Appendix 1. Linking Environmental Indicators to Farm-Level Data

Environmental indicators are linked spatially to farm-level economic data using a Geographic Information System (GIS). GIS techniques are used to create "surfaces" of environmental indicator values. Farm-level data are then linked to indicators by locating the farm on the environmental indicator surface and assigning the surface value at that location. Results are then aggregated to the national or ERS Farm Resource Region level. This spatial association is valid to the extent that spatial variations in climate, land resources (e.g., soil productivity and erodibility), and farms (e.g., variation in crops and production practices) are interrelated. ERS Farm Resource Regions are, in fact, based on identification of areas with relatively uniform farms, soils, and climate. The regions are based in part on a cluster analysis of U.S. farm characteristics (Sommer and Hines, 1991) and on USDA land resource regions (USDA-SCS, 1981).

Environmental indicators are based largely on data from the National Resources Inventory (NRI). NRI point data files are collected and maintained by the USDA's Natural Resources Conservation Service (NRCS) and contain detailed data on land use and condition for each of more than 800,000 points nationwide, including estimates of water (sheet and rill) and wind erosion on cropland. Surfaces for highly erodible land, acres with excess erosion, and the change in excess erosion are derived from NRI. Data from other sources are combined with NRI to create the nitrogen and phosphorus runoff and nitrogen leaching indices described in Appendix 2.

The surfacing technique employed is the Average Shifted Histogram (ASH) estimator, which is a non-parametric regression procedure designed to assess the density of certain characteristics in the overall land base, e.g., the prevalence of highly erodible land. Indicator surface values are developed on a per-cropland-acre basis to facilitate combining these measures with ARMS data. For HEL cropland, for example, the surface value is the proportion of cropland acres that are highly erodible.

The distribution of farms by commodity specialization and program payments is derived from the 1997 Agricultural Resource Management Survey (ARMS). ARMS is an annual sample survey of farms and agricultural commodities conducted to obtain information about the status of farmers' finances; production practices for specific commodities; use of natural, physical, and financial resources; and household economic well-being. Sponsored jointly by ERS and USDA's National Agricultural Statistics Service (NASS), ARMS began in 1996 as a synthesis of the former USDA cropping practice, chemical use, and farm costs and returns surveys, which dated back to 1975. Of particular interest for our application, agricultural producers[16] are asked about land use, cropping patterns, and government program participation.

[16]Defined as "all establishments except institutional farms that sold or would normally have sold at least $1,000 of agricultural products during the year" in the 48 contiguous States. For more information, see www.ers.usda.gov\Briefing\ARMS.

Regional or national estimates of acreage with specific environmental characteristics (e.g., the number of HEL cropland acres) on farm with payments are calculated as:

$$A_i = \sum_{k \in K} \gamma_k A_k^{ARMS} \rho_{ik}$$

where γ_k is a zero-one indicator of whether farm k receives farm program payments that would make it subject to conservation compliance; A_k^{ARMS} is the cropland acreage in farm k in Phase III of ARMS; and ρ_{ik} is the value per acre of indicator i in the area where farm k is located. The variable ρ_{ik} is constructed using the surfacing techniques described above. Because farms surveyed in Phase III of ARMS are located only at the county level, values for ρ_{ik} are assigned at the center of the county (the county centroid).

This procedure provides estimates that are often quite close to the original NRI estimates. Appendix table 1 provides estimates reported in the text (derived using the procedure detailed above) and estimates derived directly from NRI. National estimates of the extent of land that is highly erodible due to the potential for water (sheet and rill) erosion are extremely close to NRI estimates. Using the ARMS-NRI merged data, we estimate that 55.19 million acres are highly erodible due to water, less than 1 percent higher than the 54.69-million-acre estimate obtained directly from NRI. For wind erosion, the ARMS-NRI merged data indicate 55.54 million acres are highly erodible, about 7 percent higher than the 51.61-million-acre estimate obtained directly from NRI.

Appendix table 1—Acreage estimates using indictor surfaces and ARMS versus acreage estimates directly from NRI

	Estimate	NRI estimate	Difference
	million acres		*percent*
HEL cropland, wind	55.54	51.61	7.61
HEL cropland, water	55.19	54.69	0.91
Total HEL cropland, by region			
Prairie Gateway	30.24	26.67	13.39
Heartland	23.25	23.24	0.04
Northern Great Plains	17.04	18.49	-7.84
Northern Crescent	10.08	9.77	3.17
Fruitful Rim	8.81	7.31	20.52
Basin and Range	7.43	6.54	13.61
Eastern Uplands	7.29	5.77	26.34
Southern Seaboard	2.81	3.63	-22.59
Mississippi Portal	1.80	2.31	-22.08
HEL cropland, wind, erosion>T*	25.38	22.26	14.02
HEL cropland, water, erosion>T*	34.71	34.95	-0.69

*T is the soil loss tolerance, the maximum rate of soil loss that can be sustained indefinitely without productivity damage.

Source: ERS analysis of NRI and ARMS data.

