction due to conservation practice use in all eight regions, averaged over the four soil runoff potentials, was:

- 4.6 pounds per acre per year for acres with a “low” nitrogen runoff control treatment level,
- 4.4 pounds per acre per year for acres with a “moderate” nitrogen runoff control treatment level,
- 4.9 pounds per acre per year for acres with a “moderately high” nitrogen runoff control treatment level, and
- 2.9 pounds per acre per year for acres with a “high” nitrogen runoff control treatment level.

However, the expected trend of increasing amounts of reductions in nitrogen loss with increasing treatment levels was manifested for the “high” soil runoff potential.

**Percent reductions** generally increased with increasing conservation treatment levels when the “moderately high” and “high” treatment levels were combined. Percent reductions due to conservation practice use in all eight regions, averaged over the four soil runoff potentials, were:

- 29 percent for acres with a “low” conservation treatment level,
- 41 percent for acres with a “moderate” conservation treatment level,
- 54 percent for acres with a “moderately high” conservation treatment level, and
- 51 percent for acres with a “high” conservation treatment level.

These trends in model simulation results are not always manifested in each of the eight regions, as shown in tables 42 through 49. For example, the increasing trend in the average amount of the **reduction** in nitrogen loss as soil runoff potentials increased, averaged over the four conservation treatment levels, was evident in the matrix for all but three regions—the Northwest Non-Coastal (3) region, the Northern Plains (5) region, and the Lower Mississippi and Texas Gulf Coast (9) region.

An increasing trend in the average amount of the **reduction** in nitrogen loss as conservation treatment levels increase, averaged over the four soil runoff potentials, was not evident, or was only weakly evident, in all regions.

An increasing trend in the **percent reduction** in nitrogen loss as conservation treatment levels increase, averaged over the four soil runoff potentials, was evident in the matrix for four of the regions:

- the Northwest Non-Coastal (3) region,
- the Northern Plains (5) region,
- the North Central and Midwest (7) region, and
- the East Central (11) region.

Table 41. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, all eight regions combined.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	4%	26%	21%	3%	53%
Moderate	2%	9%	7%	1%	18%
Moderately high	2%	10%	6%	<1%	19%
High	1%	6%	2%	<1%	10%
All	9%	51%	36%	4%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	7.9	5.9	5.6	4.1	5.8
Moderate	10.2	10.1	10.7	8.2	10.3
Moderately high	21.5	14.4	13.3	9.0	14.8
High	35.0	26.4	25.1	20.4	27.3
All	15.7	10.7	9.1	5.7	10.4
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	3.4	2.7	2.9	2.3	2.8
Moderate	3.5	3.9	4.9	3.0	4.2
Moderately high	5.6	5.8	7.5	4.9	6.2
High	7.5	10.4	15.8	19.0	11.4
All	4.6	4.4	4.9	2.9	4.5
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	43%	46%	52%	56%	48%
Moderate	34%	39%	46%	37%	41%
Moderately high	26%	40%	57%	55%	42%
High	21%	39%	63%	93%	42%
All	29%	41%	54%	51%	44%

Table 42. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Northwest Non-Coastal (3) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	6%	21%	12%	2%	40%
Moderate	1%	1%	1%	0%	2%
Moderately high	4%	16%	5%	1%	26%
High	4%	19%	8%	0%	32%
All	15%	56%	26%	3%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	7.4	7.4	4.1	8.3	6.5
Moderate	9.9	8.6	6.4	NA	8.2
Moderately high	13.4	9.2	2.9	3.7	8.5
High	14.9	15.3	6.8	7.5	13.0
All	11.4	10.6	4.8	7.4	9.1
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	5.0	5.7	3.0	5.2	4.8
Moderate	7.6	7.4	5.3	NA	6.7
Moderately high	8.2	5.8	1.7	3.0	5.3
High	3.7	4.7	2.7	6.7	4.1
All	5.7	5.4	2.8	5.0	4.8
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	68%	77%	74%	63%	74%
Moderate	77%	86%	83%	NA	82%
Moderately high	61%	63%	59%	81%	62%
High	25%	31%	40%	89%	32%
All	50%	51%	57%	68%	52%

Table 43. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Northern Plains (5) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	2%	22%	21%	5%	50%
Moderate	2%	12%	6%	1%	20%
Moderately high	2%	15%	6%	1%	24%
High	1%	5%	1%	0%	7%
All	7%	53%	34%	6%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	1.3	1.1	1.1	0.7	1.1
Moderate	2.8	2.0	2.7	1.4	2.3
Moderately high	2.0	1.6	1.5	2.5	1.6
High	2.4	4.4	2.3	NA	3.9
All	2.1	1.8	1.5	1.0	1.6
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	0.8	0.7	0.8	0.5	0.7
Moderate	1.8	1.2	1.8	1.0	1.4
Moderately high	0.5	0.6	0.9	2.0	0.7
High	0.3	2.2	1.2	NA	1.8
All	0.8	0.9	1.0	0.8	0.9
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	58%	64%	70%	70%	67%
Moderate	63%	57%	67%	72%	62%
Moderately high	23%	37%	60%	80%	44%
High	11%	50%	52%	NA	46%
All	41%	52%	67%	73%	57%

Table 44. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Southern Plains (6) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	5%	41%	26%	3%	75%
Moderate	2%	7%	3%	<1%	11%
Moderately high	1%	7%	3%	<1%	12%
High	<1%	1%	<1%	0%	2%
All	8%	57%	32%	3%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	3.7	2.7	3.0	2.2	2.8
Moderate	6.6	5.6	4.8	2.3	5.5
Moderately high	12.1	9.3	8.7	2.4	9.2
High	35.9	10.6	6.3	NA	14.1
All	6.6	4.1	3.8	2.2	4.1
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	2.7	1.7	2.1	1.5	1.9
Moderate	3.3	2.6	3.0	1.1	2.8
Moderately high	6.1	4.9	5.3	1.8	5.1
High	21.6	7.7	3.8	NA	9.4
All	4.0	2.4	2.5	1.4	2.5
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	72%	64%	71%	66%	67%
Moderate	50%	47%	62%	47%	51%
Moderately high	50%	53%	61%	75%	55%
High	60%	73%	61%	NA	67%
All	61%	59%	67%	65%	61%

Table 45. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, North Central and Midwest (7) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	2%	20%	23%	3%	48%
Moderate	1%	7%	9%	1%	18%
Moderately high	2%	10%	8%	<1%	21%
High	2%	7%	4%	<1%	13%
All	8%	44%	44%	4%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	9.5	8.5	7.8	6.7	8.1
Moderate	12.5	12.6	12.2	9.9	12.3
Moderately high	24.3	19.0	17.5	15.0	18.9
High	37.9	33.7	29.9	25.8	32.8
All	20.8	15.6	12.6	8.8	14.4
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	4.3	3.7	4.0	4.0	3.9
Moderate	4.4	5.1	6.5	6.0	5.8
Moderately high	5.2	7.4	10.1	7.5	8.2
High	6.4	13.9	19.1	24.2	14.8
All	5.1	6.4	7.1	5.2	6.6
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	45%	44%	52%	59%	48%
Moderate	35%	41%	53%	61%	47%
Moderately high	22%	39%	58%	50%	43%
High	17%	41%	64%	94%	45%
All	24%	41%	57%	59%	46%

Table 46. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Lower Mississippi and Texas Gulf (9) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	4%	17%	12%	1%	35%
Moderate	6%	24%	18%	5%	53%
Moderately high	2%	7%	2%	0%	11%
High	<1%	1%	<1%	0%	2%
All	12%	50%	33%	6%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	22.3	18.6	12.3	9.1	16.4
Moderate	12.6	16.7	14.8	9.6	15.0
Moderately high	39.4	34.4	23.6	NA	33.7
High	61.3	55.9	37.2	NA	54.9
All	21.7	20.9	14.4	9.5	18.2
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	7.6	5.9	3.7	1.1	5.1
Moderate	3.4	5.5	3.6	1.1	4.2
Moderately high	9.4	9.8	5.3	NA	9.1
High	8.4	13.4	20.4	NA	13.2
All	5.9	6.4	3.8	1.1	5.2
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	34%	32%	30%	12%	31%
Moderate	27%	33%	24%	12%	28%
Moderately high	24%	28%	23%	NA	27%
High	14%	24%	55%	NA	24%
All	27%	31%	27%	12%	29%

Table 47. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Northeast (10) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	6%	21%	6%	<1%	34%
Moderate	3%	6%	3%	<1%	12%
Moderately high	7%	17%	3%	<1%	26%
High	6%	20%	1%	0%	28%
All	22%	64%	13%	1%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	17.4	9.6	7.1	5.3	10.5
Moderate	17.8	16.8	13.9	6.1	16.0
Moderately high	27.4	23.2	18.4	4.8	23.8
High	54.2	33.1	21.1	NA	37.3
All	31.1	21.4	12.2	5.6	22.1
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	4.3	4.3	3.7	0.8	4.1
Moderate	5.0	7.5	5.2	1.7	6.2
Moderately high	6.4	9.9	13.4	0.6	9.3
High	13.4	11.8	14.0	NA	12.3
All	7.7	8.5	6.9	1.1	8.0
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	25%	45%	51%	16%	39%
Moderate	28%	45%	37%	28%	39%
Moderately high	23%	43%	72%	12%	39%
High	25%	36%	66%	NA	33%
All	25%	40%	56%	20%	36%

Table 48. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, East Central (11) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	2%	18%	15%	1%	35%
Moderate	2%	9%	3%	<1%	15%
Moderately high	4%	18%	6%	<1%	28%
High	5%	13%	3%	0%	21%
All	13%	59%	27%	2%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	16.6	16.3	14.2	9.0	15.2
Moderate	19.1	15.4	14.3	12.4	15.6
Moderately high	37.2	30.5	25.7	11.0	30.1
High	59.4	40.4	41.8	NA	45.0
All	39.7	26.0	19.8	10.1	25.8
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	3.8	5.9	5.6	3.9	5.6
Moderate	4.5	5.5	6.7	5.5	5.6
Moderately high	9.4	11.4	13.8	7.6	11.6
High	11.0	12.5	27.2	NA	14.3
All	8.4	9.0	10.0	5.1	9.1
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	23%	36%	39%	43%	37%
Moderate	23%	36%	47%	44%	36%
Moderately high	25%	37%	54%	69%	38%
High	19%	31%	65%	NA	32%
All	21%	35%	50%	50%	35%

Table 49. Breakdown of the effects of conservation practices on total nitrogen loss with surface water runoff (nitrogen attached to sediment plus nitrogen dissolved in surface water runoff) into 16 combinations of four soil runoff potentials and four conservation treatment levels for nitrogen runoff control, Southeast Coastal Plain (12) region.

Soil runoff potential	Conservation treatment levels for nitrogen runoff control				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	15%	46%	17%	1%	78%
Moderate	2%	9%	2%	<1%	14%
Moderately high	2%	4%	1%	<1%	7%
High	<1%	1%	<1%	0%	1%
All	19%	60%	20%	1%	100%
Estimates of total nitrogen loss with surface water runoff for the no-practice scenario (average annual pounds/acre)					
Low	7.8	6.4	5.3	4.9	6.5
Moderate	9.8	12.9	10.9	9.6	12.0
Moderately high	33.4	20.2	17.8	4.3	23.3
High	19.4	15.1	17.0	NA	15.9
All	10.6	8.5	6.7	5.7	8.5
Reduction in total nitrogen loss with surface water runoff for due to conservation practices (average annual pounds/acre)					
Low	2.4	2.4	1.9	3.1	2.3
Moderate	2.3	3.8	3.2	2.9	3.5
Moderately high	8.0	7.7	5.8	2.0	7.4
High	9.0	7.1	11.9	NA	7.9
All	3.0	3.0	2.4	3.0	2.9
Percent reduction in total nitrogen loss with surface water runoff due to conservation practices					
Low	31%	37%	36%	62%	35%
Moderate	24%	30%	30%	31%	29%
Moderately high	24%	38%	32%	46%	32%
High	46%	47%	70%	NA	50%
All	28%	36%	35%	52%	34%

**Nitrogen loss in subsurface flow pathways.** The average annual reductions in nitrogen loss in subsurface flow pathways were estimated for the four soil leaching potentials and the four levels of nitrogen management. Table 50 presents estimates for the no-practice scenario and estimates of reductions in nitrogen loss in subsurface flow pathways due to conservation practices for all eight regions combined.

