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Productivity and Erodibility of U.S. Cropland

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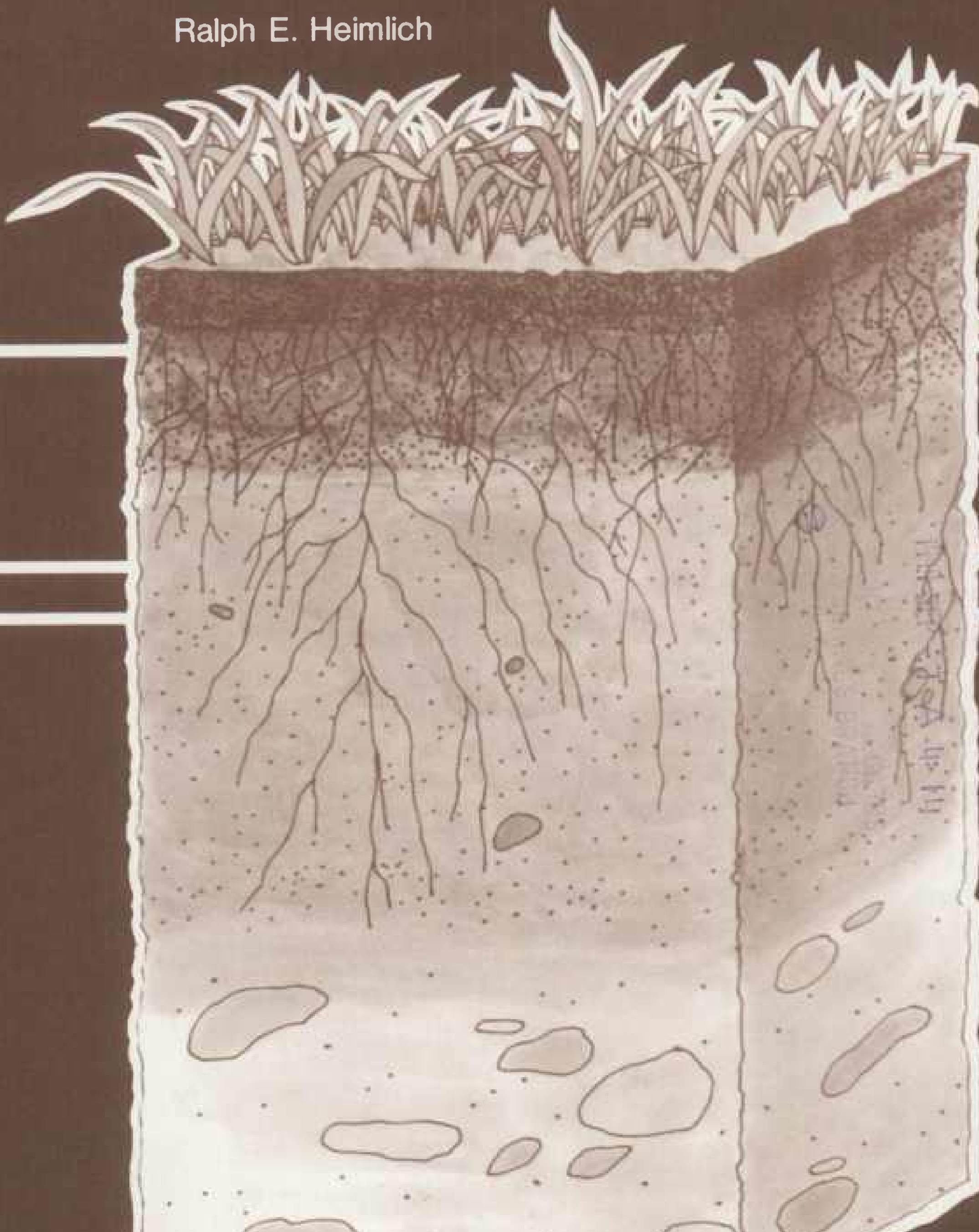

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Abstract

Soil erosion policy aiming to remove highly erodible land from production to reduce soil erosion may be dealing with some of the most productive and valuable U.S. cropland. If so, greater incentives for farmers to retire that land may be needed. The land capability classification system and USDA's prime farmland definition, used to measure the suitability of land for agricultural uses, do not provide enough information for decisions on whether highly erodible soils are less or more productive than less erodible soils. As a result, some highly erodible lands that are also highly productive may have higher opportunity costs than commonly thought and thus may need greater incentives for retirement. Opportunity costs measure the earning power of an input, soil in this case, in its best alternative use.

Keywords: Soil productivity, soil erodibility, soil erosion policy, U.S. cropland, land capability classification, prime farmland definition.

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ibility, measured by the product RKLS of the Universal Soil Loss Equation (USLE), was not well correlated with either corn silage or hay yield estimates from either source.[2] Mean corn silage and hay yields for soil erodibility classes similar to those used in the present study did not differ significantly. According to Bills, retiring highly erodible cropland would sacrifice productive capacity in proportion to the acreage retired because highly erodible soils have the same productivity as moderately erodible or nonerodible soils.

Options to retire erodible, unproductive cropland were analyzed to provide background information for the debate over the Food Security Act of 1985 (*29*). Webb, Ogg, and Huang of USDA's Economic Research Service (ERS) subdivided land groups in the existing linear programming model of the Center for Agricultural and Rural Development (CARD) to reflect differences in both inherent soil erodibility and crop yield (*37*). Differences in crop yields by soil type and soil erosion parameters for the CARD model are based on "dominant" soils for each land capability class and subclass in each Major Land Resource Area (MLRA) from a 1973 survey conducted by the Soil Conservation Service (SCS) (*8*). Yields used in the ERS/CARD model were projected using Spillman regression relationships applied to State-level yield data. The pattern of yield differences among land groups was similar to the SCS survey. The six new land groupings developed by ERS show little relationship between highly erodible soils and low corn yields (table 1). The lowest yielding land group (group 6) has mixed erosion potential. Groups with the highest erosion potential (groups 4 and 5) have higher yields than one of the groups with the lowest erosion potential (group 2). Land from almost all capability classes, especially classes II and III, appears in every land group except 6.

Bills and others used data from New York's agricultural use-value assessment program and the 1977 NRI to investigate the relationship between crop yields, net income, and the prime farmland designation (*5*). While average crop yields on prime land for important dairy crops were higher than those on land not designated prime, considerable overlap in the distributions of a soil productivity index based on total digestible nutrients (TDN) was found between the two kinds of land. When production costs were considered, significant overlap between net returns on prime and nonprime land was found (table 2).

[2]R is the rainfall erosion index, K is the soil erodibility index, and LS is the topographic factor (see the appendix for more details.)

More than 60 percent of New York's cropland is relatively productive, with TDN production greater than half as large as the State's best soil. However, little more than 30 percent of the State's acreage is classified as prime land based on physical characteristics. Although more than 70 percent of New York cropland returns less than half as much income as the best soil in the State, more than 17 percent of this low income-producing cropland is classified prime land.

Reganold and Singer investigated the relationship between the land capability classification; the Storie Index Rating (SIR), a physically based land classification system used in California; and economic returns on 744 fields in California's San Joaquin Valley (*24*). Crop output was aggregated across all crops and years and was normalized by subtracting mean output and dividing by the standard deviation. This crop

Table 1—Land capability class, erosion potential, and average corn yield, ERS/CARD model land groups

Land group	Land capability class and subclass[1]	Erosion potential[2]	Average corn yield
			Bushels per acre
1	I, IIwa, IIIwa	Low	109
2	II, III, IVw,s,c, V	Low	67
3	IIe, IIIe, IVe, RKLS less than 50	Medium	97
4	IIe, IIIe, RKLS over 50	High	85
5	IVe, RKLS over 50	High	79
6	VI, VII, VIII	High or low	37

[1]Subclasses denote dominant limitation. c = climatic; e = erosion; s = shallow, droughty, or stony soil; w = wetness; wa = wet but adequately treated.
[2]Land with high erosion potential has physical features, measured by the product RKLS of the USLE, which would result in more than 50 tons per acre per year of sheet and rill erosion if left fallow and plowed up and down the field slope (*4*).
Source: (*29*).

