Executive Summary

Purpose of study

The purpose of this study is to identify cropland areas of the country that would benefit the most from the application of conservation practices. The 1997 National Resources Inventory (NRI) was used with other national-level databases to develop a simulation model. The simulation model provided estimates of eight onsite (field-level) environmental outcomes representing about 80 percent of the cropland acres in the United States (see box inset Modeling Onsite Environmental Outcomes):

- sediment loss from water erosion (ton/a/yr sediment yield, not including ephemeral or other gully erosion)
- wind erosion rate (ton/a/yr)
- nitrogen lost with waterborne sediment (lb/a/yr)
- nitrogen dissolved in surface water runoff (lb/a/yr)
- nitrogen dissolved in leachate (lb/a/yr)
- phosphorus lost with waterborne sediment (lb/a/yr)
- phosphorus dissolved in surface water runoff (lb/a/yr)
- soil quality degradation indicator

Terraces, stripcropping, contour farming, and residue management practices were included in the analysis; other conservation practices such as buffers, grassed waterways, and nutrient management practices were not included. Thus, results are presented as potential losses of soil and nutrients from farm fields and the potential for soil quality degradation. Limitations such as incomplete cropland coverage in some regions, the lack of site-specific management practices including crop rotations, and modeling limitations noted in the report are additional reasons to consider the model output as potential losses of soil and nutrients.

Efforts are currently underway within the Conservation Effects Assessment Project (CEAP) to improve the modeling routines, obtain more complete site-specific information, and more fully account for conservation practice effects. CEAP is a multi-agency effort initiated in 2003 to estimate the environmental benefits of conservation practices at national and regional levels and to conduct case studies on the effects of conservation practices in selected watersheds.

Assessment of priority acres

Priority acres—those most in need of conservation treatment—are critical acres for one or more of the eight onsite environmental outcomes. For each outcome, critical acres were identified as acres with the highest loss estimates (or lowest soil condition rating in the case of soil quality) in the country. In many cases, cropland acres were critical for multiple outcomes. Five categories of priority acres, each representing different thresholds of severity, are presented and discussed in the report. These range from the

Modeling onsite environmental outcomes

A microsimulation modeling approach was used to estimate loss of potential pollutants from farm fields and changes in soil organic carbon. The 1997 NRI provided the analytical framework. Data on farm-level management was derived from farmer surveys and other national level databases, and data on land use and soil characteristics were provided by the NRI. The physical process model EPIC (Environmental Policy Integrated Climate) was used to estimate surface water runoff, percolation, wind erosion, sediment loss, nutrient loss, and changes in soil organic carbon for each NRI cropland sample point included in the study. Over 750,000 EPIC model runs were conducted to obtain the results summarized in this report. Model results were estimated for 15 crops representing approximately 298 million acres, or 79 percent, of United States cropland, exclusive of acres enrolled in the Conservation Reserve Program. Horticultural crops such as fruit and nuts and most vegetables were not modeled, nor were all cropland areas in the West. As a result, some areas of the country—especially the West, Florida, and parts of New England—are not well represented in these simulations.

EPIC is a point model that has been developed and parameterized on the basis of measured research data from experimental research plots and small fields. The model outputs, such as surface water runoff or sediment yield, are similar to what would be found if actual measures could be taken from the edge of an area within a field about 1 hectare (2.5 a) in size that was reasonably homogeneous. Vertically, EPIC simulates fate and transport processes through the soil profile. Thus, EPIC model output reported in this study is best represented as water, soil, and nutrient loss at the edge of a field or at the bottom of the root zone.

Models such as EPIC use mathematical representations of the real world to estimate the effects of complex and varying environmental events and conditions. They are necessary to simulate systems that are too large or too complex to realistically establish monitoring systems to measure outcomes. Models generally work best in estimating relative changes, are less effective in estimating absolute values, and can never be as accurate as scientific measurements. As applied in this study, model simulation results are used to make spatial comparisons, and so are appropriate for estimating the cropland areas of the country that have the highest potential for soil and nutrient loss. The field-level sediment and nutrient losses estimated in this study are indicators of potential environmental impacts, but they do not necessarily equate to environmental impairment because estimates are not linked to hydrologic models that simulate transport of pollutants offsite (such as to surface water bodies or ground water aquifers).

The simulation model incorporates a large amount of both physical and management data and accounts for most of the major processes involved with fate and transport of soil and nutrients. In some cases, assumptions were used to fill information gaps. In a few cases, however, it was not possible to address important factors for this study. Principal among these were the inability to simulate crop rotations because of the lack of information on farming practices specific to each crop rotation, inability to represent tile drainage or surface drainage systems because of the lack of consistent information on these features at NRI sample points, and the inability to appropriately represent poorly drained field conditions—and associated denitrification processes—during the non-growing season.

most critical 5-percent category (the 5% of acres with the highest losses or worst soil condition) to the most critical 25-percent category.

