Farmlands

Total Cropland

Note: Other indicators in this chapter will refer to the discussion of the Natural Resources Inventory (NRI) below.

The Indicator

This indicator reports the acreage of cropland in the United States. Included in this category are pastures and haylands. For the purposes of this indicator, lands that have been idled in long-term set-aside programs, such as the Conservation Reserve Program (CRP), are not included. This is in part because of the objective to report on those lands that are in active use, and because not all of the programs distinguish CRP acres equally well (the remote-sensing data from the National Land Cover Dataset [NLCD] do not separate them from active croplands). In theory, the land area utilized for animal feedlots would be included in this indicator. In practice, however, this acreage is certainly quite small and is not isolated by the various programs used in this analysis. (While the indicator definition excludes CRP lands, one of the data sources used [Economic Research Service, or ERS] does not report CRP acreage separately; thus, the ERS numbers include CRP acreage. There are other differences between the datasets; see below.)

In addition, lands used for intensive livestock feeding are included within the ambit of this indicator. However, it was not possible to determine the degree of coverage of these areas for the data sources described below.

The Data—General

Data Sources: These data were obtained from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service, National Resources Inventory (NRI) program; the USDA National Agricultural Statistical Service, Census of Agriculture; the USDA ERS, Agricultural Resources and Environmental Indicators publications; and the U.S. Geological Survey. (USGS provided access to and processing assistance with the NLCD, originally produced by a federal interagency consortium, the Multi-Resolution Land Characterization [MRLC] Consortium, see p. 207). See details below on each program.

Comparability Among Data Sources: These four data sources are not fully consistent, and comparisons should be made with care. For example, ERS and Census of Agriculture data include croplands in Alaska and Hawaii, while NRI does not, and only the ERS data reported here include acreage in the CRP—these acres were removed from the data for Census of Agriculture and NRI.

The statement that cropland, including pasture and hayland, occupies about one-fourth of the land area of the United States is based on the estimates from the four programs noted above. These estimates range, for 1997, from 431 million acres (NASS) to 496 million acres (NRI). They are compared to the land area of the lower 48 states (derived from the MRLC dataset), 1.891 billion acres. Thus, the percentages range from 22.8% to 26.2%.

USDA National Resources Inventory

Data Source: Data are from USDA, National Resources Conservation Service, Iowa State University Statistical Laboratory, Summary Report 1997 National Resources Inventory (revised December 2000).

Data Collection Methodology: The USDA Natural Resources Conservation Service, in cooperation with the Iowa State University Statistical Laboratory, conducts the NRI survey to capture data on land cover and use, soil erosion, prime farmland soils, wetlands, habitat diversity, selected conservation practices, and related resource attributes. Data are collected every 5 years from the same 800,000 sample sites in the lower 48 states, Puerto Rico, the U.S. Virgin Islands, and some Pacific Basin territories.

The estimated acreage of nonfederal cropland was classified as irrigated, non-irrigated, cultivated or noncultivated acreage. Data are collected for the NRI using a variety of imagery, field office records, historical records and data, ancillary materials, and onsite visits. The data are compiled, verified, and analyzed to provide a comprehensive summary of the state of U.S. non-federal lands. The NRI is a two-stage stratified area sample of the entire country. Stage one is the Primary Sampling Unit (PSU), and it is a sampling of an area/segment of land typically square to rectangular in shape and ranging from 40 to 640 acres but most typically 160 acres in size. Stage two requires the assignment of sampling unit points that are located within the PSU. Cropland includes pasture and areas used for the production of crops for harvest. For the purposes of this indicator, CRP lands were excluded from the NRI data.

Data Quality/Caveats: Statistics derived for the NRI database are estimates and not absolutes, resulting in some amount of uncertainty. These data are reported at the national level; state-level data are available at http://www.nhq.nrcs.usda.gov/NRI/1997/state_info.html.

Data Access: The NRI report is available at http://www.nhq.nrcs.usda.gov/NRI/1997/.

USDA Census of Agriculture

Data Source: Data are from USDA, National Agricultural Statistics Service (NASS), 1997 Census of Agriculture.

Data Collection Methodology: The Census of Agriculture is a comprehensive accounting of agricultural production information for every county in the United States. For 1992 and 1997, the census was conducted by USDA NASS; prior to 1992, the Bureau of the Census was responsible for censuses every 5 years.

The census is conducted using a mailout/mailback form, direct enumeration, telephone, personal interviews, and follow-up surveys. The mailing list, with 3.2 million contacts, is composed of individuals, businesses, and organizations that are associated with agriculture. Report forms for the 1997 Census of Agriculture were mailed to farm and ranch operators in December 1997 to collect data for the 1997 calendar year.

"Total cropland" includes harvested cropland; cropland used only for pasture or grazing; crop failure; cultivated summer fallow; idle cropland; and cropland in cover crops, legumes, and soil-improvement grasses, not harvested and not pastured. Data on CRP lands were excluded for the purposes of this indicator.

Data Quality/Caveats: The data from each report form were subjected to a detailed item-by-item computer edit. Before publication, tabulated totals for each state were reviewed by state statisticians to identify inconsistencies. Comparisons were also made with previous census data, official NASS Agricultural Statistics Board numbers, and other available check data.

Data Access: The 1964–1997 data are available at http://www.nass.usda.gov/census/census97/volume1/us-51/us1_01.pdf. The 1945–1959 data are not available online but can be obtained by e-mail from NASS at nass@nass.usda.gov.