Table 2—Distribution of prime and nonprime New York cropland by expected TDN production and net income

Net income	Prime		Not prime		Total
	High TDN[1]	Low TDN	High TDN	Low TDN	
	Percentage of cropland[2]				
High[3]	23.3	0	5.2	0.2	28.6
Low	10.6	2.1	22.8	35.8	71.4
Total	33.9	2.1	28.0	36.0	100.0

[1]High TDN (total digestible nutrient) soils have a productivity index rating of 50 or more (4.54 tons TDN = 100).
[2]Includes 7.7 million acres inventoried in the 1977 NRI as existing cropland or with high or medium potential for conversion to cropland.
[3]Soils with a net income index rating of 50 or more ($78.60 = 100).
Source: (*5*).

output for acreage-weighted field capability classes differed significantly at the 95-percent level for classes II and III and classes VI and higher (table 3). Output corresponding to class I was not significantly different from the other classes. Input differences were only significant for classes II and III. The input/output ratios, reflecting dollar inputs per dollar of output, were generally lower for lower classes (III and lower) and higher for higher classes (VI and higher). Input cost differences per unit of output between lower capability classes and higher classes by crop and year were significant in only 2 cases out of 24. Overall, 19 of 24 cases had lower input/output ratios for lower land capability classes, but input/output ratios were higher by an average of only 9.4 percent.

Data and Methods

USDA is developing what constitutes an evolving geographic information system for congressionally mandated resource appraisals (*20*) and for data needed to manage agricultural commodity programs. When combined with existing soil interpretation data, these data sources provide a basis for detailed, disaggregated resource assessments (*14*).

This analysis combines the following (see the appendix for more detail on the data sources and methods used in this analysis):

- Data from the 1982 NRI, SOILS 5, and crop budgets of the 1982 Firm Enterprise Data System (FEDS).

- Measures of crop productivity based on corn grain yields and potential net crop revenue.

- An erodibility classification based on the USLE.

Table 3—Normalized input, output, and input/output ratio means by land capability classification groupings[1]

Class grouping[2]	Input	Output	Input/output ratio
Less than 1.50	0.035 ab[3]	−0.041 ab	0.047 ab
1.51–2.50	.167 a	.130 a	−.070 ab
2.51–3.50	−.107 b	.066 a	−.108 b
3.51–4.50	−.126 ab	−.326 b	.296 ac
4.51–5.50	−.343 ab	−.566 b	.401 cb
More than 5.50	.133 ab	−.653 b	.771 c

[1]Difference between observed and average input, output, or input/output ratio divided by the standard deviation.
[2]Area-weighted average of the land capability classes of soil mapping units present in each field.
[3]Means followed by the same letter are not significantly different at the 0.05 level of probability.
Source: (*24*).

1982 National Resource Inventory

The data set from SCS's NRI contains information on land use and cover, soil type, actual and potential erosion, and other resource information. The 1982 NRI, the latest in a series of statistically based land resource inventories, contains information on rural, nonfederal U.S. land, excluding that in Alaska. This analysis uses data on nonirrigated cropland observations that include land use and cover of land for crop production, capability class and subclass, prime farmland designation, soil erosion parameters, and the SOILS 5 record identification.

Soil Survey Interpretations Record

SCS prepares and enters into a computer data base soil survey interpretations for all established soil series. Specific information for each item interpreted, including estimated crop yields, is contained in the SOILS 5 record and is matched to the individual NRI observations (*35*).

Predicted crop yields approximating those of leading commercial farmers at the management level that tends to produce the highest economic returns per acre (known as "B-level" management) are recorded on the SOILS 5 form (*32*). Yields for up to seven of the most important crops commonly grown on the soil are given for nonirrigated and irrigated cultivation, as appropriate. Yields for crops not commonly grown in the area or not feasible for production on some soils are not recorded.

Crop Budgets From the Firm Enterprise Data System

Congress requires ERS to annually estimate and publish regional and national average costs of producing major agricultural commodities. ERS bases these estimates on data on farm production expenditures and technical relationships collected from periodic USDA surveys of farm operators (*30*). Until 1983, Oklahoma State University prepared FEDS research budgets for major crops in each State that were also partially based on these data (*17*). This study uses variable production costs from FEDS budgets estimated for 1982.

Because FEDS variable production costs were prepared for wide geographic areas, they imperfectly reflect variation in costs due to resource differences. However, the kind of detailed studies necessary to determine production cost differences across soils are rarely done (*24*). Even generalized crop budgets for specific soil groups, such as those developed for the New York State use-value assessment program, have been done too infrequently to provide a comprehensive production cost data base. Nevertheless, the FEDS budgets using 1982 survey data are the only localized production cost data that can be used for a national assessment of erodibility and productivity relationships.

Productivity Measures

This study constructs and analyzes two measures of productivity: corn grain yields and a simple average of field crop revenue. This analysis uses corn grain yields to directly measure physical productivity. More than 20 percent of cropland used for crops has been planted to corn in recent years, making it a widespread crop that reflects the physical conditions needed for production of some major field crops. However, corn grain has several drawbacks as an indicator crop. SCS does not report corn yields on soils where corn is not commonly grown, despite the fact that physical conditions may be appropriate for corn production. Corn yields were reported on soils making up about 67 percent of nonirrigated cropland in the 1982 NRI. Cropland acreage without corn grain yields is indicated separately in this report and excluded from the calculated averages in the results.

An indicator crop only partially reflects the value of productive soil as an agricultural input in any area. Gersmehl and Brown show that yields for important crops on the same soil are often not correlated (*11*). They calculated and mapped their measure of the local validity of a single-number index of productivity for soils in 200 counties. Outside the Midwest, correlation between crop yields was rarely high enough to inspire confidence in any single indicator crop.

Weighting the yields of various crops that could be grown on the soil circumvents this problem by incorporating all the yield information available into a single measure. The logical economic weighting factor is the relative value of each crop that could potentially be produced on the soil. By averaging the gross revenue (yield times price) associated with each of the eight major field crops that could potentially be grown on the soil, the relative contributions of different crops are combined in an economically based measure. This measure is more complete than corn grain yield because yields for at least one of the major field crops are reported on more than 98 percent of cropland. Because soil productivity, as distinguished from crop yield, is measured by the relationship between outputs and inputs needed to obtain those outputs, this study uses variable production costs from the FEDS crop budgets to measure input use.

This analysis selected estimated crop yields from the 31,384 possibilities in the SOILS 5 data base for each of the 251,430 nonirrigated cropland sample points in the 1982 NRI. Crops included were corn grain, soybeans, wheat, sorghum grain, cotton, oats, rice, and barley. The simple average net return on all crops for which yield was available was calculated at each NRI cropland sample point (see appendix). The average net return is used as an index of productivity.

Assessing Cropland Erodibility

Bills and Heimlich used the USLE to partition cropland into classes based on its physical characteristics and the cropping system applied to it. The classes are:

Highly erodible. Land with climate and topography such that erosion above tolerable levels occurs under any practical cropping system short of permanent grass.[3]

Nonerodible. Land that can meet tolerable soil loss limits under all cropping systems.

Moderately erodible. Land that may or may not erode excessively, depending on how it is managed.

This classification was modified for the Resource Conservation Assessment (RCA) (*19*). Wind erodible land was placed in a separate class because parameters of the wind erosion predictive equation were not available to calculate the appropriate wind erodibility index.