As shown previously in table 26 for the baseline scenario, the amounts of in nitrogen loss in subsurface flow pathways are highest for soils with the highest soil runoff potential. Table 50 shows that nitrogen losses for the no-practice scenario also increase as the soil runoff potential increases.

With respect to increases in the nitrogen management levels, the matrix for nitrogen losses in the no-practice scenario exhibit decreasing trends in nitrogen loss estimates as conservation treatment levels increase, in spite of modeling efforts to remove or reverse the effects of conservation practices. These trends may be due to the benefits of practices other than nitrogen management that may be correlated with the nitrogen management treatment levels.

Table 50 shows that **reductions** in nitrogen losses follow the trend of increasing amounts with increasing soil leaching potentials. Overall losses are highest for soils with the higher soil leaching potentials, and so reductions due to conservation practices also tend to be higher for these sample points as well. The mean average annual reduction due to conservation practice use in all eight regions, averaged over the four treatment levels, was:

- 4.2 pounds per acre per year for acres with a “low” soil leaching potential,
- 6.7 pounds per acre per year for acres with a “moderate” soil leaching potential,
- 12.7 pounds per acre per year for acres with a “moderately high” soil leaching potential, and
- 13.5 pounds per acre per year for acres with a “high” soil leaching potential.

Average annual reductions in nitrogen loss in subsurface flow pathways did not, however, consistently increase as treatment levels increased (table 50). The mean average annual reduction due to conservation practice use in all eight regions, averaged over the four soil leaching potentials, was:

- 6.1 pounds per acre per year for acres with a “low” nitrogen management level,
- 3.6 pounds per acre per year for acres with a “moderate” nitrogen management level,
- 10.1 pounds per acre per year for acres with a “moderately high” nitrogen management level, and
- 9.2 pounds per acre per year for acres with a “high” nitrogen management level.

**Percent reductions** generally increased with increasing conservation treatment levels when the “low” and “moderate” nitrogen management levels were combined. Percent reductions due to conservation practice use in all eight regions, averaged over the four soil leaching potentials, were:

- 17 percent for acres with a “low” conservation treatment level,
- 14 percent for acres with a “moderate” conservation treatment level,
- 54 percent for acres with a “moderately high” conservation treatment level, and
- 61 percent for acres with a “high” conservation treatment level.

These trends in model simulation results are not always manifested in each of the eight regions, as shown in tables 51 through 58. For example, the increasing trend in the average amount of the **reduction** in nitrogen loss as soil leaching potentials increased, averaged over the four conservation treatment levels, was evident in the matrix for only four regions— the Northern Plains (5) region, the Southern Plains (6) region, the North Central and Midwest (7) region, and the East Central (11) region.

An increasing trend in the average amount of the **reduction** in nitrogen loss as conservation treatment levels increase, averaged over the four soil leaching potentials, was not evident in any of the eight regions.

An increasing trend in the **percent reduction** in nitrogen loss as conservation treatment levels increase, averaged over the four soil leaching potentials, was evident in some regions, but only when either the two lowest or the two highest treatment levels were combined.

Five of the regions had cells in the matrixes with a mean of the average annual estimates of reductions in nitrogen loss in subsurface flow pathways less than zero, indicating that conservation practices resulted in an increase in nitrogen loss in subsurface flow pathways for those groups of acres, on average.

As discussed previously, the increases in nitrogen loss in subsurface flows are largely due to relatively weak nutrient management practices on acres with erosion control treatment. A portion of the reduction in nitrogen lost with surface runoff is re-routed to subsurface loss pathways, resulting in gains or only small reductions in nitrogen loss in subsurface flows. This re-routing of surface water runoff to subsurface flow pathways also results in additional nitrogen being extracted from the soil, diminishing and sometimes offsetting the overall positive effects of conservation practices on total nitrogen loss.

In most cases, the negative reductions in the matrix cells occurred in cells with only a few sample points, and so are probably not representative estimates of reductions for the combination of treatment and soil leaching potentials of those cells.

A notable exception, however, is the North Central and Midwest (7) region, where three cells, representing significant cropped acreage, had mean average annual reductions less than zero. One cell had a “low” level of nitrogen management and the other two cells had a “moderate” level of nitrogen management.

Similarly, one cell representing significant acreage with a “moderate” nitrogen management level in the Southeast Coastal Plain (12) region had a mean reduction less than zero.

These model simulation results underscore the importance of pairing water erosion control practices with effective nutrient management practices so that the full suite of conservation practices will provide the environmental protection needed.

Table 50. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, all eight regions combined.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	2%	7%	6%	4%	18%
Moderate	7%	24%	21%	15%	68%
Moderately high	1%	2%	2%	2%	6%
High	1%	3%	2%	2%	8%
All	11%	36%	31%	23%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	20.4	20.3	13.7	12.1	16.4
Moderate	32.6	22.3	17.1	14.6	20.1
Moderately high	57.4	39.6	29.8	16.8	32.8
High	72.3	62.4	34.6	24.9	46.9
All	35.2	26.3	18.7	15.1	22.4
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	1.0	1.5	7.1	6.0	4.2
Moderate	5.6	3.1	9.4	9.4	6.7
Moderately high	14.7	8.7	17.5	10.9	12.7
High	15.4	9.3	17.6	14.2	13.5
All	6.1	3.6	10.1	9.2	7.2
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	5%	7%	52%	50%	25%
Moderate	17%	14%	55%	64%	33%
Moderately high	26%	22%	59%	65%	39%
High	21%	15%	51%	57%	29%
All	17%	14%	54%	61%	32%

Table 51. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Northwest Non-Coastal (3) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	<1%	1%	1%	1%	2%
Moderate	6%	19%	26%	38%	89%
Moderately high	<1%	<1%	1%	2%	4%
High	1%	2%	1%	1%	5%
All	7%	23%	28%	43%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	29.9	43.5	26.8	19.9	32.5
Moderate	68.2	40.2	29.7	15.2	28.3
Moderately high	27.8	93.0	30.5	16.0	26.7
High	104.2	137.2	55.8	23.9	95.4
All	71.7	50.8	30.3	15.5	31.4
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	7.8	7.4	20.3	15.7	15.4
Moderate	37.2	14.8	23.1	10.2	16.7
Moderately high	12.5	24.2	21.9	8.7	13.6
High	35.1	33.5	51.5	15.3	32.1
All	36.4	16.6	23.6	10.3	17.2
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	26%	17%	76%	79%	48%
Moderate	55%	37%	78%	67%	59%
Moderately high	45%	26%	72%	54%	51%
High	34%	24%	92%	64%	34%
All	51%	33%	78%	67%	55%

Table 52. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Northern Plains (5) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	1%	5%	5%	5%	16%
Moderate	3%	19%	19%	27%	69%
Moderately high	<1%	1%	2%	5%	9%
High	<1%	2%	2%	3%	7%
All	5%	26%	28%	40%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	7.4	10.7	11.9	12.3	11.4
Moderate	20.4	14.9	13.0	12.7	13.8
Moderately high	13.7	9.5	16.1	11.4	12.5
High	23.3	33.7	23.7	21.9	25.6
All	18.0	15.2	13.6	13.1	14.1
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	4.0	5.4	8.2	9.1	7.4
Moderate	12.8	8.8	9.9	10.4	9.9
Moderately high	2.8	5.9	13.2	9.2	9.8
High	14.6	16.9	15.7	17.6	16.7
All	10.9	8.6	10.2	10.6	10.0
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	53%	51%	69%	74%	65%
Moderate	63%	59%	77%	82%	72%
Moderately high	21%	62%	82%	81%	78%
High	63%	50%	66%	80%	65%
All	61%	57%	75%	81%	71%

Table 53. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Southern Plains (6) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	1%	3%	5%	4%	12%
Moderate	4%	25%	23%	24%	76%
Moderately high	<1%	1%	1%	1%	3%
High	1%	3%	3%	2%	9%
All	6%	32%	31%	31%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	22.4	31.5	18.9	12.6	20.3
Moderate	29.4	15.5	21.0	16.3	18.1
Moderately high	29.5	25.0	45.4	20.3	28.2
High	89.4	41.2	26.6	24.1	34.5
All	33.7	19.7	21.6	16.6	20.1
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	7.2	3.9	13.6	9.5	9.5
Moderate	11.4	4.4	13.6	11.2	9.7
Moderately high	16.8	10.8	32.1	10.5	15.4
High	31.0	13.3	17.5	16.7	16.7
All	12.7	5.4	14.3	11.4	10.5
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	32%	13%	72%	76%	47%
Moderate	39%	28%	65%	69%	54%
Moderately high	57%	43%	71%	51%	55%
High	35%	32%	66%	69%	48%
All	38%	27%	66%	69%	52%

Table 54. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, North Central and Midwest (7) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	3%	7%	7%	2%	19%
Moderate	12%	27%	23%	8%	70%
Moderately high	1%	2%	2%	1%	5%
High	1%	2%	2%	1%	6%
All	16%	39%	34%	11%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	15.2	11.5	9.1	8.6	10.8
Moderate	27.7	20.0	13.6	11.6	18.3
Moderately high	52.9	40.3	27.0	27.8	36.6
High	60.3	54.1	40.4	28.3	46.0
All	28.0	21.5	14.9	13.1	19.4
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	-1.5	-0.8	3.2	3.3	1.1
Moderate	1.4	-0.2	5.3	4.9	2.4
Moderately high	12.3	8.0	13.5	18.8	11.7
High	9.9	3.6	18.2	13.3	10.8
All	1.8	0.3	6.0	6.0	3.1
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	-10%	-7%	35%	39%	10%
Moderate	5%	-1%	39%	43%	13%
Moderately high	23%	20%	50%	68%	32%
High	16%	7%	45%	47%	23%
All	6%	2%	40%	46%	16%

Table 55. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Lower Mississippi and Texas Gulf (9) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	3%	30%	8%	16%	56%
Moderate	3%	23%	7%	8%	41%
Moderately high	0%	<1%	0%	<1%	<1%
High	<1%	1%	1%	1%	2%
All	6%	54%	15%	25%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	44.9	26.0	23.0	13.4	22.9
Moderate	52.3	43.5	24.3	17.1	35.9
Moderately high	NA	26.5	NA	36.1	29.6
High	20.1	60.8	28.8	27.1	44.5
All	48.8	34.3	23.8	15.0	28.8
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	3.4	2.7	9.3	2.7	3.6
Moderate	1.3	0.1	5.9	3.3	1.8
Moderately high	NA	-9.6	NA	-1.1	-6.9
High	11.8	9.4	8.8	2.8	7.5
All	2.3	1.7	7.8	2.9	2.9
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	8%	10%	40%	20%	16%
Moderate	3%	0%	24%	19%	5%
Moderately high	NA	-36%	NA	-3%	-23%
High	59%	15%	31%	10%	17%
All	5%	5%	33%	19%	10%