National Land Cover Dataset

These data are derived from the MRLC Consortium, which is a partnership between USGS, the U.S. Forest Service, the National Oceanographic and Atmospheric Administration (NOAA), and EPA. See the explanation of the NLCD in the national extent technical note, page 207.

USDA Economic Research Service

Data Source: Data were acquired from the U.S. Department of Agriculture, ERS, Resource Economic Division, Agricultural Resources and Environmental Indicators (AREI) 2000 and AREI 1996–97.

Data Collection Methodology: ERS provides national economic data and analysis on issues related to agriculture, food, natural resources, and rural development.

The "cropland" category includes cropland harvested, crop failure, cultivated summer fallow, cropland used only for pasture, and idle cropland. CRP lands are included. ERS compiled these data from NASS Principal Crops and Census of Agriculture data. The data used here were compiled from Krupa and Daugherty (1990), Daugherty (1995), and Vesterby and Krupa (2001).

Data Access: The 1996–97 and 2000 reports may be accessed online at http://www.ers.usda.gov/Emphases/Harmony/issues/arei2000/.

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The Farmland Landscape

The Data

Data Collection Methodology: The data presented here are from the National Land Cover Dataset (NLCD); see the technical note for the national extent indicator (p. 207) for a full description.

Data Manipulation: The U.S. Geological Survey (USGS) Earth Resources Observations Systems Data Center aggregated data from the NLCD into squares 1 km on a side (approximately 1000 30-meter by 30-meter "pixels"). Each of these larger squares was analyzed to determine its land cover composition; 1-km squares in which more than 50% of the pixels were croplands were included within the "farmland landscape." In addition, a "buffer" equivalent to a single 1-km square was added to the edge of the farmland landscape defined above, in order to incorporate areas near those with significant concentrations of cropland.

This set of "farmland landscape" squares was analyzed to determine its composition, using the land cover data for the underlying 30-meter pixels. These data are aggregated using standard regions adopted by the Natural Resources Conservation Service (http://www.nhq.nrcs.usda.gov/land/meta/m2140.html). The following land cover types were reported, based on NLCD categories: farmland, forest, grasslands/shrublands, "developed," wetlands, water, other (see the national extent technical note for further details, p. 207).

Data Quality/Caveats: Note that, in some cases, wetlands are found on croplands, and it can therefore be difficult to separate one from the other. This is especially true because these wetlands may only have water for parts of the year and may be farmed for other parts of the year. Thus, the data on wetlands reported in this indicator should be interpreted with some caution.

Fragmentation of Farmland Landscapes by Development

The Indicator

This indicator indirectly measures the fragmentation of farmland by developed or built-up areas. Cropland interspersed with residential subdivisions raises entirely different policy and farmland management implications than cropland interspersed, for example, with patches of "natural" land cover (forest, grasslands/shrublands, or wetlands). Thus, this indicator considers fragmentation to occur when croplands and natural lands are interspersed with development.

This indicator is an index of spatial fragmentation calculated from digital land cover maps classified from remote-sensing data. Land cover data from, for example, the National Land Cover Dataset (NLCD; see technical note for the national extent indicator, p. 207) will be used. This dataset has classified grid cells, or "pixels," which represent areas measuring approximately 100 feet (30 meters) across. This index is computed by analyzing classified land cover "layers" within a raster-based geographic information system (GIS).

The fragmentation index is calculated for each pixel in the farmland landscape (i.e., either cropland or nearby "natural" lands). This value is based on the characteristics of the surrounding pixel "neighborhood." Such neighborhoods are often created as 3 by 3 or 5 by 5 pixels arrangements. The value for the center pixel is based on the character of the surrounding 8 pixels (in a 3 x 3 square) or 24 pixels (in a 5 x 5 square).

Although the fragmentation index will be calculated for individual pixels, index values for pixels will be aggregated at the scale of one-kilometer squares. Rather than directly reporting index values (i.e., 0 to 1), three fragmentation classes will be reported based on a statistical analysis of these aggregated index values. Each one-kilometer square block will be classified as having a high, medium, or low level of fragmentation. The percentage of surface area in each fragmentation class will be reported by region.

A sensitivity analysis should be performed so that the overall results are not an artifact of the neighborhood size (e.g., such as the 9-pixel arrangement discussed above). In addition, by enlarging the size of the pixel neighborhood (such as to 5 x 5 pixel units), the method will be more sensitive to non-adjacent development.

The index will depend not only on the amount of development interspersed within the farmland landscape, but also on how this development is distributed spatially in the landscape. Thus, development could cover, for example, 20% of two farmland landscapes, but these two landscapes would have very different index values. Clustered rural residential development (e.g., conservation subdivisions), surrounded by cropland and natural areas, would result in relatively high fragmentation index values for those developed portions of the farmland landscape. More scattered, lower density rural residential development (e.g., large estates) would result in somewhat lower fragmentation index values for those developed portions of the farmland landscape. Yet if the total gross residential densities (e.g., total number of dwelling units) were equal in both development scenarios, the proportion of the farmland landscape with an elevated fragmentation index would be much greater in the scattered, low-density development scenario.

The index is sensitive to low-density development if this development can be detected using satellite data (i.e., the development must "fill" a major portion of the pixel used in order to be classified "developed" in the land cover dataset).