Land eroding above the soil loss tolerance level (T value) may be highly erodible land on which crops are produced or may be moderately erodible land that is not cropped using a conserving cropping system. High erosion on highly erodible land can only be brought under control by retiring the land from production. However, erosion above T on moderately erodible land can be reduced by changing the cropping system, often by using reduced tillage systems or other low-cost practices that allow continued intensive production.

Results

Results of this analysis are presented in terms of the two productivity measures: corn grain yields and net crop revenue. This section presents the following:

- Correlations between productivity, land classifications, and erodibility.

[3]The soil loss tolerance level is the maximum rate of annual soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely.

- Comparisons of the two mean productivity measures by erodibility levels.

- Distributions of estimated productivity measures by erodibility levels.

- Regression analysis of the erodibility, capability, hazard or limitations on capability, and prime farmland criteria to examine the contributions of each factor to productivity while controlling for the remaining factors.

Correlations With Productivity Measures

Measures of soil productivity, based on recorded corn grain yields and estimated net returns from nonirrigated production of major field crops, do not correlate with a measure of soil erodibility, based on factors of the USLE (table 4). Productivity measures, land capability classes, and the prime farmland definition are weakly correlated. These correlations are less reliable because these land classifications are discrete variables while productivity and erodibility are continuous variables. Land capability classes and productivity measures are weakly and negatively correlated.

The prime farmland definition (1 is prime, 0 is nonprime) is positively but weakly correlated with productivity measures. Land capability classes and the prime farmland definition are moderately well correlated. The corn grain yield measure of soil productivity is positively but weakly correlated with the net revenue measure.

Corn Grain Yields and Soil Erodibility

Average corn yield on nonirrigated nonerodible land with recorded corn yields is 97 bushels per acre, compared with only 84 bushels per acre on highly erodible land, but more than 35 percent of the nonerodible land has no recorded yield (table 5). Almost 80 percent of the highly erodible land has recorded corn grain yields. Moderately erodible land that is managed so as to erode above the T value has average yields almost as high as nonerodible land and has the highest proportion of land for which corn yield is recorded. Wind erodible land has the lowest proportion of acreage with recorded corn yields and the lowest average nonirrigated yields. In areas with high wind erosion, corn grain is probably grown more often under irrigation, with commensurately higher yields.

Land capability classes are combined to expand acreages enough to be statistically meaningful in terms of the NRI sample design. Corn yields decline as land capability classes increase. However, yield levels by capability class are inconsistent among erodibility classes. For example, average yields on nonerodible land in capability classes IV–VIII are less than yields on all erodible land, except land subject to wind erosion. However, only 36 percent of this land has recorded yields.

Table 4—Correlation matrix and statistics for nonirrigated cropland productivity, erodibility, and land classification variables, 1982

Variables	RKLS/T	Corn yield	Net crop revenue	Land capability	Prime farmland
RKLS/T[1]	1.000	—	—	—	—
Corn yield	−.110	1.000	—	—	—
Net crop revenue	−.059	.337	1.000	—	—
Land capability	.318	−.385	−.371	1.000	—
Prime land	−.187	.350	.394	−.620	1.000
Mean	6.19	92.15	6.66	2.66	1.46
Standard deviation	59.14	99.71	183.81	4.03	1.89
Minimum	0	40.00	−254.14	1.00	0
Maximum	1,535.56	163.00	246.57	8.00	1.00

— = Symmetrical entries across the main diagonal of the matrix.
[1]Continuous variable computed using USLE parameters at each 1982 NRI sample point.

Highly erodible land in these capability classes has the highest corn yields and the highest proportion of land with recorded yields. Wind erodible land in the lower land capability classes has the lowest corn yield, but much of this land requires irrigation. Even within the lower capability classes (I–III), moderately erodible land that is managed so as to erode above T has average corn yields almost as high as nonerodible land. Almost 90 percent of moderately erodible land eroding above T has recorded yields compared with only 68 percent of nonerodible land.

Differences in average corn yields by erodibility are not due to differences in land capability because yields for the land capability classes vary considerably by erodibility class.

Acreage-weighted average yields of nonirrigated corn grain are higher for cropland that meets the prime farmland definition than for cropland that does not (table 6). Yields on prime land are consistently higher than yields on nonprime land across erodibility classes. However, as previously demonstrated for land capability classes, yields on prime land are inconsistent among erodibility classes. Yields on nonprime, nonerodible land are lowest of all erodibility classes, except land subject to wind erosion.

Table 5—Corn grain yield by erodibility and land capability class, 1982[1]

Land capability class	Erodibility class					All cropland
	Non-erodible	Moderately erodible		Highly erodible	Wind erodible	
		Below T	Above T			
	Bushels per acre[2]					
I–III	99	92	96	88	82	94
IV–VIII	69	70	71	74	64	71
All	97	91	95	84	79	92
	1,000 acres					
I–III	75,025	56,868	52,461	17,480	17,862	219,696
VI–VIII	4,226	3,231	3,023	8,173	2,943	21,596
All[3]	79,250	60,099	55,484	25,654	20,805	241,292
	Percentage with yields					
I–III	67.8	76.5	88.2	95.6	43.3	72.3
VI–VIII	35.7	36.2	41.8	57.3	21.3	38.5
All	64.7	72.2	83.2	78.8	37.8	67.0

[1]Area-weighted averages of nonirrigated cropland exclude missing corn yields.
[2]Mean yields for erodibility groups and land capability classes are statistically different according to the Waller-Duncan k-ratio test, with k equaling 100, approximately equal to the 0.05 significance level (*9*).
[3]Columns may not add to totals due to rounding.

Table 6—Corn grain yield by erodibility and prime farmland definition, 1982[1]

Prime farmland definition	Erodibility class					All cropland
	Non-erodible	Moderately erodible		Highly erodible	Wind erodible	
		Below T	Above T			
	Bushels per acre[2]					
Prime	106	96	99	93	86	99
Nonprime	76	80	83	82	69	79
All	97	91	95	84	79	92
	1,000 acres					
Prime	56,273	44,152	39,772	4,015	12,057	156,268
Nonprime	22,978	15,947	15,712	21,639	8,748	85,024
All[3]	79,250	60,099	55,484	25,654	20,805	241,292
	Percentage with yields					
Prime	77.8	80.1	91.6	95.1	59.1	79.9
Nonprime	45.8	56.6	67.5	76.4	25.3	51.7
All	64.7	72.2	83.2	78.8	37.8	67.0

[1]Area-weighted averages of nonirrigated cropland exclude missing corn yields.
[2]Mean yields for erodibility groups are statistically different according to the Waller-Duncan k-ratio test, with k equaling 100, approximately equal to the 0.05 significance level (*9*).
[3]Columns may not add to totals due to rounding.

Cropland distribution in each erodibility class across groupings of nonirrigated corn grain yields provides additional information about productive soils with differences in inherent erodibility (table 7 and fig. 1). In all cases, high-yielding nonerodible land exceeds high-yielding erodible land.

The proportion of cropland for which corn grain yield is not recorded varies widely among erodibility classes. More than 60 percent of wind erodible land has no recorded nonirrigated corn yields, which is consistent with areas subject to wind erosion. However, large proportions of nonerodible and nonerosively managed, moderately erodible cropland also do not have recorded corn yield. Proportions of highly erodible and erosively managed, moderately erodible land without recorded corn yields are about half as large as proportions of nonerodible and nonerosively managed, moderately erodible land.