Appendix 2. Methodology for Constructing Nutrient Loss Indices

Nitrogen and Phosphorus Runoff Index

The Nitrogen and Phosphorus Runoff Indexes are based upon "The modified P index system to rate the potential P loss in runoff from site characteristics" found in *A Conceptual Approach for Integrating Phosphorus and Nitrogen Management at Watershed Scales* by Heathwaite et al., 2000.

The indexes consist of four transport factors and two source factors. Index scores, based on the factors described below, are computed as:

> **Nitrogen score** = (soil erosion index score * runoff index score * irrigation index score * distance to water index score) * (commercial nitrogen application + manure nitrogen application)
>
> **Phosphorus score** = (soil erosion index score * runoff index score * irrigation index score * distance to water index score) * (commercial phosphorus application + manure phosphorus application)

The indexes are calculated for each cropland data point in the 1997 National Resources Inventory (NRI) database, excluding land in aquaculture and horticultural crops. The NRI point data files are collected and maintained by USDA's Natural Resources Conservation Service (NRCS) and contain detailed information on land use and condition for more than 800,000 points nationwide. A variety of other data sources are used to calculate some of the individual factors.

Transport Factors

The *soil erosion* index score is based on estimated sheet and rill erosion reported in the 1997 NRI. Erosion rate estimates, in tons per acre per year, were made using the Universal Soil Loss Equation (USLE; see Wischmeier and Smith, 1978). Erosion rate estimates are used to classify cropland into five categories of roughly equal size, by acreage. Each of the five groups was then given a score, from lowest to highest, of 0.6, 0.7, 0.8, 0.9, or 1.0, respectively.

The *irrigation erosion* index score is based on the existence of irrigation and land slope, both of which are reported in the NRI. Land without irrigation was assigned an irrigation erosion value of 0.6. Land slope was used to classify irrigated cropland into four categories of roughly equal size, by acreage. Each of the four groups was then given a score, from lowest to highest, of 0.7, 0.8, 0.9, or 1.0, respectively.

The *runoff* index score is based on the methodology used by Kellogg (1997). Average annual precipitation was computed for each NRI point using various sources of weather data and methods of interpolation. Runoff was then estimated using a runoff curve value taken from the NRCS runoff curve table.[17] The runoff curve value depends on cropping type, conservation management, and soil hydrologic group. Cropping type was determined by land use as shown in appendix table 2. On highly erodible land, conservation management was considered good if erosion was less that twice the soil loss tolerance

[17]See http://abe.www.ecn.purdue.edu/~engelb/agen526/Runoff/cn_table.html

Appendix table 2—Runoff curve table based on NRI land use

NRI land-use designation values	Runoff curve cropping type
11 – 20	Row crops
111-116	Small grains
141 - 143	Meadow
170 - 180	Used most recent land-use designation from cropping history.

Source: National Engineering Handbook, USDA-NRCS.

or "T" factor. On non-highly erodible land, conservation management was considered good if erosion was less than T. The soil hydrologic group was taken from the Soil Interpretive Record (SIR) database associated with the NRI. The runoff estimates were used to classify cropland into five categories of roughly equal size, by acreage. Each of the five groups was then given a score, from lowest to highest, of 0.6, 0.7, 0.8, 0.9, or 1.0, respectively.

The *contributing distance or distance to water* index score is based on distance to water available in the 1997 NRI database. The values for distance to water were placed into the five groups as described in Heathwaite et al., 2000.

Source Factors

Commercial nitrogen and phosphorus application rates are computed at the county level. Each NRI point in a given county is assigned the county application rates. The values were derived from commercial fertilizer expenses from the 1997 Census of Agriculture.

Manure nitrogen and phosphorus application rates are computed at the county level. Each NRI point in a given county is assigned the county average application rates.

Nitrogen Leaching Index

The Nitrogen Leaching Index is based upon "The N index system to rate the potential loss in leaching from site characteristics determining source and transport factors" found in *A Conceptual Approach for Integrating Phosphorus and Nitrogen Management at Watershed Scales* by Heathwaite et al., 2000.

The index consists of two transport factors and two source factors. Index scores, based on the factors described below, are computed as:

> **Nitrogen score** = (soil texture index score * permeability index score) * (commercial nitrogen application + manure nitrogen application)

The index is calculated for each cropland data point in the 1997 NRI database, excluding land in aquaculture and horticultural crops. A variety of data sources were used to compile the individual factors. Nitrogen source factors are as described above.

Transport Factors

The *soil texture* index score was assigned following Heathwaite et al., 2000.[18] Data on soil texture data is from the 1997 NRI point database.

The permeability index score is based on a formula developed by Williams, Jones, and Dyke (1984). The formula uses data on precipitation, irrigation, and soil hydrologic group. Average annual and monthly precipitation was computed for each NRI point using various weather data sources and interpolation methods. The presence of irrigation was determined using NRI data. The soil hydrologic group was taken from the SIR database. The permeability estimates were used to classify cropland into five categories of roughly equal size, by acreage. Each of the five groups was then given a score, from lowest to highest, of 0, 1, 2, 4, or 8, respectively.

[18]A few soil texture categories that did not appear in this publication were assigned index scores by the authors.