Map 1 presents results for the most critical 15-percent category, consisting of critical acres with sediment loss and nutrient loss estimates in the top 15 percent nationally, wind erosion rates in the top 6 percent nationally, and soil quality degradation indicator scores in the bottom 15 percent nationally. Priority acres at this level of severity are concentrated in six areas:

- cropland in the Lower Mississippi River Basin below St. Louis and the lower reaches of the Ohio River—often critical for five or more outcomes
- cropland in the Chesapeake Bay watershed in Maryland and Pennsylvania—significant proportion of the acres were critical for five or more outcomes
- cropland in the southern two-thirds of Iowa and parts of Illinois and Missouri adjacent to Iowa—significant proportion of the acres were critical for 3 to 4 outcomes
- cropland along the Atlantic Coastal Plain stretching from Alabama to eastern Virginia and Delaware—most of the cropland acres in this area were critical for two or more outcomes
- cropland in northwestern Texas
- selected cropland regions in the West

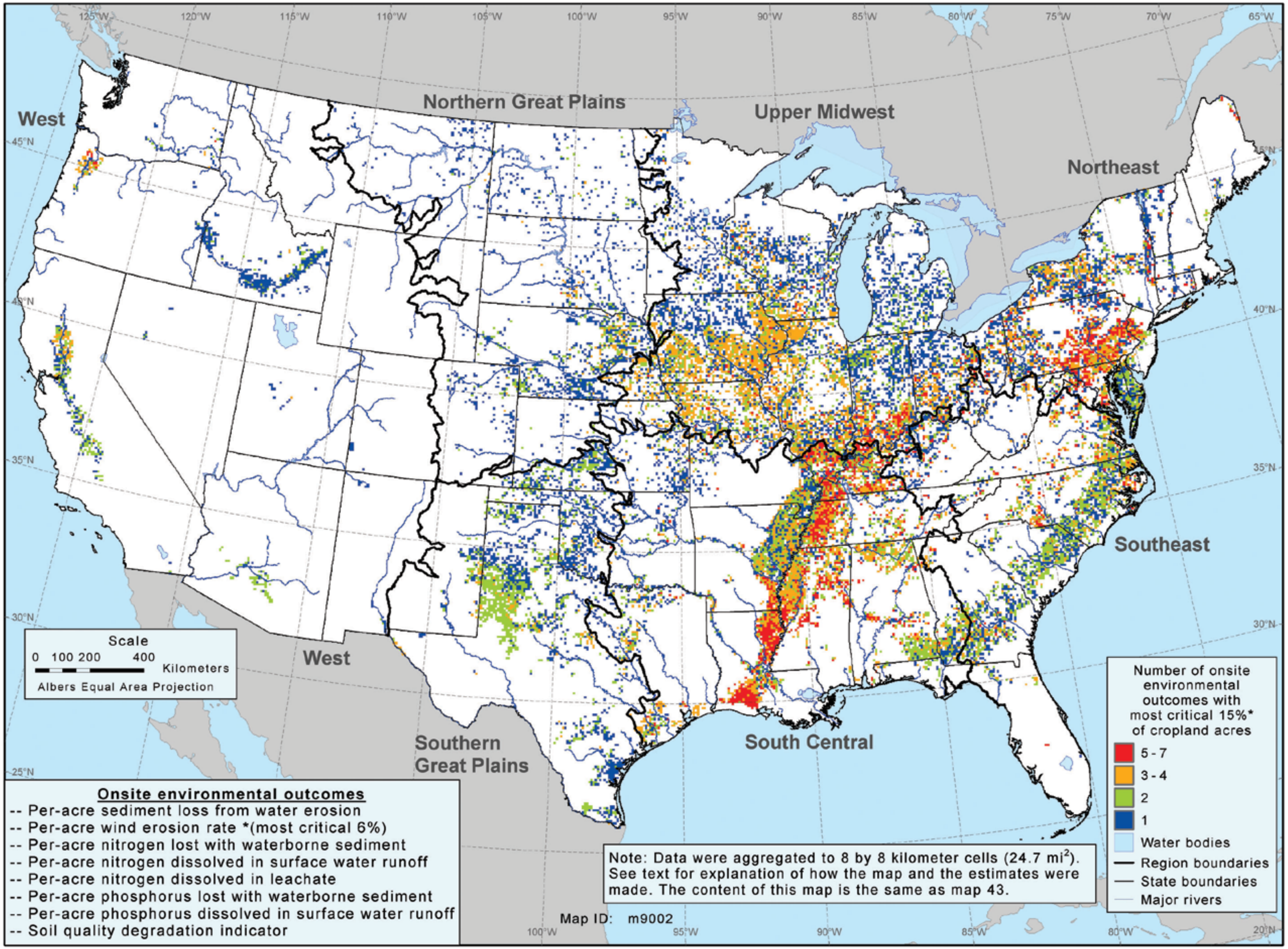
For the most critical 15-percent category, about half (155 million a) of the cropland acres included in the study were critical acres for at least one outcome, about 29 percent (87 million a) were critical for two or more outcomes, about 12 percent (36 million a) were critical for three to four outcomes, and about 4 percent (12 million a) were critical for five or more outcomes.