It should be noted that this is a subject that has garnered considerable attention in the research community. An example of an alternative approach is the one promoted by the U.S. Department of Agriculture (USDA) Economic Research Service (ERS). Its approach identifies farmland that is influenced by nearby development using property values—based on the assumption that farmland priced beyond its agricultural value must be experiencing development pressure. See *Development at the Urban Fringe and Beyond: Impacts on Agriculture and Rural Land*, AER-803; http://www.ers.usda.gov/publications/aer803/. Another approach would use data from the Natural Resources Inventory (NRI; USDA Natural Resources Conservation Service). Specifically, the "segments per unit" metric might be used for the appropriate land cover category and reported on a regional basis.

The Data Gap

Several indices have been developed to quantify various aspects of pattern at the patch, class, and landscape scales. Data appropriate for calculating this indicator are available from the NLCD, which was used to define the "farmland landscape" for this report (see p. 92). Calculating this index requires digital data and specialized software designed to analyze landscape spatial patterns. The most commonly used software for analyzing landscape spatial patterns (Fragstats) is not capable of processing the very large file sizes that would be required to calculate this index for the entire nation. It may be possible to address this analysis using a statistical sampling technique, analytical approaches relying on GIS software, or other analytical approaches; however, the details of this were not resolved in time for production of this report.

Shape of "Natural" Patches in the Farmland Landscape

The Indicator

The size, shape, and juxtaposition of habitat patches within a landscape, in addition to the total extent of the habitat, influence the population size and viability of sensitive species (Meffe and Carroll 1994). Dozens of metrics have been developed to quantify spatial pattern within landscape mosaics. Some metrics quantify the size, shape, or juxtaposition of individual patches of a single land cover type. Others quantify the spatial relationships (e.g., juxtaposition) among patches of different land cover types.

This indicator measures the geometry, or spatial configuration, of "natural" areas in farmland landscapes. Natural areas are native habitats, including forests, grasslands, wetlands, and naturalized habitats, such as land enrolled in the Conservation Reserve Program (CRP) that formerly was cropland and is now reverting to, for example, forest or grassland. For the purposes of this indicator, open water is not included; however, wetlands are included. (Special attention should be paid to the ability of the land cover datasets, which are based largely on satellite measurements, to account for wetlands.)

This indicator will be calculated for individual patches, yet index values will be reported at the national scale. The indicator will be based on perimeter-to-area (P/A) ratios that have been normalized by area (i.e., divided by the patch's area). Rather than directly reported P/A values, however, three size and shape classes will be determined by a statistical analysis of each region's P/A ratios. The shape classes will be compact (e.g., a circle, which has the lowest P/A ratio for a given area), intermediate, and elongated (e.g., a long, narrow rectangle, which has a high P/A ratio for a given area). The surface area within each size and shape class will be reported nationally. This patch-based index should be area-weighted. This weighting ensures that smaller patches (with higher P/A ratios) have less influence on the aggregate index than larger patches do. The indicator will be calculated for the aggregated area of all forests, grasslands, shrublands, and wetlands in the farmland landscape, rather than being calculated for each "natural" land cover type independently.

Landscape structure—or the spatial configuration of patches, corridors, and the intervening "matrix"—influences ecosystem integrity. Yet spatial pattern is a complex phenomenon that cannot be summarized with a single index. The number, size, shape, orientation, and spatial distribution of land cover patches are important landscape attributes. Other ecologically significant aspects of landscape pattern include the proportion and spatial arrangement of different land cover types.

Agricultural activities have extensively changed many landscapes. "Fragmentation," caused by land use changes and other disturbances, may alter landscape structure by changing land cover area and spatial configuration. Within intensively farmed landscapes, natural areas comprise a relatively small percentage of the surface area. Typically, these natural areas include relatively small and isolated remnants of formerly contiguous native vegetation, in addition to restored conservation areas (e.g., CRP land). These native and naturalized areas provide wildlife habitat, control erosion, and perform other important ecological and cultural functions. Patch size and shape influence the differentiation of patches into distinct edge and interior habitats. Small patches typically have a higher ratio of edge to interior habitat than very large patches with the same shape. Conversely, linear patches have a much higher proportion of edge to interior habitat than patches with the same area, but more compact shapes. Small or highly dissected patches may have little or no interior habitat. The functional connectivity among patches of natural areas depends not only on the distances between the patches, but on the intervening land use and land cover conditions. The land covers (e.g., built-up) and land uses (e.g., farming) that separate natural areas can significantly influence biodiversity and species abundance at landscape and regional scales.

The Data Gap

Calculating this index will require digital data and specialized software designed to analyze landscape spatial patterns. Data appropriate for calculating this index are available from the National Land Cover Dataset, which was used to define the "farmland landscape" for this report (see p. 92). However, the most commonly used software (Fragstats) for analyzing landscape spatial patterns is not capable of processing the very large file sizes that would be required to calculate this index for the nation. That said, there may be simpler approaches that would not have such computing demands, although these have not been fully explored.

It might be possible to make use of existing remote-sensing data through a procedure involving random sampling. In such a procedure, rather than processing the entire dataset, samples would be processed, much as a field program such as the USDA National Resources Inventory (http://www.nhq.nrcs.usda.gov/NRI/1997/) collects data from a representative sample of sites. However, the specific approach needed for such a sampling program was not fully explored during the development of this report.