Recorded yields are very low and very high on a smaller percentage of highly erodible land than on nonerodible land. However, more than 60 percent of highly erodible land yields 50–100 bushels per acre compared with only 30 percent of nonerodible land. More than 35 percent of erosively managed, moderately erodible cropland has high yields, while only 30 percent of nonerosively managed, moderately erod-

Figure 1

Percentage of nonirrigated cropland by corn yield and erodibility class, 1982

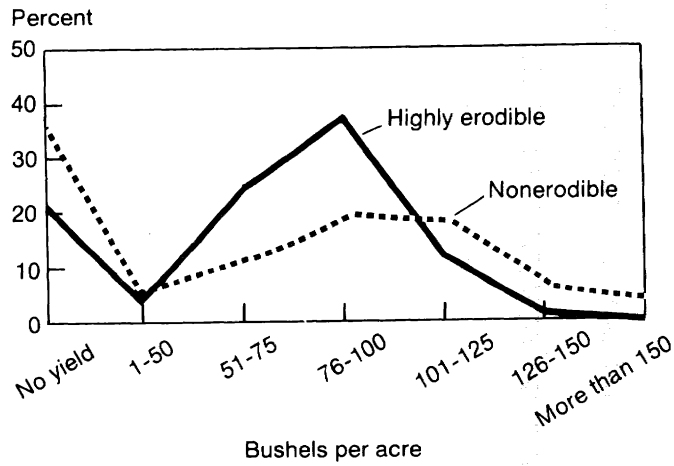


Table 7—Distribution of nonirrigated cropland acreage by corn grain yield and erodibility, 1982

Corn grain yield	Erodibility class					All cropland
	Non-erodible	Moderately erodible		Highly erodible	Wind erodible	
		Below T	Above T			
Bushels per acre	*1,000 acres*					
No yield	43,243	23,196	11,235	6,903	34,222	118,798
1–50	6,124	4,874	2,800	1,282	3,493	18,573
51–75	13,948	12,287	9,481	8,005	6,238	49,959
76–100	22,909	20,569	19,650	12,100	6,573	81,801
101–125	22,326	17,508	18,883	3,884	3,774	66,376
126–150	9,524	4,165	3,767	369	721	18,546
More than 150	4,419	697	904	14	6	6,039
All[1]	122,493	83,294	66,719	32,557	55,027	360,090
	Percent					
No yield	35.3	27.8	16.8	21.2	62.2	33.0
1–50	5.0	5.9	4.2	3.9	6.3	5.2
51–75	11.4	14.8	14.2	24.6	11.3	13.9
76–100	18.7	24.7	29.5	37.2	11.9	22.7
101–125	18.2	21.0	28.3	11.9	6.9	18.4
126–150	7.8	5.0	5.6	1.1	1.3	5.2
More than 150	3.6	.8	1.4	*	*	1.7
All[1]	100.0	100.0	100.0	100.0	100.0	100.0

* = Less than 0.1 percent.
[1]Columns may not add to totals due to rounding.

ible land has high yields. A smaller proportion of erosively managed cropland has low yields than the nonerosively managed land.

A similar situation holds for prime land. Average yields on prime land are higher than yields for nonprime land across all erodibility classes. However, although 44 percent of nonprime land yields less than 76 bushels of corn per acre, only 25 percent of prime land has yields this low.

Net Crop Revenue and Soil Erodibility

Results using the acreage-weighted average net crop revenue for eight common field crops as a measure of soil productivity are similar to those using corn grain yield. They are more easily interpreted because estimated revenue can be derived for a large percentage of data points in each erodibility group (table 8).

Erosively managed, moderately erodible land generates the highest mean net revenue for nonirrigated cropland, and wind erodible land generates the lowest (highest negative). As before, net revenue on nonirrigated, wind erodible land is less than that on irrigated wind erodible land.

On average, nonerodible nonirrigated cropland can generate higher current net revenue than highly erodible land. Moderately erodible land managed to erode below T can produce lower net revenue than erosively managed land. Differences in crop rotations, conservation practices, and tillage methods needed to reduce erosion below T may reduce revenues and increase costs, thereby cutting into net revenue. Differences in mean net revenue by erodibility classes are statistically significant in all cases.

Mean net revenue per acre decreases on land in the higher land capability classes. Mean net revenue for classes IV–VIII is negative and lower than for classes I–III for all erodibility classes. Paradoxically, mean net revenue per acre of highly erodible land and moderately erodible land is higher in both land capability class groupings than for nonerodible land. The higher proportion of highly erodible classes IV–VIII results in lower overall mean net revenue for highly erodible land. Only wind erodible land has lower mean net revenue than nonerodible land in classes IV–VIII.

As before, mean net revenue per acre of prime farmland is higher than that for nonprime farmland (table 9). This relationship is consistent across all erodibility classes. Mean net revenue per acre of erodible land is higher than that of nonerodible land for both prime and nonprime land.

The distributions of net revenue by erodibility class are also examined (table 10 and fig. 2). Net revenue is a better measure of productivity than corn grain yield because of the low proportion of land without an

Table 8—Net crop revenue by erodibility and land capability class, 1982[1]

Land capability class	Erodibility class					All cropland
	Non-erodible	Moderately erodible		Highly erodible	Wind erodible	
		Below T	Above T			
	Dollars per acre[2]					
I–III	11.40	19.61	25.89	16.50	–19.87	12.31
IV–VIII	–25.89	–17.80	–16.55	–17.94	–39.21	–35.79
All	7.86	15.70	21.34	1.58	–24.63	6.66
	1,000 acres					
I–III	110,643	74,375	59,489	18,295	41,208	304,009
IV–VIII	11,604	8,656	7,134	13,974	13,454	54,821
All[3]	122,247	83,031	66,623	32,268	54,661	358,830
	Percentage with revenues					
I–III	99.8	99.6	99.7	99.6	99.4	99.7
IV–VIII	99.3	99.9	100.0	98.9	99.0	99.5
All	99.8	99.7	99.9	99.1	99.3	99.7

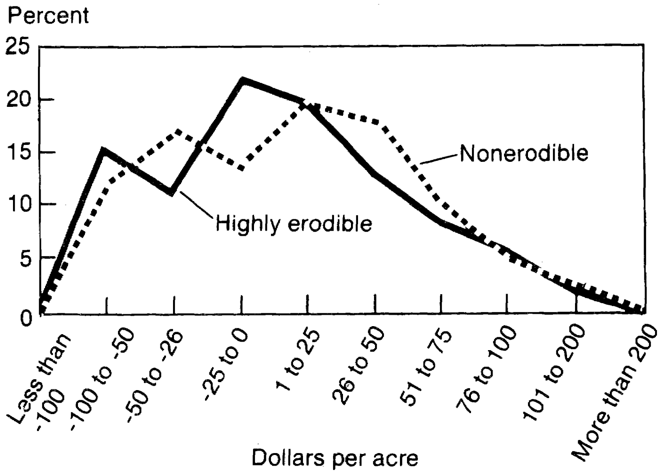
[1]Area-weighted averages of average net revenue from major field crops on nonirrigated cropland for which yields were recorded.
[2]Mean revenue for erodibility groups and land capability classes is statistically different according to the Waller-Duncan k-ratio test, with k equaling 100, approximately equal to the 0.05 significance level, except for totals of land capability classes VI and VII (*9*).
[3]Columns may not add to totals due to rounding.

estimated return compared with the high proportion of land without corn grain yields. Overall, less than 0.3 percent of nonirrigated cropland has no return because recorded yields for at least one crop are unavailable, while 33 percent of nonirrigated cropland did not have an estimated corn grain yield.

Results based on estimated net revenue are inconsistent with the conventional wisdom that net revenue is lower on highly erodible or erosively managed land.

Figure 2

Percentage of nonirrigated cropland by net crop revenue and erodibility class, 1982



The distribution of net revenue for highly erodible land is similar to that for nonerodible land. Erosively managed, moderately erodible land has the smallest proportion of negative returns and the largest proportion of high returns.