Table 56. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Northeast (10) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	1%	1%	3%	3%	8%
Moderate	8%	16%	14%	7%	44%
Moderately high	6%	10%	13%	3%	32%
High	3%	7%	4%	1%	15%
All	18%	34%	34%	14%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	58.5	51.0	48.7	35.1	46.4
Moderate	90.7	50.6	30.7	27.5	47.7
Moderately high	108.9	47.1	44.4	29.7	55.5
High	124.2	76.6	35.6	33.8	72.1
All	100.1	54.6	38.2	29.9	53.8
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	8.7	-3.4	38.2	28.3	23.4
Moderate	17.8	12.3	19.2	16.7	16.1
Moderately high	30.2	7.7	32.1	18.7	22.7
High	27.0	11.3	21.0	16.9	17.7
All	22.8	10.1	26.2	19.2	19.1
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	15%	-7%	78%	81%	50%
Moderate	20%	24%	63%	61%	34%
Moderately high	28%	16%	72%	63%	41%
High	22%	15%	59%	50%	25%
All	23%	18%	68%	64%	35%

Table 57. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, East Central (11) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	1%	1%	2%	2%	5%
Moderate	11%	34%	24%	7%	75%
Moderately high	2%	5%	5%	3%	14%
High	1%	3%	1%	<1%	5%
All	14%	43%	32%	11%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	29.4	19.9	12.2	10.0	15.8
Moderate	48.1	35.6	20.3	15.3	30.6
Moderately high	36.4	66.2	23.5	15.5	37.0
High	49.1	66.6	28.6	17.5	51.0
All	45.9	40.4	20.8	14.8	31.9
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	8.1	-0.7	2.5	3.3	2.5
Moderate	10.7	4.1	8.8	5.7	6.7
Moderately high	4.1	19.4	7.7	5.9	10.6
High	15.5	11.6	13.8	4.4	12.1
All	10.0	6.1	8.6	5.4	7.3
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	27%	-4%	20%	33%	16%
Moderate	22%	12%	44%	37%	22%
Moderately high	11%	29%	33%	38%	29%
High	31%	17%	48%	25%	24%
All	22%	15%	41%	37%	23%

Table 58. Breakdown of the effects of conservation practices on nitrogen loss in subsurface flow pathways into 16 combinations of four soil leaching potentials and four conservation treatment levels for nitrogen management, Southeast Coastal Plain (12) region.

Soil leaching potential	Conservation treatment levels for nitrogen management				All
	Low	Moderate	Moderately high	High	
Percent of cropped acres					
Low	1%	6%	5%	3%	15%
Moderate	4%	13%	9%	5%	31%
Moderately high	1%	6%	5%	1%	14%
High	6%	17%	11%	6%	41%
All	13%	42%	29%	16%	100%
Estimates of nitrogen loss in subsurface flow pathways for the no-practice scenario (average annual pounds/acre)					
Low	29.8	61.5	20.2	10.4	35.6
Moderate	59.2	45.4	24.4	33.5	39.0
Moderately high	49.2	47.3	40.4	22.6	43.1
High	74.3	87.6	41.0	26.0	63.4
All	61.7	65.2	32.6	25.5	49.0
Reduction in nitrogen loss in subsurface flow pathways for due to conservation practices (average annual pounds/acre)					
Low	1.0	-0.8	7.7	2.9	2.7
Moderate	12.4	8.1	9.0	13.9	9.9
Moderately high	9.0	5.8	17.5	2.9	9.8
High	8.5	6.3	16.4	7.2	9.6
All	8.9	5.8	13.0	8.3	8.7
Percent reduction in nitrogen loss in subsurface flow pathways due to conservation practices					
Low	3%	-1%	38%	28%	8%
Moderate	21%	18%	37%	41%	25%
Moderately high	18%	12%	43%	13%	23%
High	11%	7%	40%	28%	15%
All	14%	9%	40%	33%	18%

## Appendix A: Adjustment of CEAP Sample Weights for the 2003-06 CEAP Sample for Use with the 12 New CEAP Production Regions

The first CEAP national assessment was based on a subset of NRI sample points from the 2003 NRI.<sup>17</sup> The 2001, 2002, and 2003 Annual NRI surveys were used to draw the sample.<sup>18</sup> The sample is statistically representative of cultivated cropland acres for the year 2003. Statistical sample weights were originally derived for each CEAP sample point so as to approximate acres reported in the 2003 NRI for similar cropping systems when aggregated to the 4-digit HUC level.

These original CEAP sample acreage weights, however, distort the cultivated cropland acreage estimates when the sample points are aggregated to geographic areas other than the 4-digit HUC. It was thus necessary to adjust the sample weights for reporting cultivated cropland acres by the new CEAP production regions.

### Original Derivation of Cropping Systems

Cropping systems were originally derived based on the 2003 NRI database for cultivated cropland, as described in the CEAP documentation report “CEAP and NRI Cropping Systems 2008 Documentation.” (A cropping system represents a suite of crops that is typically grown in the same field over a period of a few years.) This set of data (BROAD03=1) included 96,661 points representing 309,866,800 cultivated cropland acres. The five year crop sequence from 1999 through 2003 was used to derive the NRI cropping systems. Second crops (NRI variable name “sdcdrpxx”) were included when reported. NRI crop groups were simplified somewhat prior to developing cropping systems to help reduce the number of possible crop combinations. Oats was combined with “other close grown crops;” tobacco was combined with vegetables; summer fallow and idle cropland were combined; the three types of NRI hay were combined into one group; and the three types of NRI pasture were combined into one group.

A total of 62 cropping systems were derived as shown in Table A1. Except for single-crop systems, cropping systems were derived based on the dominant sets of crop sequences. The entire collection of NRI cultivated cropland points was used without consideration for regional dominance. Each of the single-crop systems (systems 2 through 23) was included regardless of how many samples were in the set to provide perspective on the frequency at which “continuous cropping” was present in the NRI. The simplest cropping systems that were mutually exclusive were identified first—through cropping system number 35. Subsequent cropping systems are not mutually exclusive as they depend on the order of operation. For example, cropping systems 40 and 41—rice with other crops—include a small number of points with hay. And, consequently, the following 6 hay systems (43-48) do not include any rice, nor do any of the remaining cropping

systems. Similarly, cropping systems numbered above 50 do not include any hay. And so on. The order of operations was determined so as to preserve cropping systems that are important either for data analysis or for other uses. Some cropping systems consist of only a few points and represent less than 1 percent of the cultivated cropland acreage. These were retained to facilitate the derivation of the more aggregated primary cropping systems for use in reporting.

The last cropping system—number 100, at the bottom of the table—consists of 16 2003 NRI sample points that were either aquaculture or non-cultivated crops for all 5 years. This tiny set represents only 36,800 acres. These acres were excluded from the CEAP sample domain. Also shown in Table A1 are four other NRI cropping systems without representation in the CEAP samples—systems 20-23. These are combinations of either fallow and idle with no other crops, with hay only, with pasture only, or with hay and pasture only. The presence of either fallow or idle qualifies the sample as cultivated cropland according to the NRI land use classification rules. Since all the final CEAP samples include at least one close grown or row crop (with the exception of 43 samples with continuous annual hay which is typically a small grain hay), these systems are not represented by CEAP samples. This set (system 100) represents about 5 million acres. These acres were also excluded from the CEAP sample domain prior to derivation of the original CEAP sample weights.

Cropping systems were also derived originally for each CEAP sample point. The rules used for the 2003 NRI sample points were applied to the crops reported for each sample point in the CEAP survey. The number of CEAP sample points corresponding to the original NRI cropping systems are also shown in table A1.

The NRI-CEAP Cropland Survey reported 144 different specific crops grown at 18,691 final sample points. Specific crops were often a combination of crop species and crop use. For example, corn for grain and corn for silage and corn for seed were reported as separate crops in the survey database. These 144 specific crops were aggregated into 20 CEAP crop groups, shown in table A2, to correspond to the NRI crop groups. The crop groups used for NRI crop reporting are also shown in table A2.

While the majority of samples consist of a single crop for each of the three years, it is common to have 2 crops per year. In a few cases, more than 2 crops per year occur. The maximum number of crops reported per year ranged from 3 in 2005 to 5 in 2003 and 2004. Multiple harvests within a year were often reported as separate crops as well. In most cases, samples with 3 or more crops reported per year were instances of split fields, which were simplified by dropping the crops in the part of the field that did not correspond to the NRI cropping history.

<sup>17</sup> See “United States Department of Agriculture, Natural Resources Conservation Service. 2007. 2003 National Resources Inventory. <http://www.nrcs.usda.gov/technical/nri>.”

<sup>18</sup> Information about the CEAP sample design is in “NRI-CEAP Cropland Survey Design and Statistical Documentation,” available at <http://www.nrcs.usda.gov/technical/nri/ceap>.

The crop sequence for each CEAP sample point was converted to the simpler representation in terms of the 20 CEAP crop groups shown in table A2. Typical crop sequences look like the following:

	Year 1	Year 2	Year 3
Sample point A	CN_ _ _ _	SB_ _ _ _	CN_ _ _ _
Sample point B	CN_WH_ _	SB_WH_ _	CN_WH_ _
Sample point C	VT_VT_VT_ _	VT_VT_VT_ _	VT_VT_VT_ _
Sample point D	WH_HY_ _	HY_HY_ _	VT_SB_CG_ _
Sample point E	_SG_ _	FW_ _ _ _	_ _CT_ _

Sample E represents the case where crops were reported for a split field and subsequently edited by dropping some of the crops. Re-plantings were generally edited in the same manner.

### Adjustment of acreage weights to represent the 12 new CEAP production regions

The original sample weights used for reporting 2003-06 CEAP findings in the first national assessment reports were adjusted so that, when aggregating over CEAP sample points to obtain estimates for CEAP production regions, the acreage estimates would correspond to the acreage estimates derived from the full 2003 NRI set of points for a set of major cropping systems within each production region.

The first step in this process was to define the “major” cropping systems—cropping systems suitable for reporting—within each of the 12 CEAP production regions (table A3). The original 62 cropping systems for the 2003 NRI and for the 2003-06 CEAP sample, as described above and listed in table A1, were retained without modification or adjustment. These were combined within each production region so that each major cropping system would have sufficient sample size to allow estimates to be reported. These major cropping systems by production region were derived both for the 2003 NRI points and the 2003-06 CEAP sample points using the same rules, and are presented in table A3.

For each production region and major cropping system, the sum of the original CEAP sample weights is compared to the 2003 NRI estimate of cultivated cropland acres in table A3. The ratio of the 2003 NRI acres to the sum of the original CEAP weights provides a multiplier which, when multiplied times the original CEAP sample weights at each sample point produces a set of adjusted weights that can be used to accurately aggregate CEAP sample results to the production region level for reporting.

Thus, aggregating over the CEAP sample point weights within each production region reproduces the estimates of cultivated cropland acreage that correspond to estimates from the full 2003 NRI, as shown in the following table.

PR ID	Number of 2003 NRI points	2003 cultivated cropland acres	Number of 2003-06 CEAP sample points*	Sum of adjusted CEAP sample weights
1	563	1,214,000	158	1,214,000
2	1,125	3,440,500	111	3,440,500
3	4,560	12,315,000	890	12,315,000
4	1,208	2,432,200	190	2,432,200
5	11,255	47,688,900	1,518	47,688,900
6	13,806	63,829,400	2,615	63,829,400
7	42,114	117,423,200	8,065	117,423,200
8	1,631	6,431,200	232	6,431,200
9	6,940	21,162,500	1,820	21,162,500
10	3,430	6,547,500	888	6,547,500
11	3,323	8,723,200	915	8,723,200
12	5,080	13,502,000	1,289	13,502,000
All 12 regions	95,035	304,709,600	18,691	304,709,600

\* Includes 368 CEAP sample points in the “West” region.