References

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Nitrate in Farmland Streams and Groundwater

This technical note also applies to the following indicators:

- **Farmlands: Phosphorus in Farmland Streams**
- **Forests: Nitrate in Forest Streams**
- **Urban/Suburban: Nitrate in Urban Streams**
- **Urban/Suburban: Phosphorus in Urban Streams**

This technical note supplements the technical note for

- **Fresh Waters: Phosphorus in Lakes, Reservoirs, and Large Rivers**

The Indicators

Nitrogen (N) and phosphorus (P) are chemical elements that serve as essential nutrients for plants and animals, but at excessive concentrations they can contaminate groundwater and streams. In surface waters they can promote excessive growth of algae (nitrogen typically causes blooms in coastal waters, whereas phosphorus more commonly causes blooms in freshwater systems), whose decay removes oxygen and threatens aquatic animals. At high concentrations, some forms of nitrogen (e.g., nitrate and ammonia) can be directly toxic to fish and create health problems for humans. In groundwater, excessive nitrate poses a threat to humans who drink from contaminated wells. Common forms of nitrogen that are readily available to plants for growth include nitrate and ammonia, and phosphate is the plant-available form of phosphorus. Sources include precipitation, dissolved natural minerals, farm and domestic fertilizers, discharges from septic systems, and effluents from sewage treatment plants.

Graphs for stream sites show mean-annual concentrations of dissolved nitrate plus nitrite or total phosphorus. Graphs for groundwater data are based on nitrate concentration in one sampling of each well. Data are reported as either parts per million (milligrams per liter) as nitrogen or parts per million (milligrams per liter) as phosphorus. The data are labeled "mean total nitrate" although the analytical method actually reports nitrate plus nitrite. This reporting convention is reasonable because except in highly polluted waters, nitrite levels are only a very small fraction of the total and can, therefore, be considered insignificant.

The Data

Data Source: The data were collected and analyzed by the U.S. Geological Survey (USGS) National Water Quality Assessment (NAWQA) program in 36 major river basins and aquifers distributed across the United States from 1992 to 1998. NAWQA samples watersheds with relatively homogeneous land use/land cover to better illuminate the effect of land use on water quality. For this report, data from watersheds where a single land use typically was predominant were used to characterize water quality conditions in farmlands, forests, and urban settings.

Nutrient data are from 15 to 25 samples collected annually at stream sites draining 105 agricultural, 38 urban and suburban, and 36 forested areas. Nitrate data were from samples collected at 1,190 wells in agricultural, 601 wells in urban and suburban, and 79 wells in forested areas. These data are summarized at http://water.usgs.gov/nawqa. Note that the sites labeled "urban" in this analysis should overlap with the "urban and suburban lands" defined as the subject of this report (see pp. 181), but, since different definitions were used in the two efforts, this might not always be the case.

Information on the drinking water standard for nitrogen can be found at http://www.epa.gov/safewater/mcl.html#inorganic. Information on the 1986 phosphorus recommended goal for preventing excess algae growth can be found in EPA 440/5-86-001 (see references). Information on regional nutrient (phosphorus) criteria can be found at http://www.epa.gov/waterscience/criteria/nutrient/ecoregions.

For farmlands, extensive data have been collected from different farming systems at the watershed-level scale, from 1991 to 2000, that will become available shortly through the National Agricultural Library (http://www.nal.usda.gov/). These data will allow additional investigations of the effect of land use and specific farming practices on water quality.

Data Collection Methodology: All samples were collected and analyzed by USGS according to the overall NAWQA design (Gilliom et al. 1995). Stream water samples were collected using depth and width integrating techniques so that the sample is representative of the water flowing past the sampling point (Shelton 1994). Groundwater samples were collected primarily from monitoring wells and low-capacity domestic wells using procedures that resulted in a sample representative of water in the aquifer (Lapham et al. 1995). Methods employed for random selection of well locations for targeted land use are described by Scott (1989) and Squillace and Price (1996). Methods for sample preservation and processing can be found in Shelton (1994) for stream samples and in Koterba et al. (1995) for groundwater samples. Fishman (1993) and Patton and Truitt (1992) describe analytical methods used for nutrient constituents. Land use in the watersheds upstream of stream sampling points or in the vicinity of wells was characterized according to procedures described in Gilliom and Thelin (1997) and Koterba (1998), respectively.

Data Analysis: The data are highly aggregated and should be interpreted mainly as an indication of general national patterns. The data were collected and analyzed by NAWQA in 36 major river basins and aquifers distributed across the United States from 1993 to 1998. The watersheds and aquifers studied were selected to be generally representative of water and land use in each area. Because this is a national assessment, the percentage of targeted land use varies across the nation. For example, watersheds dominated by agricultural land varied from 10 to 99% as cropland and/or pasture; urban and suburban land varied from 6 to 100%; and forested land ranged from 61 to 100%. Water quality is affected by both the percentage of land use in a watershed and the proximity of that land use (as a source of contamination) to streams and rivers. For example, agricultural or urban/suburban land uses might exert a dominant influence on a stream or river, in spite of occupying a small percentage of land cover in the watershed, if these land uses are located in close proximity to the river or stream.

Data Quality/Caveats: Sampling sites were selected to be representative of specific land use types rather than locations where contamination was known or suspected. All samples were collected, processed, preserved, and analyzed using the same methods. Nutrient data were reviewed to identify outliers and inconsistent results by the teams who collected the samples and by a national team (Mueller 1998). Most data have been published by USGS in a series of technical reports focusing on specific study areas and in national summary results (see http://water.usgs.gov/nawqa for a list of reports).

Data Access: All data used in this document are summarized at http://water.usgs.gov/nawqa.

References

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Phosphorus in Farmland Streams

See the technical note for Nitrate in Farmland Streams, p. 232.

Pesticides in Farmland Streams and Groundwater

See the technical note for the core national contaminants indicator, p. 210.