An assessment of priority cropland acres for all five categories of severity (5-, 10-, 15-, 20-, and 25% categories) leads to the following conclusions:

- Critical cropland acres that are most in need of conservation treatment to manage soil loss, nutrient loss, or soil quality degradation are distributed throughout all the major cropland areas of the country.
- Critical acres are more concentrated in some regions of the country than in other regions.
- Critical acres for multiple onsite environmental outcomes are concentrated in a few cropland areas. These acres should represent the highest priority acres for conservation treatment.
- The loss pathways and specific treatment needs vary from region to region; for example, the most critical acres for nitrogen runoff loss and nitrogen leaching loss are primarily in different cropland areas.

Priority acres are identified in this study on a per-acre basis; that is, those cropland acres where investment in conservation practices would poten-

Map 1 Priority cropland acres with highest potential for soil loss, nutrient loss, and soil quality degradation



tially have the greatest benefits at the field level. Most conservation practices are designed to abate pollution sources at the field level. However, there are other considerations that can factor into the determination of priority areas for conservation program implementation, such as potential for soil and nutrient losses from farm fields to migrate into lakes, rivers, streams, or ground water in sufficient amounts to contribute to water quality impairment; total loadings delivered to sensitive downstream ecosystems including estuaries and coastal waters; and cost effectiveness of conservation practices.

Major findings for onsite environmental outcomes

Cropland that is most in need of conservation practices is determined by the amount and timing of precipitation, field management activities including irrigation, soil characteristics, and the presence or absence of conservation practices. The model simulation results showed that the loss of sediment, nitrogen, and phosphorus can vary considerably from field to field even within fairly small geographic areas. This variability was often related to differences in sources, amounts, and timing of nitrogen and phosphorus inputs, as well as differences in tillage practices. Results presented in the report show that soil texture and hydrologic soil group also accounted for a large part of the variability.

The critical acres identified in the study account for the bulk of the total tons of eroded soil and the total pounds of nutrient loss from all cropland acres. This disproportionality occurs because of a minority of acres with high estimates of losses. For example, the 5 percent of acres with the highest per-acre sediment loss accounted for 34 percent of the total tons of sediment loss estimated for all cropland acres, and the 10 percent of acres with the highest per-acre sediment loss accounted for 50 percent of the total tons of sediment loss. The 2 percent of acres with the highest wind erosion rates accounted for 42 percent of the total tons of wind erosion. This disproportionality was also evident for nitrogen and phosphorus loss.

	Percent of total pounds lost from all cropland acres for the 5% of acres with the highest losses	Percent of total pounds lost from all cropland acres for the 10% of acres with the highest losses
Nitrogen dissolved in leachate	44	74
Nitrogen dissolved in surface water runoff	32	57
Nitrogen lost with waterborne sediment	23	47
Phosphorus dissolved in surface water runoff	24	36
Phosphorus lost with water-borne sediment	31	46

Maps presented in the main body of the report identify areas of the country with the greatest potential for loss of soil and nutrients from farm fields and areas with potential for soil quality degradation. For reporting of summary statistics, seven geographic regions were delineated on the basis of similar hydrologic characteristics (precipitation, surface runoff, and percolation), shown on map 1.

Northeast region. Critical acres in the Northeast region were largely the result of sediment loss from water erosion and nitrogen and phosphorus lost with waterborne sediment. For these three outcomes, the Northeast region had the highest average losses of any of the seven regions. Sediment loss averaged 3.2 tons per cropland acre per year in this region, and nitrogen and phosphorus lost with waterborne sediment averaged 13 and 3 pounds per acre per year, respectively. Nitrogen and phosphorus dissolved in surface water runoff were also important determinants of critical acres in the Northeast region. High levels of nitrogen dissolved in leachate contributed to critical acres in some places. Many of the critical acres in the Northeast region had high losses for multiple outcomes.