As indicated earlier in this report, the CEAP sample points from the original “West” region—368 sample points—could not be used to summarize findings by the CEAP production regions because the full set of APEX modeling results were not available. Thus, the sum of the adjusted CEAP sample weights understates the cultivated cropland acres in four production regions (highlighted in yellow in the table below), as shown by comparing the table below to the table above.

Production region	Number of 2003-06 CEAP sample points*	Sum of adjusted CEAP sample weights
Northwest Coastal (1)	158	1,214,000
California Coastal (2)	0	0
Northwest Non-Coastal (3)	817	11,477,012
Southwest Non-Coastal (4)	15	155,242
Northern Plains (5)	1,518	47,688,900
Southern Plains (6)	2,606	63,563,684
North Central and Midwest (7)	8,065	117,423,200
South Central (8)	232	6,431,200
Lower Mississippi and Texas Gulf Coast (9)	1,820	21,162,500
Northeast (10)	888	6,547,500
East Central (11)	915	8,723,200
Southeast Coastal Plain (12)	1,289	13,502,000
All 12 regions	18,323	297,888,439

\* Excludes 368 CEAP sample points in the “West” region that could not be used in the national assessments because the full set of APEX modeling results were not available.

Results for two of these production regions—the California Coastal region (2) and the Southwest Non-Coastal region (4)—were not included in this report because neither region had enough 2003-06 sample points to support a regional assessment. When the remaining 2 regions that did not have sufficient sample size are dropped from the table—the Northwest Coastal region (1) and the South Central region (8)—the regional and total estimates of cultivated cropland acres match those presented in table 1.

Table A1. Original cropping systems based on rules derived using the 2003 NRI and then applied to the 2003-06 CEAP sample points.

System number	Cropping system name (nricropsys5)	No. of 2003 NRI cultivated cropland points	2003 NRI acres	No. of CEAP sample points*
1	CN-SB only, w/wout FWID	33,797	94,516,400	7,122
2	corn only, w/wout FWID	3,446	9,668,600	1,196
3	soybean only, w/wout FWID	2,590	6,656,400	949
4	cotton only, w/wout FWID	2,432	8,747,200	715
5	sorghum only, w/wout FWID	538	2,239,400	68
6	wheat only, w/wout FWID	7,894	38,194,500	1,774
7	rice only, w/wout FWID	739	2,228,800	179
8	veg/tobacco only, w/wout FWID	666	1,363,600	90
9	peanuts only, w/wout FWID	96	346,100	16
10	sunflower only, w/wout FWID	10	23,800	3
11	sugar beet only, w/wout FWID	7	15,200	4
12	potato only, w/wout FWID	31	54,700	5
13	NRI other row only, w/wout FWID	364	1,216,300	70
14	barley only, w/wout FWID	316	996,400	87
15	NRI other close grown only, w/wout FWID	825	2,925,200	164
20	pasture only, with FWID	60	200,300	0
21	hay only, with FWID	176	662,500	0
22	pasture and hay only, with FWID	4	8,800	0
23	fallow and/or idle only	1,370	4,248,800	0
27	annual hay only, w/wout FWID (CEAP only)	0	0	43
30	CN-SB-WT only	5,856	15,613,100	1,005
31	SG-WT only	1,611	9,059,800	221
32	SB-WT only	2,158	6,889,600	617
33	CT-PN only	387	1,451,500	110
34	SB-CT only	558	1,742,200	116
35	CN-CT only	412	1,490,000	149
40	RI-SB w/wout other crops	1,428	4,853,600	293
41	RI w/wout other crops, no SB	108	379,200	31
43	HAY/PAST-CN-SB, w/wout other crops	2,794	7,081,000	78
44	HAY/PAST-CN-CLOSE, w/wout other crops (no SB)	1,255	3,364,300	109
45	HAY/PAST-CN, w/wout other crops (no SB, close)	2,536	7,180,600	362
46	HAY/PAST-SB, w/wout other crops (no CN)	960	2,525,700	90
47	HAY/PAST-CLOSE, w/wout other crops (no CN, SB)	2,200	7,306,600	308
48	HAY/PAST w/wout other crops (no CN-SB-close)	529	1,678,500	38
52	veg/tobacco and close grown only	570	2,038,700	212
53	veg/tobacco w/wout other row crops (some close)	2,345	6,727,400	318
60	mix of remaining close grown crops, no row	2,939	12,159,600	302
61	CN and close grown crops	1,862	7,239,600	496
62	SB and close grown crops	333	1,063,100	78
63	CN-SB and close grown crops	612	1,632,600	134
64	CT and close grown crops	602	2,393,700	105
65	SG and close grown crops	109	566,800	11
66	SF and close grown crops	1,267	4,951,500	120
67	PO and close grown crops	559	982,000	89
68	SU and close grown crops	229	616,800	61
69	PN and close grown crops	55	197,700	11
70	OTHROW and close grown crops	90	385,900	23
71	CT-PN and close grown crops	100	380,000	22
72	CT-SB and close grown crops	155	433,300	41
73	CT-CN and close grown crops	98	336,900	10
80	PO and other row crops (some close)	518	1,292,600	47
81	SU and other row crops (no PO)(some close)	671	2,702,500	64
82	SF and other row crops (no PO,SU)(some close)	1,075	4,039,700	65

Table A1.—continued.

System number	Cropping system name (nricropsys5)	No. of 2003 NRI cultivated cropland points	2003 NRI acres	No. of CEAP sample points*
83	remaining CT-SG crop mixes (row and close)	868	3,618,600	85
84	remaining CT-PN-row and other crops	263	767,200	34
85	remaining CT-CN-row and other crops	416	1,202,400	41
86	remaining CN-SB-row and other crops	875	2,663,000	45
87	remaining CN-SG crop mixes (row and close)	556	2,364,200	75
88	remaining SB-SG crop mixes (row and close)	914	2,871,000	183
89	remaining NRI OTHROW-row and other crops	190	574,400	8
90	remaining PN-row and other crops	221	700,100	30
100	NRI crops are: 171, 5, 6, 2, 400, 900, or missing	16	36,800	0
totals		96,661	309,866,800	18,722

Source: Table reprinted from "CEAP and NRI Cropping Systems 2008 Documentation."

\* Included are 31 points that were later dropped from the 2003-06 final sample because of inadequate survey data to run the APEX model.

The following abbreviations are used in this table:

CN—corn  
 SB—soybean  
 FWID—fallow or idle  
 SG—sorghum  
 CT—cotton  
 PN—peanuts  
 RI—rice  
 PAST—pasture  
 CLOSE—any close grown crops, such as wheat, barley, oats, or grass seed  
 SU—sugar beets  
 SF—sunflower  
 OTHERROW—NRI "other row crop" category  
 PO—potato

**Table A2.** Crop groups used to define cropping systems (CEAP crops listed are those reported in the CEAP surveys).

Crop groups	Crop Group Abbreviation	CEAP crop code	CEAP crop	NRI crop code	NRI crop
<b>Row Crops</b>					
Corn	CN	191	Corn, All	11	Corn
	CN	218	Corn, dry fodder, hogged	11	Corn
	CN	6	Corn, grain	11	Corn
	CN	38	Corn, seed	11	Corn
	CN	5	Corn, silage	11	Corn
	CN	7	Corn, white	11	Corn
	CN	19	Popcorn	11	Corn
	CN	2110	Sweet corn, fresh	11	Corn
	CN	4110	Sweet corn, processing	11	Corn
	CN	246	Sweet corn for seed	11	Corn
Sorghum	SG	192	Sorghum, All	12	Sorghum
	SG	25	Sorghum, grain	12	Sorghum
	SG	24	Sorghum, silage	12	Sorghum
Soybean	SB	26	Soybeans	13	Soybeans
Cotton	CT	282	Cotton, Pima	14	Cotton
	CT	281	Cotton, Upland	14	Cotton
Peanuts	PN	16	Peanuts	15	Peanuts
Sugar beets	SU	28	Sugar beets for sugar	17	Sugar beets
Potatoes	PO	20	Potatoes	18	Potatoes
Sugarcane	SC	29	Sugarcane for sugar	20	Other Row Crops
Sunflower	OS	148	Sunflower seed, non-oil	21	Sunflower
	OS	30	Sunflower seed, oil	21	Sunflower
Other row crops	OR	160	Guar	20	Other Row Crops
	OR	181	Kenaf	20	Other Row Crops
	OR	98	Safflower	20	Other Row Crops
Beans and Peas	BP	3	Beans, dry edible	19	Vegetables
	BP	2122	Green peas, Fresh	19	Vegetables
	BP	4122	Green peas, Processing	19	Vegetables
	BP	169	Lentils	19	Vegetables
	BP	268	Lima beans, dry	19	Vegetables
	BP	2115	Lima beans, fresh	19	Vegetables
	BP	4115	Lima beans, processing	19	Vegetables
	BP	197	Mung beans	19	Vegetables
	BP	123	Peas, all other	19	Vegetables
	BP	200	Peas, Austrian winter	19	Vegetables
	BP	124	Peas, black eye	19	Vegetables
	BP	125	Peas, cowpeas	19	Vegetables
	BP	17	Peas, dry edible	19	Vegetables
	BP	4131	Snap bean, processing	19	Vegetables
	BP	2131	Snap beans, fresh	19	Vegetables
	BP	243	Southern peas, cowpeas, etc	19	Vegetables

**Table A2.—continued.**

Crop groups	Crop Group Abbreviation	CEAP crop code	CEAP crop	NRI crop code	NRI crop
Vegetables and Tobacco	VT	32	Tobacco, (other)	16	Tobacco
	VT	193	Tobacco, burley	16	Tobacco
	VT	196	Tobacco, flue-cured	16	Tobacco
	VT	103	Beets	19	Vegetables
	VT	104	Broccoli	19	Vegetables
	VT	105	Brussel sprouts	19	Vegetables
	VT	2106	Cabbage, Fresh	19	Vegetables
	VT	4106	Cabbage, Processing	19	Vegetables
	VT	4	Cantaloupe	19	Vegetables
	VT	107	Carrots	19	Vegetables
	VT	108	Cauliflower	19	Vegetables
	VT	109	Celery	19	Vegetables
	VT	249	Chinese cabbage	19	Vegetables
	VT	185	Collards	19	Vegetables
	VT	2111	Cucumbers, Fresh	19	Vegetables
	VT	4111	Cucumbers, Processing	19	Vegetables
	VT	112	Eggplant	19	Vegetables
	VT	114	Garlic	19	Vegetables
	VT	117	Lettuce, head	19	Vegetables
	VT	149	Lettuce, other	19	Vegetables
	VT	146	Lettuce, romaine	19	Vegetables
	VT	13	Melons, honeydew	19	Vegetables
	VT	187	Mustard greens	19	Vegetables
	VT	135	Onions, dehydrated	19	Vegetables
	VT	120	Onions, dry	19	Vegetables
	VT	126	Peppers, bell	19	Vegetables
	VT	127	Peppers, chili	19	Vegetables
	VT	244	Peppers, hot	19	Vegetables
	VT	128	Pumpkins	19	Vegetables
	VT	129	Radishes	19	Vegetables
	VT	4132	Spinach, processing	19	Vegetables
	VT	133	Squash, summer	19	Vegetables
	VT	150	Squash, winter	19	Vegetables
VT	31	Sweet potatoes	19	Vegetables	
VT	2134	Tomatoes, fresh	19	Vegetables	
VT	4134	Tomatoes, processing	19	Vegetables	
VT	145	Turnips	19	Vegetables	
VT	236	Vegetables, other	19	Vegetables	
VT	37	Vegetables, seeds	19	Vegetables	
VT	33	Watermelons	19	Vegetables	
<b>Hay, Pasture, Fallow, and Idle</b>					
Pasture	PS	316	Pasture as crop rotation	200	Pasture
Hay	HY	219	Sorghum, hay	12	Sorghum
	HY	310	Clover	144	Hay, all types
	HY	311	Grasses, other than clover	144	Hay, all types
	HY	226	Grass silage	144	Hay, all types
	HY	1	Hay, Alfalfa and alfalfa Mix	144	Hay, all types
	HY	232	Hay, Bahia	144	Hay, all types
	HY	231	Hay, Bermuda grass	144	Hay, all types
	HY	11	Hay, other	144	Hay, all types
	HY	217	Hay, small grain	144	Hay, all types
	HY	225	Hay, wild	144	Hay, all types
	HY	23	Silage & haylage	144	Hay, all types
	HY	180	Sorghum-sudan cross	144	Hay, all types
	HY	167	Sudan	144	Hay, all types
	HY	199	Teff	144	Hay, all types
	HY	39	Vetchseed, hairy	144	Hay, all types