Soil Organic Matter

The Indicator

Soil organic matter would be reported as the percentage of organic matter (dry weight) in the upper soil profile (4–6 inches). The data would be presented as a percentage of all croplands having several ranges of percent organic matter, on a national basis and on a regional basis for the latest year for which data are available. It should be noted that it may prove difficult to discern trends in organic matter using the coarse ranges chosen (less than 2%, 2 to 4%, and greater than 4%); an approach addressing change on the regional or local level may be necessary.

Soil organic matter content in the upper soil profile (4–6 inches) was chosen because human activity, particularly management practices, has had its greatest impact here. Soil organic matter content is related to the cation exchange capacity of the soil, soil water-holding capacity, nitrogen mineralization rates, and microbial activity.

Soil organic matter content is also related to biogeochemical processes, and the cycling of carbon and nitrogen within the upper soil profile is related to soil carbon content. Measurement of changes in the soil organic matter content over time provides a quantitative assessment of the soil capacity to support crops and other plant and animal life.

Soil organic matter content is a critical component of soil structure and is vital to all soil processes. Soil organic matter provides the chemical and biological basis for soil components (sand, silt, and clay) to form soil aggregates and is critical in key physical processes (such as water and gas exchange, penetration resistance, and compaction). Differences in climate, parent material, and management history have produced large regional differences in soil organic matter content.

In addition, since soil organic matter is about 60% carbon, the amount of organic matter is a predictor of the amount of carbon in soils. Storage of carbon in soils has become important in international negotiations on the management of greenhouse gas emissions, as increased carbon storage can be useful in offsetting emissions of carbon from fuel burning and other sources. In order to be of use to such negotiations, this indicator would probably need to measure carbon in the upper 3 feet of soil, not just the upper 4–6 inches. While this is not the current focus of the indicator, such a presentation would make this indicator analogous to those in the forest and grasslands and shrublands chapters (pp. 123 and 165).

The Data Gap

U.S. Department of Agriculture soil survey data (contained within the State Soil Geographic Database [STATSGO] and Soil Survey Geographic [SSURGO] datasets) provide an initial county-level estimate of soil organic matter content, but there are no programs in place to monitor and report soil organic matter content on a national basis. Universities and other research institutions have carried out observations of the changes in soil organic matter content under different management practices, but the results of these investigations do not provide national coverage. The STATSGO database is available at http://www.ftw.nrcs.usda.gov/stat_data.html and SSURGO is available at http://www.ftw.nrcs.usda.gov/ssur_data.html.

Soil Erosion

The Indicator

This indicator presents the percentage of U.S. cropland (minus pastures, but including Conservation Reserve Program [CRP] acreage) in each of three categories of land condition (least prone, moderately prone, and most prone to erosion), based on both inherent soil properties and management practices, for 1982, 1992, and 1997, for both wind and water erosion. Also, those lands most prone to wind and water erosion are mapped.

Soil erosion is affected both by the inherent properties of the soil, landscape, and region (e.g., slope, soil type, rainfall) and by management factors that may change more rapidly (specifically, the use of terracing, wind barriers, and the type, amount, and duration of vegetative cover). Soils with higher inherent likelihood of eroding and with high vulnerability due to the way they are managed are likely to erode the most. (Enrollment of these acres into the CRP, which requires steps toward reducing erosion (e.g., planting perennial grasses), will lead to improvement of this indicator.) Conversely, soils with low inherent likelihood of eroding and low vulnerability because of good management are likely to erode least.

Categories for this indicator were developed using parameters measured for use in the Universal Soil Loss Equation (USLE) and Wind Erosion Equation (WEQ). These equations were developed to predict long-term average erosion based on measurements of the inherent soil and plot features and management and surface treatment factors. For water erosion (USLE), inherent soil and plot factors are R, rainfall and runoff; K, soil erodibility; and L and S, topographic factors related to slope steepness and length of slope. Management and surface treatment factors included C, cover management, which essentially measures whether and how much vegetative cover is left on the soil surface, and P, support practice factor, which measures whether there are features such as terraces. The equation form is A (annual soil erosion per unit area) = C*P*R*K*L*S. For wind, the inherent soil and plot factors are I, soil erodibility index, and C, climatic factor. Management and surface treatment factors are K, ridge roughness; L, unsheltered distance along the prevailing wind direction; and V, vegetative cover. Wind erosion, E (annual soil erosion per unit area), is a function of I, K, C, L, and V (see references for more details).

This report uses the underlying principles of these equations to identify cropland area with combinations of inherent soil properties and management practices that are likely to erode most and least. Though inherent soil properties change slowly or not at all, management practices can significantly reduce erosion. Thus, reductions in acreage with high propensity to erode result primarily from application of management practices that reduce erosion, including removal of acreage from cultivation, such as CRP.

Areas with the least susceptibility to both wind and water erosion ("least prone") are generally those with a predicted erosion rate of less than 1 ton per acre per year. Areas with the greatest susceptibility to erosion ("most prone") are those with a predicted erosion rate of 3 tons per acre or more. Areas with moderate susceptibility to erosion have predicted values between about 1 and 3 tons per acre per year.

Standard application of both USLE and WEQ uses the equations to predict total erosion, in tons per acre. In this report, we have chosen not to take this last step in the process. We do so because we believe taking this step overstates actual erosion, as the USLE does not account for deposition, only the initiation of soil movement. Some soil particles move only very short distances, and when erosion is reported in units of "tons per acre" there is a strong implication (and sometimes an explicit statement) that these tons of soil are lost from the farm field.

The WEQ estimates how much eroding soil leaves the downwind edge of the field, in tons per acre per year.