About a third of nonirrigated cropland with negative estimated returns is nonerodible. Wind erodible cropland has a higher proportion of nonirrigated cropland with negative net revenue, primarily due to the need for irrigation in wind erosion areas. Two-thirds of wind erodible cropland irrigated in 1982 has positive estimated net revenue as irrigated cropland.

The conventional wisdom that highly productive and highly erodible land are mutually exclusive is also incorrect. Although nonerodible cropland makes up the largest portion (35 percent) of cropland with an estimated net revenue of more than $75 per acre, more than 9 percent of such land is highly erodible. A larger proportion of erosively managed, moderately erodible land yields high returns than nonerosively managed, moderately erodible land, but the absolute amounts are almost equal. Erosively managed, highly erodible cropland and wind erodible cropland make up more than 36 percent of all high-return cropland.

Despite the differences in mean net crop revenue between higher and lower capability classes and between prime and nonprime land, cropland productivity

Table 9—Net crop revenue by erodibility and prime farmland definition, 1982[1]

Prime farmland definition	Erodibility class: Non-erodible	Moderately erodible: Below T	Moderately erodible: Above T	Highly erodible	Wind erodible	All cropland
	Dollars per acre[2]					
Prime	24.06	28.02	34.64	24.53	-8.20	24.17
Nonprime	-15.63	-8.64	-3.56	-1.87	-34.41	-14.30
All	7.86	15.70	21.34	1.58	-24.63	6.66
	1,000 acres					
Prime	72,372	55,125	43,426	4,220	20,392	195,536
Nonprime	49,875	27,906	23,198	28,048	34,269	163,295
All[3]	122,247	83,031	66,623	32,268	54,661	358,830
	Percentage with revenues					
Prime	99.8	99.7	99.8	99.7	99.5	99.8
Nonprime	99.0	99.6	100.0	99.0	98.4	99.5
All	99.8	99.7	99.9	99.1	99.3	99.7

[1]Area-weighted averages of average net revenue from major field crops on nonirrigated cropland for which yields were recorded.
[2]Mean revenue for erodibility groups is statistically different according to the Waller-Duncan k-ratio test, with k equaling 100, approximately equal to the 0.05 significance level (9).
[3]Columns may not add to totals due to rounding.

in these classifications overlaps significantly (figs. 3 and 4). A greater proportion of classes I–III land and prime land shows positive net revenue from crop production than classes IV–VIII land and nonprime land. However, the distributions in both figures overlap substantially. Despite the greater mean yield and mean net revenue on classes I–III land and prime land, such land is not necessarily productive. Conversely, land classified as nonprime or classes IV–VIII does not preclude the possibility that it is highly productive.

Combined Factors Affecting Productivity

Thus far, the productivity of cropland with varying erodibility and differences in productivity by erodibility level, by land capability class, and by the USDA prime farmland definition have been examined individually. However, the relationships between these attributes and productivity cannot be adequately shown by use of simple correlations and cross-tabulations. Multiple linear regression can help decompose the relative contributions of these attributes toward the soil's productivity.

The regression model discussed here takes the following form:

$$Y = B_1D_1 + B_2D_2 + B_3D_3 + B_4D_4 + u$$

where:

Y = The dependent variable, which measures soil productivity with either estimated corn grain yield or average net crop revenue.

D_1 = Vector of dummy variables for soil erodibility classes based on the USLE parameters RKLS/T, 5 levels.

D_2 = Vector of dummy variables for land capability classes I–VIII.

D_3 = Vector of dummy variables for land capability subclasses c–w.

D_4 = Dummy variable for USDA prime farmland, 2 levels.

Table 10—Distribution of nonirrigated cropland acreage by net crop revenue and erodibility, 1982

Net crop revenue	Erodibility class					All cropland
	Non-erodible	Moderately erodible		Highly erodible	Wind erodible	
		Below T	Above T			
Dollars per acre	*1,000 acres*					
No yield	246	263	96	289	366	1,260
Less than −50	14,508	6,682	4,759	4,961	12,998	43,907
−50 to −26	21,166	7,523	4,192	3,722	16,064	52,667
−25 to −0	17,336	14,538	9,650	7,306	12,226	61,055
1 to 25	24,413	21,914	18,420	6,453	8,425	79,626
26 to 50	22,141	15,674	14,193	4,381	3,466	59,854
51 to 75	12,226	8,344	7,747	2,726	1,139	32,182
More than 75	10,457	8,356	7,663	2,719	344	29,539
All[1]	122,493	83,294	66,719	32,557	55,027	360,090
	Percent					
No yield	0.2	0.3	0.1	0.9	0.7	0.3
Less than −50	11.8	8.0	7.1	15.2	23.6	12.2
−50 to −26	17.3	9.0	6.3	11.4	29.2	14.6
−25 to 0	14.2	17.5	14.5	22.4	22.2	17.0
1 to 25	19.9	26.3	27.6	19.8	15.3	22.1
26 to 50	18.1	18.8	21.3	13.5	6.3	16.6
51 to 75	10.0	10.0	11.6	8.4	2.1	8.9
More than 75	8.5	10.0	11.5	8.4	.6	8.2
All[1]	100.0	100.0	100.0	100.0	100.0	100.0

[1]Columns may not add to totals due to rounding.

B_1–B_4 = Vector of coefficients for each level of each of the dummy independent variables.

u = An error term measuring variation in productivity unaccounted for by the independent variables.

The independent variables are all discrete categorical variables that show into what class of the particular attribute (erodibility, capability, hazard, "primeness") the observation on the dependent variable falls. The estimated coefficient for each level of each attribute adds or subtracts from the mean productivity. Thus, the model calculates the estimated productivity as the algebraic sum of the coefficients of appropriate levels of each attribute. For example, corn grain yield on nonerodible prime land in class II with an erosion hazard is estimated to be 137.3 − 31.3 − 12.5 + 2.3 = 95.8 bushels per acre (table 11). The model estimates average net crop revenue on such land to be −\$43.54 + \$57.53 − \$24.16 + \$17.65 = \$7.48.

The explanatory power of the yield regression model is good, with the model accounting for more than 94 percent of the variation in corn grain yield (R^2 = 0.943). The same independent variables account for much less of the variation in net revenue, about 30 percent of total variance. However, because all the independent variables are categorical, one of the columns representing a dummy variable in each group in the design matrix X is a linear combination of the others, and the matrix is greater than full rank. Consequently, when the normal equations are solved with the generalized inverse of the X′X matrix, the estimated coefficients are only one of many possible solutions (*26*, p. 161). Nevertheless, the relative differences in productivity between each class are reliably estimated. Erodibility, land capability class and subclass, and primeness are easily determined proxies for the underlying physical factors that determine productivity, but the estimated model shows the relationship of each of these classification systems to soil productivity, controlling for the presence of the other classification systems.

In both models, sheet and rill erodibility adds more to average productivity than nonerodibility. That is, the average productivity on highly erodible land is higher than that for nonerodible land, other factors held constant. Erosively managed, moderately erodible land shows the second highest productivity, while wind erodible soils show the lowest productivity.

In both models, capability classes I–III have higher productivity than other classes, other factors held equal. In the net revenue model, classes I–III show a greater positive effect on revenue than other classes. Land in class I is even more productive than is apparent since, by definition, it has no subclass to further reduce average productivity, while all other classes must have a subclass rating.