**Table A2.—continued.**

Crop groups	Crop Group Abbreviation	CEAP crop code	CEAP crop	NRI crop code	NRI crop
Fallow and Idle	FI	333	Idle or fallow (2003 only)		summer fallow or idle
	FW	333	Summer fallow	170	summer fallow
	ID	318	Idle cropland	180	Idle cropland
<b>Close Grown Crops</b>					
Wheat	WH	34	Wheat, All	111	wheat
	WH	172	Wheat, All, for seed	111	wheat
	WH	163	Wheat, durum	111	wheat
	WH	164	Wheat, other spring	111	wheat
	WH	165	Wheat, winter	111	wheat
Rice	RI	21	Rice	113	Rice
	RI	319	Rice, sweet	113	Rice
	RI	178	Rice, wild	113	Rice
Barley	BY	190	Barley, All	114	Barley
	BY	290	Barley, Feed	114	Barley
	BY	2	Barley, feed or malt	114	Barley
	BY	291	Barley, Malt	114	Barley
	BY	173	Barley, seed	114	Barley
Small grain crops	SM	15	Oats	112	Oats
	SM	84	Buckwheat	116	Other Close Grown
	SM	161	Emmer and spelt	116	Other Close Grown
	SM	22	Rye	116	Other Close Grown
	SM	162	Triticale	116	Other Close Grown
Other close grown crops	CG	35	Alfalfa seed	116	Other Close Grown
	CG	228	Bentgrass seed	116	Other Close Grown
	CG	229	Bermuda grass seed	116	Other Close Grown
	CG	40	Bluegrass seed	116	Other Close Grown
	CG	215	Brome grass seed	116	Other Close Grown
	CG	85	Canola	116	Other Close Grown
	CG	153	Cilantro	116	Other Close Grown
	CG	194	Clover seed	116	Other Close Grown
	CG	214	Clover seed, crimson	116	Other Close Grown
	CG	43	Clover seed, red	116	Other Close Grown
	CG	203	Clover seed, white	116	Other Close Grown
	CG	317	Field and forage crops, Other	116	Other Close Grown
	CG	9	Flaxseed	116	Other Close Grown
	CG	10	Forage and green chop	116	Other Close Grown
	CG	138	Grass seed, other	116	Other Close Grown
	CG	41	Lespedeza seed	116	Other Close Grown
	CG	141	Millet	116	Other Close Grown
	CG	94	Mustard seed	116	Other Close Grown
	CG	42	Orchard grass seed	116	Other Close Grown
	CG	18	Peppermint	116	Other Close Grown
	CG	170	Rapeseed	116	Other Close Grown
	CG	136	Rye grass seed	116	Other Close Grown
	CG	168	Sage	116	Other Close Grown
	CG	44	Tall fescue seed	116	Other Close Grown
CG	45	Timothy seed	116	Other Close Grown	

Source: CEAP and NRI Cropping Systems 2008 Documentation

**Table A3.** Major cropping systems defined for the 12 new CEAP production regions (PRs), providing basis for sample weight adjustment.

Production region number	Major cropping system	No. of 2003-06 CEAP sample points	Sum of original CEAP sample weights	No. of 2003 NRI points	No. of 2003 cultivated cropland acres	PR and cropping system multiplier
1	Wheat only, w/wout FWID	21	233,823	63	183,400	0.784353
1	All Hay-crop mixes	15	70,038	100	192,900	2.7542188
1	Mix of remaining row crops only	19	81,362	37	50,600	0.6219115
1	Other close grown crops only	91	841,866	283	636,300	0.7558206
1	Remaining mix of row AND close crops	12	74,563	80	150,800	2.0224489
2	rice only, w/wout FWID	36	581,454	204	600,000	1.0318953
2	veg and/or tobacco only, w/wout FWID	14	263,136	184	353,300	1.3426508
2	Mix of remaining row crops only	20	855,671	196	928,400	1.0849962
2	Remaining mix of row AND close crops	24	741,178	242	730,400	0.9854581
2	Hay-crop mix or other close-grown crops	17	688,902	299	828,400	1.2024938
3	wheat only, w/wout FWID	336	5,237,699	1126	4,323,500	0.8254579
3	barley only, w/wout FWID	58	584,879	152	292,100	0.4994192
3	PO and close grown crops	75	634,265	504	756,400	1.1925613
3	Sugar beets with other crops	61	473,755	352	562,700	1.187745
3	All Hay-crop mixes	80	1,542,838	991	2,134,600	1.3835546
3	Mix of remaining row crops only	63	686,260	175	390,400	0.5688808
3	Other close grown crops only	97	1,339,580	796	2,855,800	2.1318618
3	Remaining mix of row AND close crops	120	1,814,434	464	999,500	0.5508606
4	cotton only, w/wout FWID	33	315,512	150	246,500	0.7812697
4	wheat only, w/wout FWID	27	318,336	177	328,700	1.0325573
4	CT and close grown crops	18	213,061	91	160,400	0.7528369
4	Sorghum and other row crops	21	366,192	156	255,900	0.6988145
4	Mix of remaining row crops only	19	265,831	104	169,500	0.6376231
4	Remaining mix of row AND close crops	28	337,811	65	142,500	0.4218336
4	Hay-crop mix or other close-grown crops	44	797,906	465	1,128,700	1.4145769
5	CN-SB only, w/wout FWID	205	5,077,059	1095	3,556,000	0.7004055
5	Corn only, w/wout FWID	41	1,042,354	129	404,800	0.3883518
5	Wheat only, w/wout FWID	395	12,739,650	1834	11,022,600	0.86522
5	SB-WT only	135	4,487,960	713	2,923,700	0.6514541
5	Vegetables/tobacco with close grown only	78	2,697,293	289	1,245,000	0.4615739
5	SF and close grown crops	96	3,117,644	1097	4,254,200	1.3645561
5	CN and/or SB with Close Grown	144	3,684,780	1191	4,222,000	1.1457945
5	CN and hay-other crop mix	22	501,285	307	934,200	1.8636116
5	Hay-crop mix no CN	51	1,667,861	536	2,601,700	1.5599022
5	Mix of remaining row crops only	52	1,420,458	375	1,040,900	0.7327918
5	Other close grown crops only	193	7,240,725	1863	8,232,900	1.1370271
5	Remaining mix of row AND close crops	106	3,770,622	1826	7,250,900	1.9229982
6	CN-SB only, w/wout FWID	201	4,052,440	1018	3,445,600	0.8502532
6	corn only, w/wout FWID	194	3,855,815	895	3,594,700	0.9322803
6	cotton only, w/wout FWID	235	4,429,286	847	3,681,900	0.8312627
6	sorghum only, w/wout FWID	50	1,644,806	351	1,471,200	0.8944522
6	wheat only, w/wout FWID	950	24,642,935	4194	20,594,400	0.8357121
6	SG-WT only	200	5,680,268	1513	8,670,200	1.5263717
6	CT-SG only	49	1,269,672	466	1,905,900	1.5010958
6	CT and close grown crops	69	1,483,395	385	1,739,500	1.1726479
6	CN and/or SB with Close Grown	222	5,849,459	1141	5,736,200	0.9806377
6	All Hay-crop mixes	123	3,255,042	575	2,329,300	0.7155976
6	Mix of remaining row crops only	126	2,638,555	822	3,195,900	1.2112313
6	Other close grown crops only	75	2,143,314	426	2,109,300	0.98413
6	Remaining mix of row AND close crops	121	3,123,913	1173	5,355,300	1.7142923

**Table A3—continued.**

Production region number	Major cropping system	No. of 2003-06 CEAP sample points	Sum of original CEAP sample weights	No. of 2003 NRI points	No. of 2003 cultivated cropland acres	PR and cropping system multiplier
7	CN-SB only, w/wout FWID	5554	81,757,632	28865	81,191,400	0.9930743
7	corn only, w/wout FWID	536	8,103,601	1340	3,191,800	0.3938743
7	soybean only, w/wout FWID	334	4,287,452	736	1,652,700	0.3854737
7	CN-SB-WT only	492	5,858,610	3406	9,141,200	1.5603018
7	SB-WT only	289	3,867,223	688	1,784,300	0.4613905
7	vt with other row crops only	49	744,564	381	1,035,700	1.3910146
7	CN and/or SB with Close Grown	185	2,710,443	635	1,721,800	0.6352466
7	SB and SG with or w/out Close Grown	79	1,065,377	355	981,800	0.9215515
7	CN and hay-other crop mix	285	4,445,452	3630	10,539,000	2.3707378
7	Hay-crop mix no CN	133	2,039,617	719	2,117,100	1.0379889
7	Mix of remaining row crops only	57	780,461	743	2,112,000	2.7060945
7	Other close grown crops only	20	361,550	143	391,800	1.0836673
7	Remaining mix of row AND close crops	52	1,079,487	473	1,562,600	1.4475392
8	CN-SB only, w/wout FWID	19	335,271	70	253,600	0.7564032
8	wheat only, w/wout FWID	22	773,816	303	1,203,000	1.554633
8	RI and SB only, w/wout FWID	20	413,676	128	417,000	1.0080346
8	CN and/or SB with Close Grown	52	1,197,750	173	555,900	0.4641203
8	SG and other row drops	13	579,854	91	407,900	0.7034535
8	SG with close grown crops	12	343,465	58	258,900	0.7537885
8	Mix of remaining row crops only	35	1,015,273	384	1,622,500	1.5980927
8	Remaining mix of row AND close crops	28	658,856	147	525,500	0.7975946
8	Hay-crop mix or other close-grown crops	31	1,218,409	277	1,186,900	0.974139
9	CN-SB only, w/wout FWID	256	1,711,982	533	1,277,200	0.746036
9	soybean only, w/wout FWID	352	4,068,845	1094	3,014,800	0.7409474
9	cotton only, w/wout FWID	274	3,333,219	818	2,813,900	0.8441989
9	rice only, w/wout FWID	138	1,840,607	519	1,561,400	0.8483072
9	CN-CT only	66	864,269	194	708,100	0.8193051
9	RI and SB only, w/wout FWID	250	3,301,151	1003	3,332,100	1.0093753
9	CN and/or SB with Close Grown	156	1,400,057	741	1,913,100	1.3664443
9	CT and SB with or w/out other crops	85	891,576	548	1,665,500	1.8680407
9	Mix of remaining row crops only	168	2,608,114	777	2,665,500	1.0220029
9	Remaining mix of row AND close crops	47	534,980	494	1,686,100	3.1517095
9	Hay-crop mix or other close-grown crops	28	358,991	219	524,800	1.4618766
10	CN-SB only, w/wout FWID	211	1,284,297	519	824,600	0.6420634
10	corn only, w/wout FWID	216	1,558,268	541	988,300	0.6342296
10	soybean only, w/wout FWID	33	197,443	67	102,700	0.5201502
10	CN and/or SB with Close Grown	205	1,376,206	458	774,200	0.5625613
10	CN and hay-other crop mix	132	1,096,739	1414	3,025,600	2.7587228
10	Mix of remaining row crops only	37	329,959	169	280,600	0.85041
10	Remaining mix of row AND close crops	26	336,604	93	212,600	0.6316028
10	Hay-crop mix (no CN) or other close-grown crops	28	270,846	169	338,900	1.2512647
11	CN-SB only, w/wout FWID	391	3,405,230	981	2,393,900	0.7030068
11	corn only, w/wout FWID	73	697,777	187	499,200	0.715415
11	soybean only, w/wout FWID	74	791,430	210	514,400	0.6499631
11	CN and/or SB with Close Grown	156	1,687,548	586	1,640,800	0.9722983
11	CT w/ or w/out other row crops, no CGC	65	699,113	199	499,800	0.7149058
11	Mix of remaining row crops only	40	411,426	189	436,200	1.0602145
11	Remaining mix of row AND close crops	49	615,417	151	503,700	0.8184699
11	Hay-crop mix or other close-grown crops	67	856,114	820	2,235,200	2.6108665