The Data

Data Source: Acreage estimates for lands in each of the three categories were developed using data provided by USDA's Natural Resources Conservation Service, from the National Resources Inventory (NRI). For information on NRI methods, applicability of results, and access to information, see the technical note for Total Cropland, page 229.

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Soil Salinity

The Indicator

This indicator would be reported as the percentage of croplands nationally having one of three salinity levels (less than 2 decisiemens per meter [dS/M], 2 to 4 dS/m, and greater than 4 dS/M; see below for discussion/description). In addition, the percentage of croplands with elevated soil salinity (over 4 dS/m) would be mapped on a Major Land Resource Area (MLRA) basis. (MLRAs are aggregations of geographic areas, usually many thousand acres in extent, which are characterized by a particular pattern of soils, climate, water resources, and land use. See http://www.statlab.iastate.edu/soils/MLRAweb/mlra/ for a discussion and map.)

Salinization is the process by which salts accumulate in the soil. Soil salinity hinders the growth of plants by limiting their ability to take up water. Soluble salts, particularly sodium salts, may also harm soils by reducing soil structure, tillage properties, and permeability to water.

Soil salinization is most often associated with irrigated agriculture because when water is applied to the land to nourish crops, much of it is taken up by plants (or evaporating directly from the soil surface) and is returned to the atmosphere. Since only pure water evaporates from the soil surface or transpires from the plant surfaces, the salts are left behind in the soil. Thus, irrigation has the potential to lead to excess accumulation of salts in the soil. The occurrence of saline soils, however, is not restricted to irrigated soils. The same processes of mineral weathering or dissolution and subsequent concentration because of water evaporation often lead to high salt levels in soils of arid and semiarid regions. The scarcity of rain that makes these areas arid restricts the possibility of leaching and thus leads to salt accumulation. A special case of dryland salinity of particular concern to the northern Great Plains is that of saline seeps. A saline seep occurs when water in excess of that required by plants percolates below the root zone and, upon encountering some type of barrier or restricting layer, moves laterally downhill and emerges in a seepage area, having picked up dissolved salts in transit. Saline seeps are often encountered where farmers practice a wheat-fallow rotation; during dry periods, such a rotation may serve to conserve some water during the non-cropped period to aid the following crop, but in somewhat wetter years, the precipitation in excess of that required by plants initiates the process that leads to a seep. Drainage from saline seeps is estimated to affect about 2.5 million acres in the northern Great Plains.

Soluble salts in soils are measured by determining the electrical conductivity of a saturated paste extract; the units of conductance are reported as dS/m. Few plants are affected when the extract conductivity is below 2 dS/m, while some sensitive plants are affected when values are between 2 and 4 dS/m. Many plants are affected when values are above 4, and few plants can survive at values greater than 16 dS/m. Salts are usually most damaging to young plants, but not necessarily at the time of germination, although high salt concentrations can slow or inhibit seed germination. Most plants are least affected by soil salts when in their mature stages.

Reduced permeability to water is a common problem with salt-affected soil. Soil porosity becomes gradually altered and some soils can become completely impermeable. The mechanisms responsible are swelling of clays, which reduces pore sizes, and dispersion of the soil, so that aggregates break down, and smaller mineral and organic particles move with water and begin to fill smaller pore spaces. Dispersion is the most frequent cause of reduced infiltration. The measurement that most accurately determines whether the soil is affected by soluble salts is the exchangeable sodium percentage, which expresses the portion of the total exchangeable cations that are sodium. An exchangeable sodium percentage value equal to or greater than 15 indicates a sodic soil.

The Data Gap

Soil salinity measurements are needed on dominant soils, on cropping patterns, and particularly on water management practices under both irrigated and non-irrigated conditions in arid and semiarid regions. Salinity measurements are often included in routine soil tests. However, there is no unified effort in place to collect and analyze the results over uniform regions. A program that can monitor changes over time as a function of soils and management practices is vitally needed.

Soil salinity measurements should include data on dominant soils, cropping patterns, and, particularly, water management practices such as irrigation and drainage. Gathering together the existing but fragmented data, collecting new data, and analyzing the results to ensure national coverage require a coordinated effort. Satellite-based technologies, while promising, are able to detect only visible salt deposits. Since visible surface salts are incorporated into the soil by tilling, these approaches may be of use primarily to complement soil testing.

Soil Biological Condition

The Indicator

The Nematode Maturity Index (NMI) is a weighted mean frequency of taxa assigned weights ranging from 1 to 5, with a smaller weight being assigned to taxa with relative tolerance to disturbance and a larger weight to taxa that are more sensitive to disturbance. The index combines both free-living and plant-parasitic nematodes but excludes taxa that simply respond ephemerally to added nutrients. This index can detect differences among fields in a regional survey more reliably than one that measures only free-living nematodes (Neher and Campbell 1996). (See references for a variety of publications that support the use of soil organisms, particularly nematodes, as indicators of soil quality.)

This index is based on the principle that different taxa have different sensitivities to stress or disruption of the successional sequence because of differences in their life history characteristics. Because succession may be disrupted at various stages by common agricultural practices, such as cultivation and applications of fertilizer and pesticides, the successional status of a soil community may reflect the history of disturbance. However, although a disturbance, such as the addition of animal manure to soil, initially produces a predominance of nematodes with smaller values, the abundance of nematodes with large maturity index values soon increases.