The decline in productivity for higher capability classes is not monotonic. The reduction in corn grain

Figure 3

Percentage of nonirrigated cropland by net crop revenue and land capability class, 1982

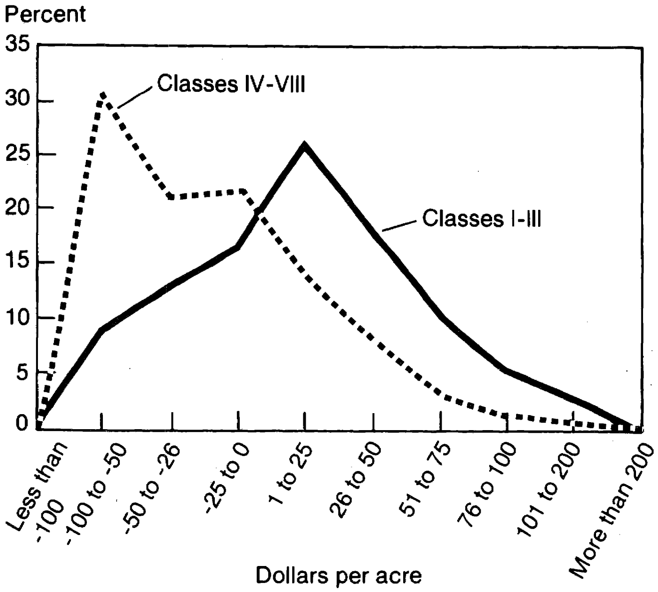
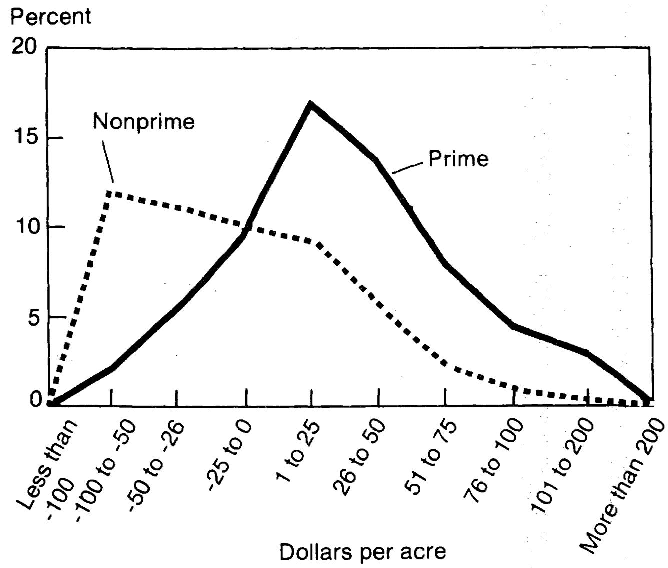


Figure 4

Percentage of nonirrigated cropland by net crop revenue and USDA prime farmland definition, 1982



yield is larger under classes IV and V than under classes VI or VII. The reduction in productivity under class VIII is zero, since productivity is normalized to that of class VIII, despite the fact that class VIII land is least suited to cultivation.

The capability subclasses reflect the kinds of hazards or limitations to cropping that are associated with reductions in productivity, other things being equal. Class I land has, by definition, no limitations and is not assigned a subclass. Soil wetness (subclass w) is associated with zero reduction in productivity below the average, since productivity is normalized to the w subclass in the model. Climate (subclass c) is the hazard associated with the greatest reduction in productivity, while erosion (subclass e) and soil depth or stoniness (subclass s) have lower reductions in productivity.

The large productivity reduction associated with the erosion hazard subclass appears to contradict the large addition to productivity associated with highly erodible land, since both factors should be measuring the same soil attribute. This contradiction may be partly explained by recalling that subclass e is first in the hierarchy of limitations set up in the land capability class system. If land is not rated class I and no other limitation is judged dominant, subclass e is assigned. Much land with a complex of problems leading to reduced capability for agriculture is assigned subclass e, regardless of its potential erodibility. Thus, 51.7 percent of cropland inventoried in 1982 was in subclass e, although only 7.1 percent of all cropland was highly erodible (*13*).

Table 11—General linear model estimates of contributions to nonirrigated cropland productivity, 1982[1]

Variable	Corn grain yield		Net crop revenue	
	Parameter (Bi)	Standard error	Parameter (Bi)	Standard error
Erodibility:				
Nonerodible	137.3	2.43	-43.54	2.50
Moderately ≤ T	134.2	2.43	-32.72	2.50
Moderately > T	139.6	2.43	-24.24	2.50
Highly	142.5	2.43	-18.31	2.50
Wind	126.7	2.43	-58.95	2.50
Land capability class:				
I	-23.2	2.43	67.67	2.51
II	-31.3	2.43	57.53	2.50
III	-46.6	2.43	47.68	2.50
IV	-55.8	2.43	35.79	2.50
V	-52.4	2.45	30.95	2.52
VI	-46.3	2.44	20.74	2.51
VII	-39.8	2.45	11.23	2.52
VIII	0	na	0	na
Land subclass:				
c	-42.8	.10	-33.81	.10
e	-12.5	.04	-24.16	.06
s	-25.8	.06	-17.35	.09
w	0	na	0	na
Prime farmland:				
Prime	2.3	.04	17.65	.06
Nonprime	0	na	0	na
R-square	0.943		0.301	

na = Not applicable.
[1]Statistical Analysis System (SAS) General Linear Models (GLM) procedure with categorical variables produces a singular X'X matrix and uses a generalized inverse to solve the normal equations. All parameter estimates are biased but are best linear unbiased estimates (BLUE) for some linear combination of the parameters (*26*). All parameters are significantly different from zero at the 99-percent confidence level.

The physical criteria for prime land add to average productivity, all other factors held equal. The increase for corn grain yield amounts to about 2 bushels. For the net revenue measure, however, prime land adds almost $18 per acre.

Conclusions and Implications

The conventional wisdom regarding the current productivity of highly erodible soils is incorrect. Highly erodible soils and erosively managed, moderately erodible soils are not significantly less productive than nonerodible or nonerosively managed, moderately erodible soils, in terms of either corn grain yield or net crop revenue from common field crops. The correlation between continuous measures of soil erodibility and continuous measures of productivity is extremely weak, indicating that the relationship between soil erodibility and current productivity is insignificant.

Distributions of corn grain yield and net crop revenue by erodibility class show that significant acreages of soils at all but the highest levels of productivity can be found in each erodibility class. However, although continued erosion may reduce yields in the long run, establishing evidence for this relationship is beyond the scope of this study. Such research needs physically based analyses that can take into account both current and future productivity under continued erosion.

This study shows that the land best suited to cultivation (land capability classes I–III) has higher mean yields and higher mean net revenue than land less suited to cultivation (classes IV–VIII). However, productivity distributions for the two groupings of land capability classes overlap substantially, making generalizations about productivity based on capability class difficult.

The effect of higher land capability class on corn grain yield, as reflected in the regression coefficients, is less consistent for individual capability classes than for groupings of better (classes I–III) and poorer (classes IV–VIII) soils. Although the reduction in corn grain yield associated with classes VI and VII is less than that associated with classes III, IV, and V, the effect of capability class on net crop revenue is consistently negative as the class level increases. The prime land designation shows a larger positive effect on net crop revenue than on corn grain yield. Again, substantial overlap between productivity distributions of prime and nonprime land make generalizations based on mean productivity difficult.

The implications of these findings are twofold. First, policy and program decisions designed to affect use of eroding or erodible land cannot presume that this land has low opportunity costs. While erodible land may or may not earn lower revenue over the long term, the decision to restrict production in the short term and associated operator incentives required to obtain that decision must reflect current productivity. Since current productivity is uncorrelated with erodibility, idling some highly erodible land may also idle some of our most productive and valuable cropland. If so, retirement incentives may have to be made larger than originally thought necessary.