**Table A3—continued.**

Production region number	Major cropping system	No. of 2003-06 CEAP sample points	Sum of original CEAP sample weights	No. of 2003 NRI points	No. of 2003 cultivated cropland acres	PR and cropping system multiplier
12	CN-SB only, w/wout FWID	288	2,051,602	714	1,573,500	0.7669614
12	corn only, w/wout FWID	53	529,642	114	283,500	0.5352675
12	soybean only, w/wout FWID	113	961,076	254	678,300	0.7057718
12	cotton only, w/wout FWID	132	1,638,755	410	1,297,200	0.7915764
12	CT-PN only	90	1,666,829	231	820,600	0.4923121
12	vt with other row crops only	58	739,082	303	877,600	1.1874197
12	CN and/or SB with Close Grown	244	1,594,228	889	1,671,900	1.0487207
12	CT with other row crops, no close grown	96	1,016,299	429	1,198,600	1.1793775
12	CT and close grown, w/ or w/out other crops	51	547,265	186	627,400	1.1464291
12	Mix of remaining row crops only	79	1,617,572	747	2,122,600	1.3122139
12	Remaining mix of row AND close crops	64	688,055	383	1,056,800	1.5359234
12	Hay-crop mix or other close-grown crops	21	248,708	420	1,294,000	5.2028794
		18,691	304,342,099	95,035	304,709,600	

## Appendix B: Intrinsic Vulnerability Factor for Soil Runoff

Not all acres require the same level of conservation treatment because of differences in inherent vulnerabilities due to soils and climate. Inherent vulnerability factors for surface runoff include soil properties that promote surface water runoff and erosion—soil hydrologic group, slope, and soil erodibility (the water erosion equation K-factor). Soil runoff potentials were estimated for each sample point on the basis of a single set of criteria for all regions and soils in the United States to allow for regional comparisons.

Four soil vulnerability levels are defined: high, moderately high, moderate, and low. A “high” soil potential indicates that the intrinsic vulnerability of the soil is high for surface water runoff, and that sediment loss at the edge of the field would be expected to be relatively high compared to other acres if there were no conservation practices in use. A “low” soil potential indicates that the intrinsic vulnerability of the soil is low for surface water runoff, and sediment loss at the edge of the field would be expected to be relatively low compared to other acres.

Criteria for four classes of soil runoff potential were derived using a combination of soil hydrologic group, percent slope, and K-factor, as shown in table B1. Figures B2 through B9 show the percentages of cultivated cropland acres in each region for each of the four levels of the soil runoff potential. Because a consistent set of criteria were used for all regions of the country, some soil vulnerability potentials are not well represented in every region.

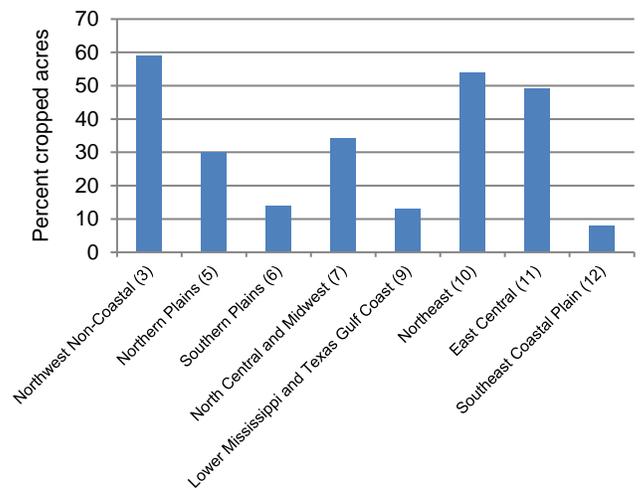
Three regions have the highest percentages of acres with inherent vulnerability factors for surface runoff (fig. B1):

- the Northwest Non-Coastal (3) region, where 58 percent of the cultivated cropland acres have a “high” or “moderately high” soil runoff potential;
- the Northeast (10) region, where 54 percent of the cultivated cropland acres have a “high” or “moderately high” soil runoff potential; and
- the East Central (11) region, where 49 percent of the cultivated cropland acres have a “high” or “moderately high” soil runoff potential.

Three regions have few acres with inherent vulnerability factors for surface runoff (fig. B1):

- the Southeast Coastal Plain (12) region, where only 8 percent of the cultivated cropland acres have a “high” or “moderately high” soil runoff potential;
- the Lower Mississippi and Texas Gulf Coast (9) region, where only 9 percent of the cultivated cropland acres have a “high” or “moderately high” soil runoff potential; and
- the Southern Plains (6) region, where only 13 percent of the cultivated cropland acres have a “high” or “moderately high” soil runoff potential.

**Figure B1.** Percent cultivated cropland acres in each region with a “high” or “moderately high” soil runoff potential.



In the remaining two regions—the North Central and Midwest (7) region and the Northern Plains (5) region—about half of the cultivated cropland acres have a “low” soil runoff potential and the rest of the acres have varying levels of soil runoff vulnerabilities.

**Table B1.** Criteria for the soil runoff potential.

Soil runoff potential	Acres with soil hydrologic group A	Acres with soil hydrologic group B	Acres with soil hydrologic group C	Acres with soil hydrologic group D
Low	All acres	Slope<4	Slope<2	Slope<2 and K-factor<0.28
Moderate	None	Slope >=4 and <=6 and K-factor<0.32	Slope >=2 and <=6 and K-factor<0.28	Slope<2 and K-factor>=0.28
Moderately high	None	Slope >=4 and <=6 and K-factor>=0.32	Slope >=2 and <=6 and K-factor>=0.28	Slope >=2 and <=4
High	None	Slope>6	Slope>6	Slope>4

Hydrologic soil groups are classified as:

**Group A**—sand, loamy sand, or sandy loam soils that have low runoff potential and high infiltration rates even when thoroughly wetted.

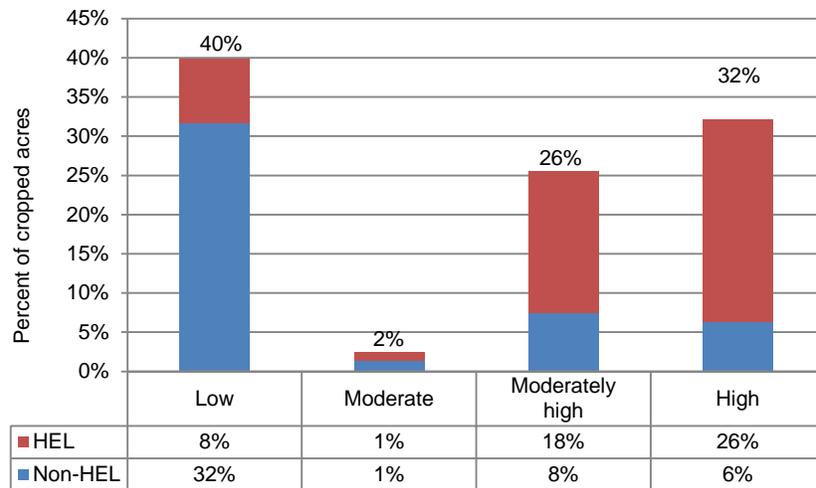
**Group B**—silt loam or loam soils that have moderate infiltration rates when thoroughly wetted.

**Group C**—sandy clay loam soils that have low infiltration rates when thoroughly wetted.

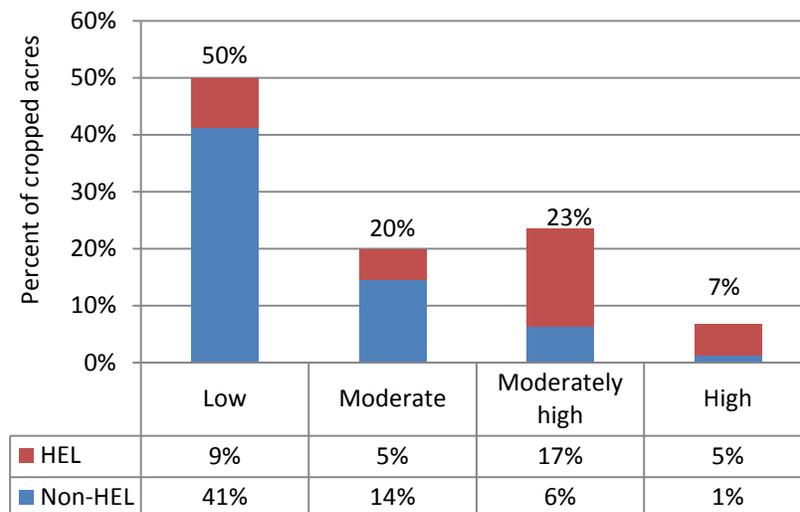
**Group D**—clay loam, silty clay loam, sandy clay, silty clay, or clay soils that have very low infiltration rates when thoroughly wetted.

The K-factor is a relative index of susceptibility of bare, cultivated soil to particle detachment and transport by rainfall. It is determined by the composition of the soil, saturated hydraulic conductivity, and soil structure.

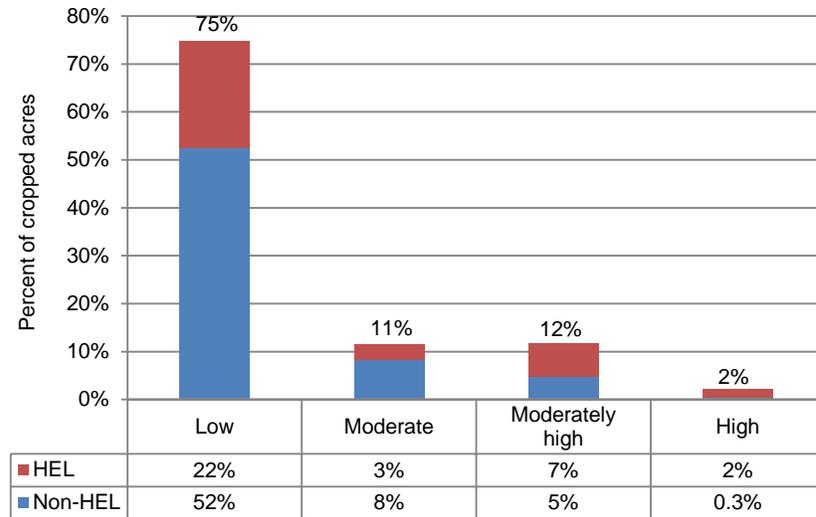
**Figure B2.** Soil runoff potential for cropped acres in the Northwest Non-Coastal (3) region.