Maturity indices have the strength of responding to a variety of land management practices across plant species, soil types, and seasons (Neher et al. 1995). Nematode community structure and function are known to change in response to land management practices such as nutrient enrichment through fertilization by organic or inorganic nitrogen, cultivation, liming, and drainage, as well as to changes in plant community composition and age and to toxic substances such as heavy metals, pesticides, and petroleum products.

The Data Gap

Sampling should be carried out in autumn after cultivation of fields harvested in the fall; this will minimize within-field sampling variation. Free-living nematode populations are generally at their peak at this time because crop residues are incorporated into soil by cultivation and temperatures are moderate.

Cobb's sieving and sugar centrifugal-flotation methods are recommended to optimize recovery of entire nematode communities from soil (Neher et al. 1995). Neher et al. (1998) suggest that it is unnecessary to calibrate indices of nematode community structure at a scale finer than the USDA's Land Resource Regions.

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Status of Animal Species in Farmland Areas

The Indicator

As discussed on the indicator page, there are multiple approaches to reporting on animal species in farmland areas. One might be to report on the status of species that favor those habitats that existed before farmland was created in an area. Such an approach would, for example, focus on grassland birds in areas of the Great Plains—species that inhabited prairies that have now been converted to farmland. Another approach might be to focus on species that are able to take advantage of farmland landscapes—many game birds and small mammals, for example. Both of these approaches would be useful, but by themselves would be incomplete.

A more appropriate approach, recommended here, would be to focus on the full breadth of species that might inhabit farmlands. To follow the examples above, this would include both grassland birds and game birds and small mammals. Such an approach has been suggested, based on expectations that one might encounter a variety of birds in different regions of the nation. An index could be developed based on comparing this expectation with data on the presence of birds on farmlands in that region—data that may already be available for a significant percentage of farmlands (Breeding Bird Survey, http://www.mbr-pwrc.usgs.gov/bbs/bbs.html; additional information on such an approach toward determining an index of bird "integrity" can be found at htpp://landscape.forest.wisc.edu/LandscapeEcology/Articles/v7i2p137.pdf).

Several reviewers of this report recommended that this indicator focus on domestic animals—their numbers, condition, diversity, and the like. The Farmlands Work Group determined that it was appropriate to focus on the status and trends in wild species as part of this measure (which is intended to describe ecosystem conditions). A measure describing domestic animals would have been appropriate as part of the "human use" set of indicators, but was determined not to be of sufficiently high priority for inclusion.

The Data Gap

There are two major national-scale sources of information on species population status and trends. These include NatureServe's compilation of information from state-based Heritage programs, which provides status information on a global, national, and state basis (www.natureserve.org) for a large number of species, and the U.S. Geological Survey's Breeding Bird Survey (http://www.mbr-pwrc.usgs.gov/bbs/bbs.html), which provides population trend information for a large number of resident birds of North America.

Both programs provide information on a geographic scale that is usually larger than and is not limited to farmlands. Thus, it is likely that it would be necessary to undertake additional work to target these data only to farmlands.

Native Vegetation in Areas Dominated by Croplands

The Data Gap

The technical note for the grasslands/shrublands indicator on non-native plant cover (see p. 261) describes some of the public and private efforts under way to determine the extent of non-native plant cover, which would be useful for inferring the coverage of native species.

The technical note for the farmlands extent indicator (p. 229) describes sources of information on the extent and location of croplands.

Stream Habitat Quality

This technical note is also for the stream habitat indicator for the freshwater system.

The Indicator

The habitat quality of streams and rivers is dependent upon the presence of an appropriate, but changing, mix of habitat features. Key among these are the presence of riffles and pools, size distribution of streambed sediments and embeddedness (degree to which larger gravel and cobbles are buried in silt), amount of large woody debris, and bank stability, although different stream habitat rating methods may measure additional characteristics.

In addition, habitat quality is a relative value, meaning that it must be evaluated in relation to the habitat needs of the native flora and fauna in a region. Therefore, protocols to measure stream habitat quality generally provide for calibration according to a regional reference—that is, stream habitat quality is measured against the values that would be found in a relatively undisturbed or "natural" reference stream in that region. Finally, all stream habitat quality measurement protocols measure a variety of parameters, but not all combine these parameters into a single overall index.

Stream habitat quality measurement is an area of significant current research work. Following are references for four efforts that have or are developing regional or national protocols for this purpose.

References

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Major Crop Yields

The Data

Data Source: Data for 1950 through 1998 are from the U.S. Department of Agriculture National Agricultural Statistics Service (NASS), Historical Track Records, United States Crop Production, May 2001. The historical data can be located by using the Crop Production Historical Records link at http://www.usda.gov/nass/pubs/histdata.htm. Data for 1999 and 2000 are from USDA-NASS, Agricultural Statistics 2001; http://www.usda.gov/nass/pubs/agr01/acro01.htm.

Data Collection Methodology: State offices collect and estimate crop yield data from sample surveys of farmers and their business associates (farm service agencies, cotton gins, marketing associates). NASS obtains the yield estimates, which are verified and analyzed on a national level. Survey data are supplemented by information from the Census of Agriculture, which is carried out every 5 years.

Data Manipulation: Yields, which are generally reported as bushels per acre for corn, soybeans, and wheat, and as tons per acre for hay and cotton, were divided by their respective value for 1975. Thus, values above 1.0 indicate higher yields than in 1975, and values lower than 1.0 indicate lower yields than in 1975.

Data Access: See the Web sites listed under "Data Source."