Second, current land classification systems need to provide more adequate information for policy and program decisions affecting cropland productivity. For more information on the need for better erodibility classifications, see (*21, 2, 13*). No single classification system can do all things equally well. Confusion about productivity and erodibility of soil resources results partly from classification systems that try to combine various soil attributes that should be kept separate. Attempts to combine both short-term and long-term productivity characteristics lead to measures with little precision for resource assessment and policy analysis. Combining physical limitations that have both long- and short-term physical and economic consequences with measures of soil productivity compounds the problem. Only by deriving measures that separate short- and long-term productivity from short- and long-term limitations on land use can an accurate picture of the relationship between soil productivity and erodibility be obtained.

This research shows that although land better suited for cultivation (classes I–III) has higher mean corn grain yields and higher mean net crop revenue than does land in higher capability classes by erodibility class, productive and unproductive land can be found in all land capability classes. The land capability classification system is deficient for a number of reasons that limit its usefulness for national resource and productivity assessments (*13, 18, 6*). The prime farmland definition also fails to discriminate adequately between lands with high and low current productivity.

A system of productivity measures is needed that can accommodate not only current productivity, or the ability to produce high yields, but continued productivity over a long period under ongoing erosion, compaction, salinity, and a host of other natural and human-induced strains imposed on the soil. Even more valuable for further research and understanding would be related measures of short- and long-term productivity that would examine the ratio of output to necessary inputs required to produce the output.

The basis for such a new classification already exists in the form of the crop productivity models at the heart of the Erosion and Productivity Impact Calculator (EPIC) and Minnesota Productivity Index (PI) models (*23, 38*). EPIC even includes components designed to estimate changes in the costs of production (fertilizer and lime) as the soil deteriorates under continued erosion. However, the kind of detailed studies necessary to determine differences in purchased inputs and machinery operations applied to different soils to produce a given output are rarely done (*24*).

Consistent estimates of average net return to crop production for common field crops for a single year and over a 20–50 year period for each soil, using standard technology found in the region, would be very useful and appear to be technically feasible. As an additional benefit, this system would allow re-evaluation of soil loss tolerance values on a more scientific basis that incorporates economic information.

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Appendix

This analysis combines the following:

- Data from the 1982 NRI, SOILS 5, and 1982 FEDS crop budgets.

- Measures of crop productivity based on corn grain yields and potential net crop revenue.

- An erodibility classification based on parameters of the USLE.

1982 National Resource Inventory

The NRI data set contains information on land use and cover, soil type, actual and potential erosion, and other resource information. The 1982 NRI is the latest in a series of statistically based land resource inventories conducted in 1958, 1967, 1975, and 1977. The two-stage stratified random sample contains information on 841,860 points located in nearly 350,000 primary sampling units on rural, nonfederal land, excluding that in Alaska. This analysis uses data on 251,430 nonirrigated cropland observations. For more specific information on the NRI data set, see (*20*) and (*35*).

The NRI data set contains five important types of information for this study:

- 1982 land use and cover for crop production.

- Land capability class and subclass determined from soil surveys for inventoried sample points or, where necessary, determined by soil scientists in the field.

- Soils designated as prime farmland on an approved State SCS list of soil mapping units.

- Soil type based on the SOILS 5 record identification, permitting association of estimated yield potentials with the NRI record.

- Soil erosion characteristics, including the USLE parameters and those needed to estimate wind erosion.

Soil Survey Interpretations Record

SCS prepares and enters into a computer data base soil survey interpretations for all established soil series (*32*). The complete SOILS 5 data form for each soil contains 7,294 bytes of information on physical and chemical soil properties, predictions of soil behavior for specified land uses, and estimated crop yields for individual crops under specified management. SCS develops first drafts of soil interpretations at the local or State level. State soil scientists and the National Technical Centers review and approve the drafts. Each State conservationist is responsible for the accuracy of all State soil interpretations. Other State and Federal agencies cooperating in the National Cooperative Soil Survey request specific interpretations to fulfill their needs and consult with SCS personnel to develop the interpretations.

Soil survey interpretations are developed for phases of soil taxonomic units that represent soil map units. A unique sequential record number consisting of a two-digit State code and a four-digit number denotes each interpretation. A surface layer texture modifier and a texture term, slope class, and flooding class are used to define the specific soil phase to which data pertains. Specific lines for each item interpreted, including yields, are contained in the SOILS 5 record and match the NRI record pertaining to each sample point (*35*).

SCS collects crop yield data to support interpretations. Data from research plots, field trials, and farmers' fields are collected and analyzed. Estimated yields are established for benchmark soils based on review of yield data from all available sources. All States that contain the soil review the estimates, which generally apply throughout an MLRA. Crop yield estimates on individual soil surveys generally coincide with SOILS 5 data, but may be adjusted as needed to fit local conditions.

Predicted crop yields approximating those of leading commercial farmers at the management level that tends to produce the highest economic returns per acre (known as "B-level" management) are recorded on the SOILS 5 form (*32*). This management level includes using the best crop varieties; balancing plant populations and fertilizers to the potential of the soil; controlling erosion, weeds, insects, and diseases; maintaining optimum soil tilth and adequate drainage; and carrying out timely operations.

Yields are entered for class-determining phases that significantly influence crop yield or management. Flooding, slope, surface texture, erosion, and climatic factors determine common phases. Yields for up to seven of the most important crops commonly grown on the soil are given for nonirrigated and irrigated cultivation, as appropriate.

Estimated yield for a particular crop can be absent from SOILS 5 for three reasons. First, the crop may not be commonly grown in the area but could produce good yields if it were grown. For example, some of the productive soils of the Central Valley in California could produce high yields of corn grain, but farmers usually grow higher valued fruit or vegetable crops, so corn grain yields are not listed.

Second, yields will not be listed for some phases of a soil because yields are not economically feasible, even though yields are listed for other phases of the soil. For example, corn grain yield may not be listed for a soil with a slope range of 15–25 percent, even though yields are listed for the soil with slope ranges of 0–3 percent, 3–8 percent, and 8–15 percent.

Finally, a soil may have no yield listed, even though the crop is commonly grown in the area and the soil phase is not particularly limiting, simply because the estimated yield is too low to be economically feasible. In all three cases, where no yield is reported for a crop on a soil, the crop was not included in this study's results.

National average yields for the eight common field crops and the acreage on which these crops were grown, and on which nonzero yields are estimated are compared with those from the 1982 Census of Agriculture. (app. table 1).

Despite the fact that census yields are calculated from farmers' estimates of crop production and acreage and SOILS 5 yields are informed judgments of soil scientists, national averages of the two sets of yield data are remarkably similar. The SOILS 5 yields are generally higher than average yields reported in the census of agriculture. Only 3 of 15 yield estimates from SOILS 5 are lower than reported in the census reports. This is expected, given that SOILS 5 yields are estimated for high management levels that may not be present in all areas or for all crops.

Nonirrigated yields ranged from 5.7 percent lower to 20.2 percent higher than corresponding census yields. Irrigated yields were more consistently higher, ranging from 4.4 percent to 157.8 percent higher than reported yields. The acreage-weighted average difference between the two sets of yields, which accounts for small acreage of some crops with large differences in yields, shows that SOILS 5 yields are only 0.1 percent higher than those census reports.

Crop Budgets From the Firm Enterprise Data System

Congress requires ERS to annually estimate and publish the national and regional average costs of producing major agricultural commodities. USDA conducts periodic surveys of farm operators for data on farm production expenditures. A modified version of the Oklahoma State University crop budget generator is used in conjunction with these data to estimate production costs for each State with significant production of major crops (*17*).