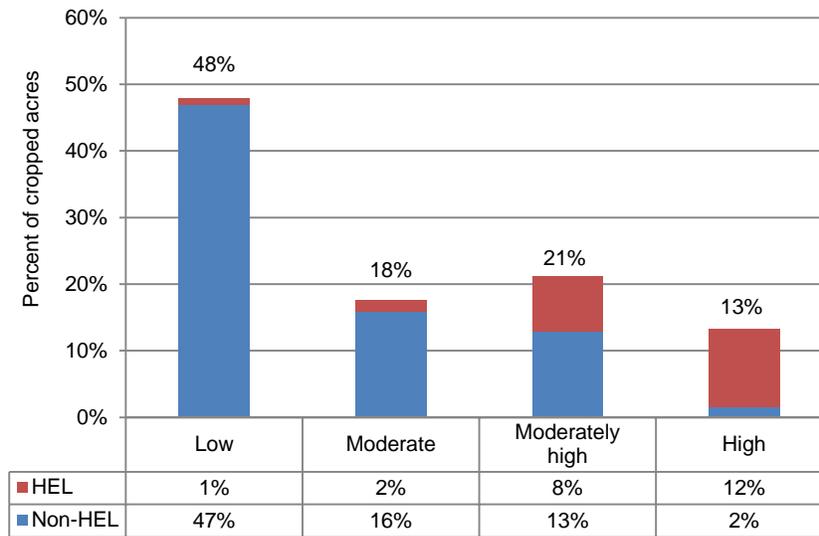
**Figure B3.** Soil runoff potential for cropped acres in the Northern Plains (5) region.



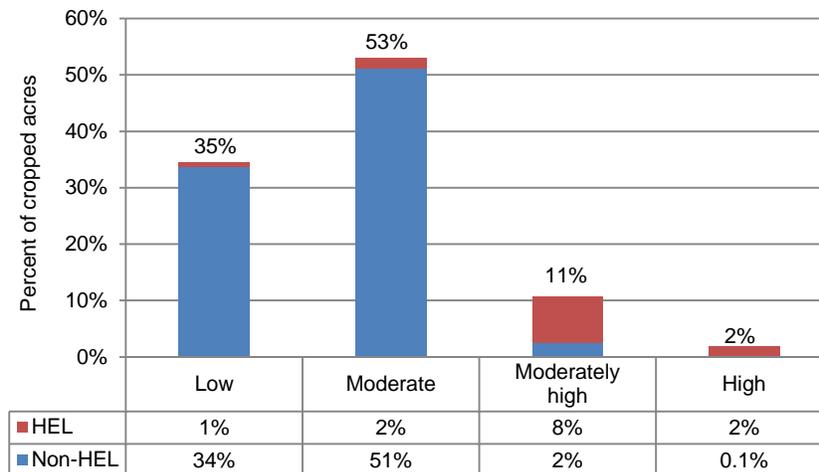
**Figure B4.** Soil runoff potential for cropped acres in the Southern Plains (6) region.



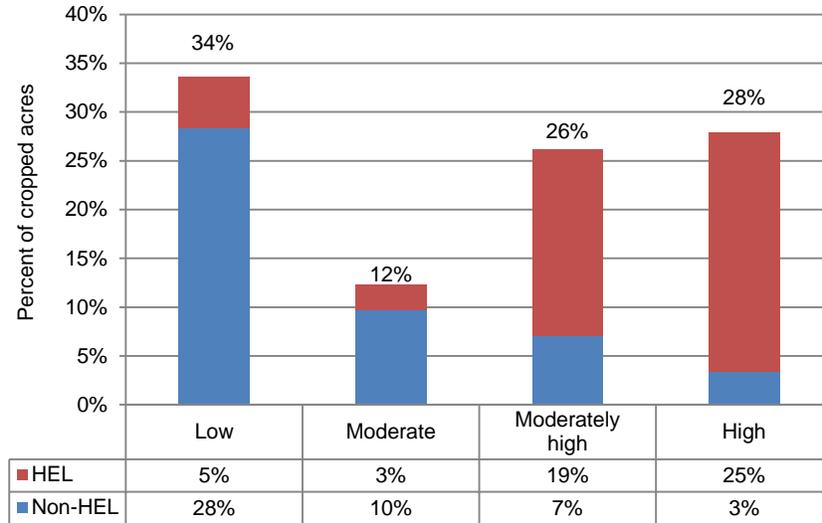
**Figure B5.** Soil runoff potential for cropped acres in the North Central and Midwest (7) region.



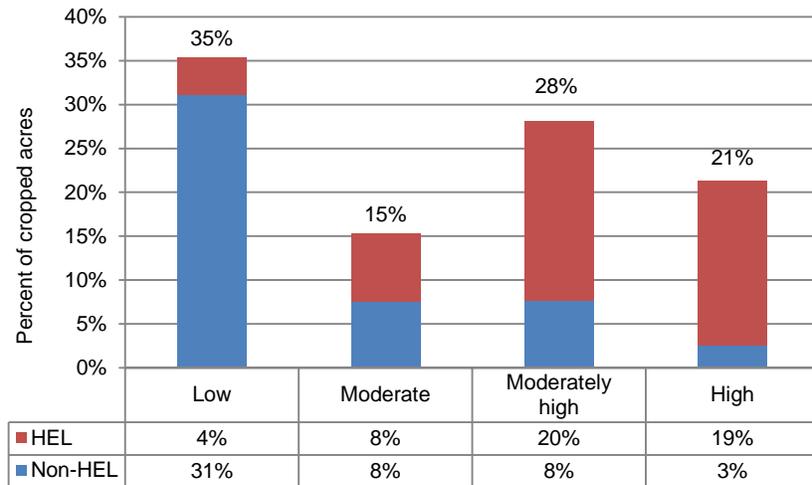
**Figure B6.** Soil runoff potential for cropped acres in the Lower Mississippi and Texas Gulf Coast (9) region.



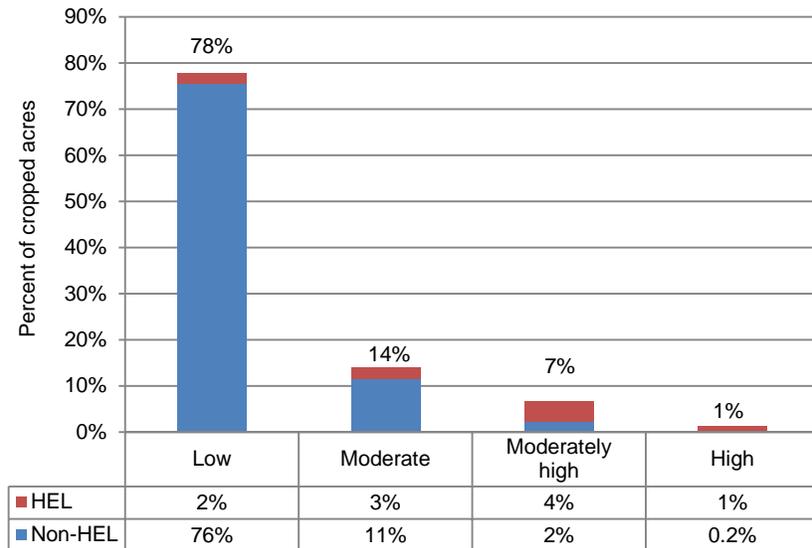
**Figure B7.** Soil runoff potential for cropped acres in the Northeast (10) region.



**Figure B8.** Soil runoff potential for cropped acres in the East Central (11) region.



**Figure B9.** Soil runoff potential for cropped acres in the Southeast Coastal Plain (12) region.



## Appendix C: Intrinsic Vulnerability Factor for Soil Leaching

Inherent vulnerability factors for loss of nutrients in subsurface flows include soil properties that promote infiltration—soil hydrologic group, slope, water erosion equation K-factor, and coarse fragment content of the soil. Soil leaching potentials were estimated for each sample point on the basis of a single set of criteria for all regions and soils in the United States to allow for regional comparisons.

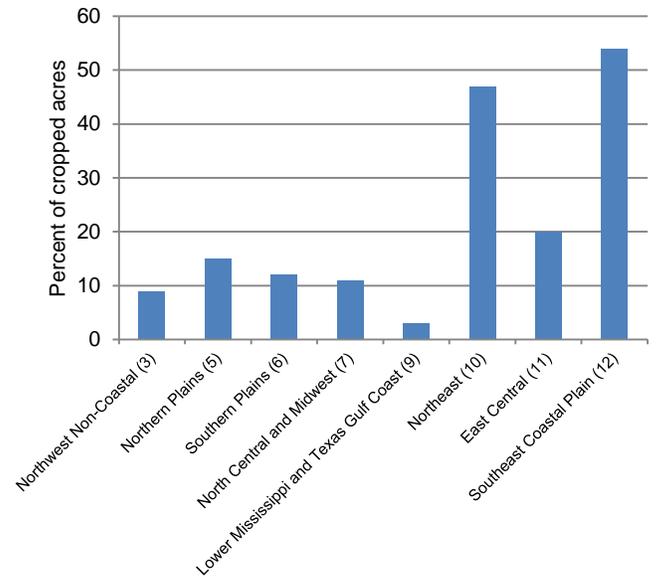
Four soil vulnerability levels are defined: high, moderately high, moderate, and low. A “high” soil potential indicates that the intrinsic vulnerability of the soil is high for water infiltration, and that nutrient losses through subsurface flow pathways would be expected to be relatively high compared to other acres if there were no nutrient management practices in use. A “low” soil potential indicates that the intrinsic vulnerability of the soil is low for water infiltration, and nutrient losses through subsurface flow pathways would be expected to be relatively low compared to other acres.

Criteria for four classes of soil leaching potential were derived using the criteria presented in table C1. Figures C2 through C9 show the percentages of cultivated cropland acres for each of the four levels of the soil leaching potential in each region.

Two regions have the highest percentages of acres with inherent vulnerability factors for infiltration (fig. C1):

- the Southeast Coastal Plain (12) region, where 54 percent of the cultivated cropland acres have a “high” or “moderately high” soil leaching potential; and
- the Northeast (10) region, where 47 percent of the cultivated cropland acres have a “high” or “moderately high” soil leaching potential.

**Figure C1.** Percent of cultivated cropland acres in each region with a “high” or “moderately high” soil leaching potential.



Because a consistent set of criteria were used for all regions of the country, some soil vulnerability potentials are not well represented in every region. For example, the Lower Mississippi and Texas Gulf Coast (9) region had only 3 percent of cropped acres with a “high” or “moderately high” soil leaching potential.

In the remaining five regions, the bulk of the cropped acres (69 to 89 percent) had a “moderate” soil leaching potential. Thus, other soil leaching potentials in these five regions are sometimes poorly represented in the sample.