Agricultural Inputs and Outputs

The Indicator

This indicator presents ratios of certain major inputs identified and quantified by the U.S. Department of Agriculture (USDA) to total agricultural outputs, also as quantified by USDA. The intent is to report the amount of inputs needed to produce a unit of output, because the quantities of, and tradeoffs between, individual inputs (such as pesticides and fertilizer) are important. For example, if decreasing amounts of fertilizer are required to produce a unit of output, this has implications for the cost of production (fertilizer is a significant cost) and for off-farm environmental impacts (excess fertilizer can contribute to water pollution).

The Data

Data Source: Data came from *Agricultural Productivity in the United States* published by USDA's Economic Research Service (ERS).

Data Collection Methodology: The output data represent all agricultural outputs, including animals and animal products (meat animals, dairy products, poultry, and eggs) and crops (food grains, feed crops, oilseed crops, sugar crops, cotton and cotton seed, vegetables and melons, and fruit and tree nuts). Aggregation of multiple outputs or inputs into a single index often requires assumptions about the comparability of unlike things—adding tons of corn to tons of strawberries would be nonsensical. USDA economists use an approach that involves determining the adjusted price of a given output, which is multiplied by the output quantity, so that all outputs can be added together into the single value shown here. ERS developed a similar scheme for adding inputs together; however, because the focus in this indicator is on changes in different inputs as well as the overall amount of inputs, the individual inputs are presented here. The yearly quantity of each input has been adjusted to some extent by ERS to reflect the changes in quality. For example, similar results can now be achieved with smaller quantities of pesticides. Thus, a larger quantity of less effective pesticide might be treated as equal to a smaller quantity of a more effective pesticide. The same is true for the other inputs, such as labor, whose quantities have been quality-adjusted over time.

Data Manipulation: Each input has been divided by the total farm output for that year. The data from ERS are all relative to a given year (1948) and are not reported as actual quantities. Because the focus of this report is on 1950–2000, we chose the midpoint (1975) as a more appropriate index year. Because of this, data (inputs and outputs) were simply divided by the 1975 value. All input data were then divided by the value of total outputs for any given year to produce the data shown in the figure.

Data Access: The data are available at http://www.ers.usda.gov/publications/aib740/; a more detailed version of the data is available at http://www.ers.usda.gov/data/sdp/view.asp?f=inputs/98003/.

Monetary Value of Agricultural Production

The Indicator

The gross value of agricultural production is a measure of the physical output of major crops and livestock multiplied by price (in dollars) received by producers. (The values have all been converted to 1999 dollars.)

The geographic distribution of agricultural sales is a measure of gross sales by crop and livestock producers per square mile. These data do not reflect payments received by producers through government income support, commodity, or conservation programs, nor do they reflect economic activity associated with food processing and distribution or off-farm service and supply businesses.

The Data

Data Source: Data on the dollar value of agricultural sales are from the U.S. Department of Agriculture (USDA) Economic Research Service (ERS), which reports farm income and farm cash receipts.

Data for agricultural sales per square mile are from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA), Regional Economic Information System branch (http://www.bea.doc.gov/bea/regional/reis/), which calculates county cash receipts.

Data Collection and Manipulation (Dollar Value of Agricultural Sales): The USDA National Agricultural Statistics Service (NASS) conducts national surveys that measure acres planted and harvested, yields, production, and market prices. The estimates include cash receipts from the marketing of about 150 crop and livestock commodities.

ERS uses NASS-published, calendar-year cash receipts for major livestock and commodity-producing states. ERS develops indexes to indicate direction and magnitude of changes in monthly sales quantities and multiplies them by NASS-published monthly prices. Data for other states are developed in cooperation with the NASS state offices, which use all available sources, including informed opinions, often corroborated by data from state survey programs, producer associations, and the state's extension service. California data come from state-conducted surveys.

ERS adjusts NASS quantity and value of production data for major crop commodities in major producing states to adjust for production of feed used on farms for livestock and for Commodity Credit Corporation sales and to account for the fact that some sales do not take place in the same year as the crop is harvested. Data from NASS that cannot be released to the public because of confidentiality constraints are included in the overall ERS dataset.

Data were adjusted for inflation using the Gross Domestic Product Implicit Price Deflator (IPD) provided by the Economic Research Service. All data were adjusted to the average level of prices that existed in 1999. The following formula was used to convert each figure in the series from current dollars to constant dollars (available at http://www.owlriver.com/pie.mhsc.org/DataPages/sd-079.htm).

$$\text{Year Z constant dollar value} = \frac{\text{(Year Z current dollar value)*(Base year IPD index number)}}{\text{Year Z IPD index number}}$$

Data Collection and Manipulation (Agricultural Sales per Square Mile): The U.S. Department of Commerce's BEA uses a variety of data sources to develop county-level estimates of farm receipts. For 16 major producing states, NASS-affiliated state offices prepare annual county estimates of farm cash receipts. For other states, state-level cash receipts estimates produced by NASS are allocated by BEA to counties in proportion to the corresponding Census of Agriculture data for the relevant year.

These county-level data were used to produce county-level estimates of cash receipts per square mile by dividing total cash receipts by the number of square miles in a county. County area data are from a standard dataset produced by Environmental Systems Research Institute, Inc. (ESRI; http://www.esri.com), a maker of geographic information system software and data products.

Data Access: Data on U.S. national farm cash receipts for 1924–1999 are available online at http://www.ers.usda.gov/data/farmincome/finfidmu.htm.

The U.S. county cash receipts data can be requested through BEA, Regional Economic Information System branch (http://www.bea.doc.gov/bea/regional/reis/).

Recreation on Farmlands

There is no technical note for this indicator.