Upper Midwest region. Critical acres in the Upper Midwest region were also primarily the result of sediment loss and nitrogen and phosphorus lost with waterborne sediment. Estimates of nitrogen and phosphorus lost with waterborne sediment in the Upper Midwest region were second only to those in the Northeast, averaging 12 and 2 pounds per acre, respectively. Sediment losses averaged 2 tons per acre, which ranked third among the seven regions. High levels of nitrogen dissolved in surface water runoff and in leachate and phosphorus dissolved in surface water runoff were also determinants of critical acres in some places.

South Central region. The most densely concentrated critical acres for multiple onsite environmental outcomes in the country occurred along the Mississippi River within the South Central region. All outcomes except wind erosion contributed significantly to critical acres in this region. Average per-acre estimates of sediment loss, nitrogen dissolved in surface water runoff, nitrogen dissolved in leachate, and phosphorus dissolved in surface water runoff were the second highest among the seven regions. Per-acre estimates of nitrogen and phosphorus lost with waterborne sediment were the third highest among the regions. The potential for soil quality degradation was also high in this region.

Southeast region. The predominant determinant of critical acres in the Southeast region was nitrogen dissolved in leachate. Nitrogen dissolved in leachate averaged nearly 30 pounds per acre per year in the region, which was substantially higher than in any other region. The highest average loss of phosphorus dissolved in surface water runoff was also observed for cropland acres in the Southeast region. In a few places, high levels of sediment loss and nitrogen and phosphorus lost with waterborne sediment contributed to critical acres. The potential for soil quality degradation was high in the Southeast region, as well.

Southern Great Plains region. Wind erosion was the predominant determinant of critical acres in the Southern Great Plains region. Wind erosion averaged over 5 tons per acre per year for cropland acres in this region. Soil quality degradation was also an important determinate of critical acres. In some places, nitrogen dissolved in leachate or surface water runoff contributed to critical acres.

Northern Great Plains region. Critical acres in the Northern Great Plains region were less dense than in other regions, although critical acres were distributed throughout all cropland areas in the region. The predominant cause for critical acres in this region was wind erosion. The potential for soil quality degradation also accounted for a significant number of critical acres.

West region. Only the major cropland areas in the West were included in the study, representing about 25 percent of the cropland in the region. About 80 percent of the acres included in the study in the West region were irrigated. For these areas, the predominant determinant of critical acres was high levels of nitrogen dissolved in surface water runoff from irrigated acres, with highest losses in the Snake River Basin in Idaho, central California, and southern Arizona. Phosphorus dissolved in surface water runoff was an important determinant of critical acres in some places. The potential for soil quality degradation was also a significant factor in California and Arizona. The Willamette River Basin had a concentration of critical acres for multiple environmental outcome categories, including sediment loss, nitrogen and phosphorus lost with waterborne sediment, and nitrogen dissolved in leachate.

Effects of tillage. Model simulation results obtained in this study accounted for the effects of residue management by simulating three tillage types—conventional tillage, mulch tillage, and no-till. Tillage practices have a direct influence on sheet and rill and wind erosion processes. A subset of model runs where all three tillage systems were included in model simulations was used to assess the effects that tillage had on wind erosion, sediment loss, and nutrient loss estimates. This tillage comparison subset of model runs included eight crops and represented about 70 percent of the cropland acres covered by the study. Acreage representation of the three tillage systems in this tillage-effects baseline was: 59 percent for conventional tillage, 21 percent for mulch tillage, and 21 percent for no-till. When compared to model simulation results assuming 100 percent of the acres had conventional tillage, these tillage practices accounted for:

- 32 percent reduction in sediment loss (0.8 ton/a/yr reduction, on average)
- 26 percent reduction in wind erosion rates (0.3 ton/a/yr reduction, on average)
- 7 percent reduction in nitrogen loss (3.2 lb/a/yr reduction, on average)
- 13 percent reduction in phosphorus loss (0.4 lb/a/yr reduction, on average)

Effects of terraces, contour farming, and stripcropping. Three conservation practices—contour farming, stripcropping, and terraces—were shown to have a significant influence on sediment loss and nutrient loss estimates in the model simulations. These three practices are used on about 32 million acres, or about 10 percent of cultivated cropland, according to the 1997 NRI. For comparison to the results for the model runs that included these three conservation practices, an additional set of model runs were conducted after adjusting model settings to represent no practices. For acres that had one or more of these three conservation practices:

- sediment loss was reduced 54 percent (1.8 ton/a/yr reduction, on average)
- nitrogen loss was reduced 16 percent (7 lb/a/yr reduction, on average)
- phosphorus loss was reduced 28 percent (1 lb/a/yr reduction, on average)

Reductions in sediment and nutrient loss varied considerably by region, with the highest reductions generally found in areas with the highest loss estimates.