**Table C1.** Criteria for the soil leaching potential.

Soil leaching potential	Acres with soil hydrologic group A	Acres with soil hydrologic group B	Acres with soil hydrologic group C	Acres with soil hydrologic group D
Low	None	None	None	All acres except organic soils
Moderate	None	Slope $\leq 12$ and K-factor $\geq 0.24$ or slope $> 12$	All acres except organic soils	None
Moderately high	Slope $> 12$	Slope $\geq 3$ and $\leq 12$ and K-factor $< 0.24$	None	None
High	Slope $\leq 12$ or acres classified as organic soils	Slope $< 3$ and K-factor $< 0.24$ or acres classified as organic soils	Acres classified as organic soils	Acres classified as organic soils

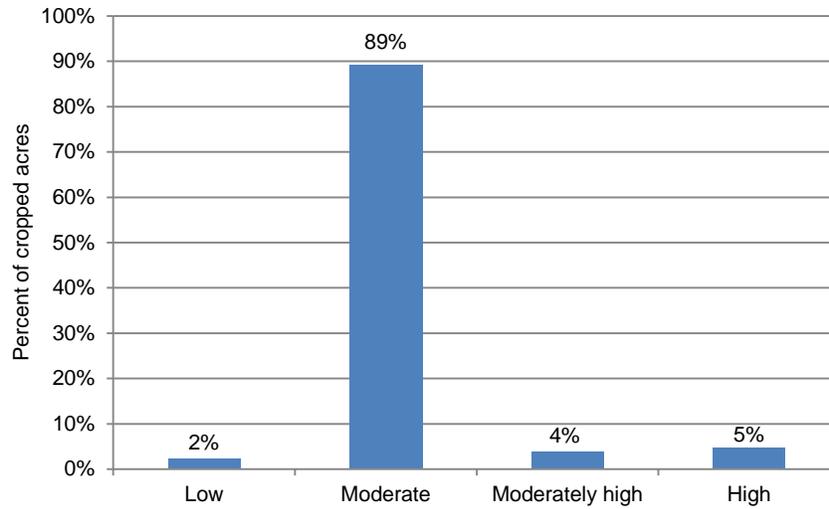
Coarse fragments (stones and rocks) in the soil make it easier for water to infiltrate rather than run off. If the coarse fragment content of the soil was greater than 30 percent, the soil leaching potential was increased two levels (moderate and moderately high to high, and low to moderately high). If the coarse fragment content was greater than 10 percent but less than 30 percent, the soil leaching potential was increased one level.

Hydrologic soil groups are classified as:

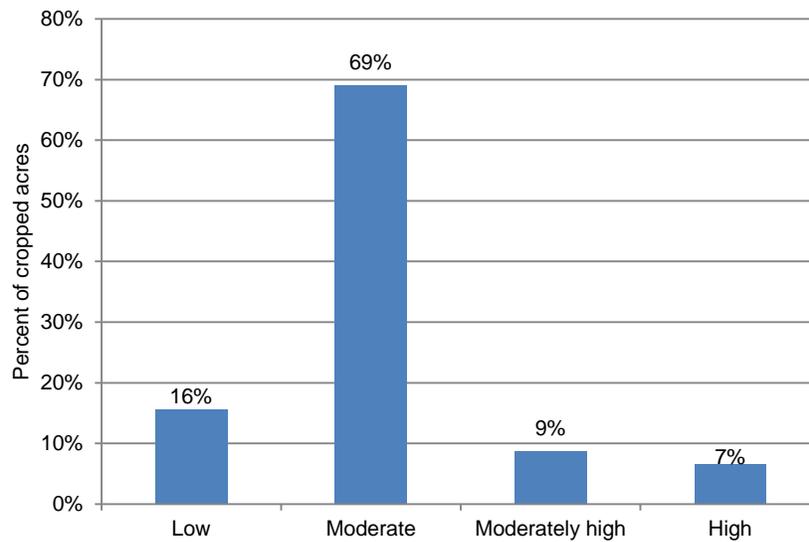
- Group A**—sand, loamy sand, or sandy loam soils that have low runoff potential and high infiltration rates even when thoroughly wetted.
- Group B**—silt loam or loam soils that have moderate infiltration rates when thoroughly wetted.
- Group C**—sandy clay loam soils that have low infiltration rates when thoroughly wetted.
- Group D**—clay loam, silty clay loam, sandy clay, silty clay, or clay soils that have very low infiltration rates when thoroughly wetted.

The K-factor is a relative index of susceptibility of bare, cultivated soil to particle detachment and transport by rainfall. It is determined by the composition of the soil, saturated hydraulic conductivity, and soil structure.

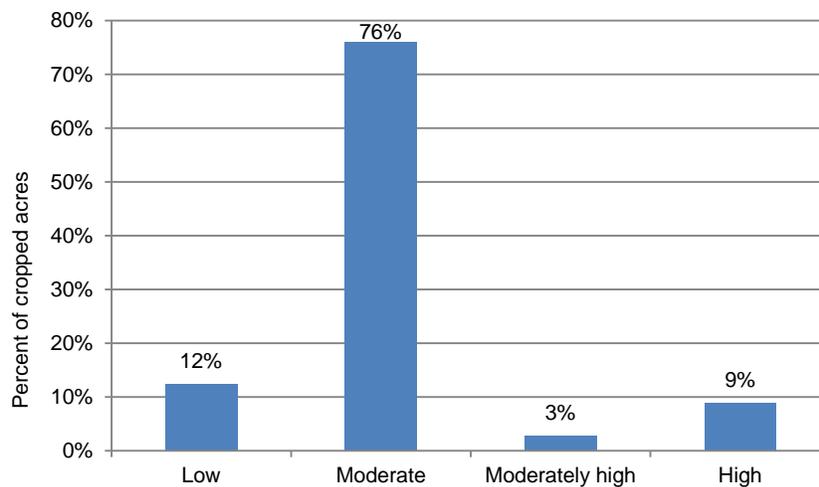
**Figure C2.** Soil leaching potential for cropped acres in the Northwest Non-Coastal (3) region.



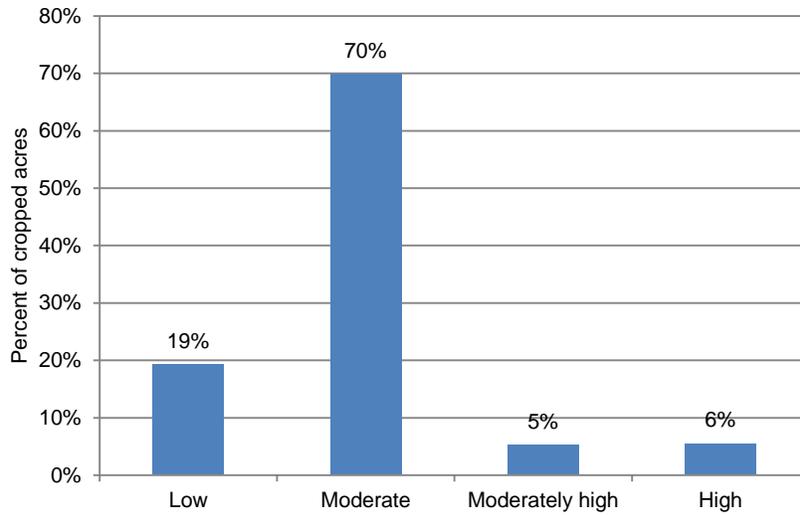
**Figure C3.** Soil leaching potential for cropped acres in the Northern Plains (5) region.



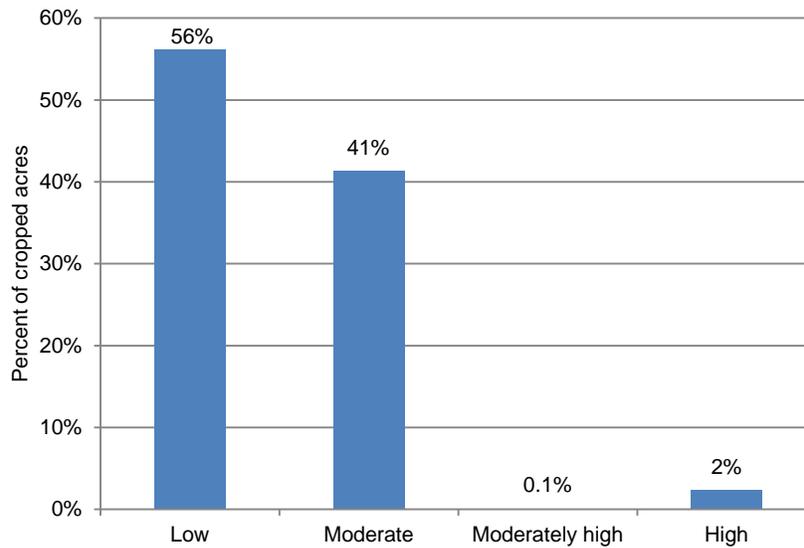
**Figure C4.** Soil leaching potential for cropped acres in the Southern Plains (6) region.



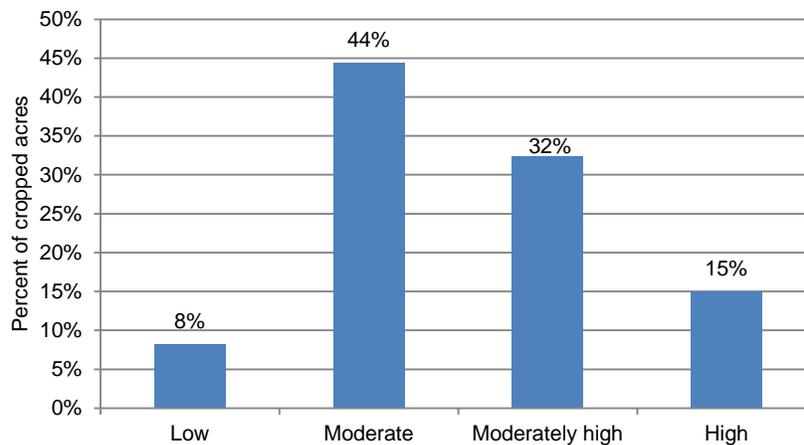
**Figure C5.** Soil leaching potential for cropped acres in the North Central and Midwest (7) region.



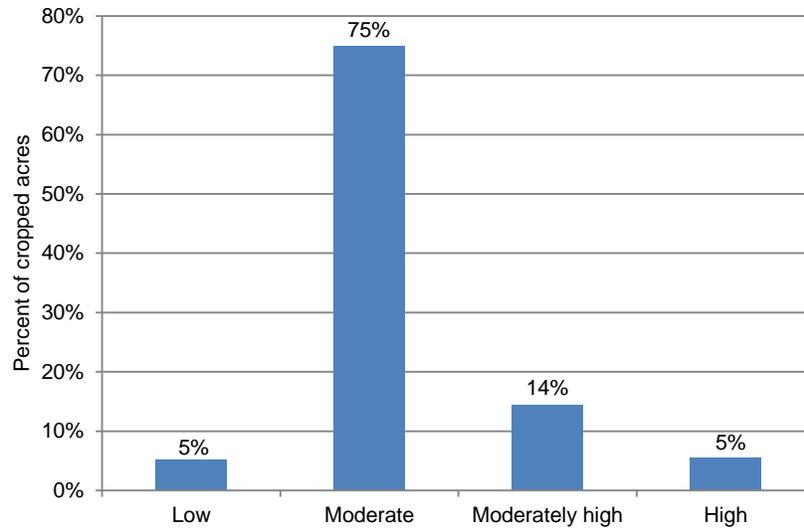
**Figure C6.** Soil leaching potential for cropped acres in the Lower Mississippi and Texas Gulf Coast (9) region.



**Figure C7.** Soil leaching potential for cropped acres in the Northeast (10) region.



**Figure C8.** Soil leaching potential for cropped acres in the East Central (11) region.



**Figure C9.** Soil leaching potential for cropped acres in the Southeast Coastal Plain (12) region.