The 1982 FEDS budgets were primarily derived from these data to represent sub-State production areas. Thus, the budget data reflect localized combinations of tillages, owner and custom operations, and pesticide regimes corresponding to the surveyed proportions of these items. Since the 1982 FEDS budgets were estimated, USDA has revised cost-of-production budgets, estimation procedures, and presentation tables to reflect changes in legislative requirements, probability-based survey data, and suggestions of the National Cost of Production Review Board. Input costs used in this analysis are restricted to variable costs reported in the FEDS budgets, which include the following:

- Costs of seed, fertilizer, lime, herbicides, and machinery fuel, lubrication, repairs and labor needed to plant the crop.
- Costs of machinery.
- Costs of custom operations for harvest.
- Interest on operating capital.

Ownership costs (including replacement, taxes, interest and insurance on tractors and machinery), charges for land, general farm overhead, and returns to risk and management are not included in variable costs.

The FEDS budgets, while imperfect, are among the few choices for a national assessment of erodibility and productivity relationships. The kind of detailed studies necessary to determine production cost differences across soils are rare (*24*). Even generalized crop budgets for specific soil groups, such as those developed for the New York State use-value assessment program, have been done too infrequently to provide a comprehensive production cost data base.

Productivity Measures

This study constructs and analyzes two measures of productivity: corn grain yields and an index based on net returns to crop production. This analysis uses corn grain yields to directly measure productivity.

The study used the following formula to calculate net crop revenues at each NRI sample point for 1982:

$$NR = (\sum_{i=1}^{n} Q_i * P_i - C_i)/n$$

where:

NR = Net revenues from crop production at the sample point.

Q_i = 1982 soil-specific crop yield of the ith crop.

P_i = 1982 season-average market price per unit of the ith crop.

C_i = 1982 FEDS variable production cost of the ith crop.

n = The number of crops with nonzero yield.

Target prices could have been used instead of season-average market prices to calculate net crop revenues that would more accurately reflect the economic signals to which participating farmers respond. Comparison of returns calculated using both sets of prices in related work shows that differences between the distributions of returns for nonerodible and highly erodible land are statistically insignificant. The absolute level of returns is higher if target prices are used.

Appendix table 1—Estimated and reported national average crop yields, 1982

Crop	Estimated[1]		Reported[2]	
	Yield	Acreage[3]	Yield	Acreage[4]
	Bushels per acre	*Million acres*	*Bushels per acre*	*Million acres*
Corn grain:				
Nonirrigated	103.9	75.3	106.0	59.9
Irrigated	128.4	8.1	122.1	6.7
Soybeans:				
Nonirrigated	36.9	60.6	30.7	60.7
Irrigated	43.9	.2	34.1	1.1
Wheat:				
Nonirrigated	32.0	76.0	31.8	63.6
Irrigated	67.1	4.9	64.3	3.3
Sorghum grain:				
Nonirrigated	56.8	12.6	53.6	9.7
Irrigated	114.0	2.7	78.0	1.5
Oats:				
Nonirrigated	63.3	8.0	55.0	8.9
Irrigated	80.2	.1	68.7	.2
Barley:				
Nonirrigated	46.1	5.2	48.2	6.5
Irrigated	81.5	1.9	78.0	1.7
	Hundredweight per acre	*Million acres*	*Hundredweight per acre*	*Million acres*
Rice:				
Irrigated	123.5	3.9	47.9	3.2
	Pounds per acre	*Million acres*	*Pounds per acre*	*Million acres*
Cotton:				
Nonirrigated	424.4	9.9	450.0	5.6
Irrigated	973.1	5.4	850.0	2.8

[1]SOILS 5 estimated crop yields for soils where the crop was grown according to the 1982 NRI, weighted by NRI cropland acreage.
[2]Computed from production and acreage of each crop reported in the 1982 Census of Agriculture.
[3]NRI irrigated and nonirrigated cropland acreage on which the specified crop was grown and SOILS 5 estimated irrigated and/or nonirrigated crop yield for the crop is available.
[4]Harvested acreage of a specified crop for which either none of the crop was irrigated (nonirrigated) or the entire crop was irrigated (nonirrigated). Acreage on which part of the crop was irrigated was excluded.

Although including both outputs and input requirements in a measure of soil quality seems clearly desirable, very little consistent information is available on agricultural production costs across multicounty areas. Agricultural economists and Extension specialists at land grant universities have constructed representative crop budgets for sub-State regions within particular States.

However, these crop budgets show either an average or a recommended input use for geographic areas containing a wide variety of different soil types and topographic conditions. These figures do not adequately reflect the variation in costs due to soil erodibility.

The extent to which production costs increase from erosion and the factors that would contribute to increased costs on erodible soils are uncertain (*1*, pp. 29–35). Erodible soils that are eroded may have significantly higher costs than those that are not eroded. A few studies have collected information on the actual inputs used on particular fields and the resulting outputs (*24*).

Such studies are too few to provide comprehensive data, and the fragmentary results should not be extrapolated too widely. Until more detailed studies of cost differences on soils of varying erodibility have been conducted, the 1982 FEDS budgets remain the most consistent source of production cost data.

Average net crop revenue used in this study is not intended as an estimate of actual revenue from farming each type of soil but as a comprehensive productivity index. It is not an estimate of actual revenue because it excludes fixed production costs, is a simple average of as many of the eight major field crops for which yields were available, and is applied to all cropland soils whether these eight crops were actually grown in 1982 or not.

Farmers' actual crop rotations would not include all of the crops and would probably be more heavily weighted toward one or two crops. The acreage-weighted average net return to crop production is calculated from the simple average net return at each sample point using the expansion factor as the acreage weight.

Assessing Cropland Erodibility

This analysis calculates a measure of inherent soil erodibility from the USLE parameters contained on each NRI record following. Numerical limits to the classes are as follows:

Nonerodible = $[R*K*(LS)]/T < 2$;

Moderately erodible:

Managed to erode below T = $2 \leq [R*K*(LS)]/T < 15$ and $A < T$;

Managed to erode above T = $2 \leq [R*K*(LS)]/T < 15$ and $A \geq T$;

Highly erodible = $[R*K*(LS)]/T \geq 15$;

Wind erodible = $W > T$;

Where:
- R = the rainfall erosion index of the USLE
- K = the soil erodibility index of the USLE
- LS = the topographic factor of the USLE
- T = the soil loss tolerance value of the USLE
- A = estimated rate of sheet and rill erosion using the USLE
- W = estimated rate of wind erosion using the wind erosion equation (WEE)

Wind erodible land was segregated in a separate class because parameters of the wind erosion predictive equation were not available to calculate the appropriate wind erodibility index.

The class limit of 15 for highly erodible land in this definition, compared with the limit of 8 for both sheet and rill and wind erosion in the conservation compliance and sodbuster provisions of the Food Security Act of 1985, is better suited to the objective of this research. Since RKLS/T equals the inverse of the cropping and practice factors (1/CP), a class limit of 15 implies management changes consistent with reducing the combined CP factor below 0.06 to achieve tolerable soil loss. This is an extremely difficult objective for row crop production given existing technology. This limit fits the concept of highly erodible land as land that cannot meet soil loss tolerances except through conversion to permanent cover.

The RKLS/T limit of 8 used in implementing the Food Security Act of 1985 only implies reduction of CP below 0.125 to achieve tolerable soil loss, well within the range of continuous row crop systems using conservation tillage technology. The limit of 8 was an expedient choice to maximize the cropland acreage subject to conservation provisions, but it does not require conversion out of use for annual crop production.

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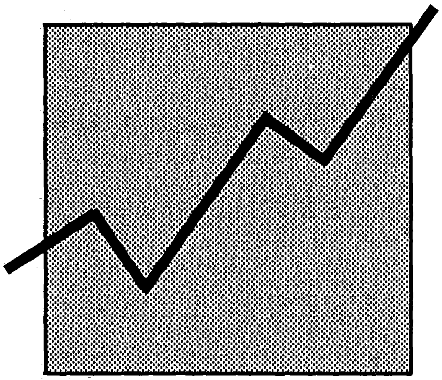

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