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CHAPTER 12
Soil Erosion and Degradation in the Southern Piedmont of the USA

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12.1 INTRODUCTION

S. W. Trimble in 1974 and 1975 published two important papers on soil erosion in the southern Piedmont of the United States. His publications form the basis for an analysis of soil degradation and its influence on soil productivity. Trimble traced the erosive land use of the southern Piedmont (VA, NC, SC, GA and ALA) from 1700 to 1970. He quantified the amount of erosion in space and time by using a variety of data and techniques. The four major objectives of the study were (i) to ascertain if soil erosion was occurring before European settlement, (ii) to show that erosion increased with the accelerating erosive activities of European man, (iii) to describe the spatial and chronological pattern of erosive land use and consequent erosion, and (iv) to show that erosive land use in the Piedmont has subsided and only a few vestiges remain. A second study was designed to quantify the volume of erosion by comparing present soils with those in the virgin condition and extrapolating the results by integrating modern soil surveys and erosion surveys made about 35 years earlier.

The southern Piedmont is an erosional landscape about 750 miles (1200 km) long and 150 to nearly 200 miles (240–320 km) wide. It has a gently to strongly rolling topography with a few broad plateaux. The normal topography is a gently rolling upland with moderate to steep valley slopes that grade to the adjacent stream system. The soils are in residuum from acid and basic igneous rocks, metavolcanics, slates, sandstones and Triassic sediments. The saprolite is several feet thick in most places and is loamy or sandy. Many of the weatherable minerals originally in the rock are absent in the upper part of the saprolite and the nutrient content is low (Calvert *et al*., 1980; Cady, 1950). The saprolite is easily dug and eroded, has a bulk density of 1.3–1.4 in the upper part, and has moderate to low permeability (O'Brien and Buol, 1984). The major soils of the Piedmont are Ultisols that have low cation exchange capacity and base saturation of <35% (*Agriculture Handbook*). Alfisols are common in saprolite from more basic rock and their nutrient status is somewhat better. The surface horizons of the Ultisols from acid igneous rocks are loamy sands to sandy loams and under mature forests are relatively thin—less than 3 or 4 inches (75–100 mm) (Davis *et al.*, 1931). The B horizons are clay in all but a few soils. Most upland Piedmont soils are well to moderately well drained.

12.2 METHODS

Trimble's studies (1974, 1975) were based upon historical records of land use and population migration. Data were extracted from many sources. The

Table 12.1 Relative rates of erosion under various types of cover and cover conditions (Trimble, 1974)[c]

Type and cover condition	Percentage of row crop erosion rate[a]
Row crop—poor or no rotation	0.80–1.00
Small grains (autumn planted)	0.30–0.40
Small grains (spring planted)	0.40–0.50
Grasses and legumes in rotation	0.10–0.20
Pasture (excellent cover)[b]	0.01
Pasture (good cover)	0.03
Pasture (fair cover)	0.07
Pasture (poor cover)	0.15
Pasture (very poor cover or idle)	0.30
Woods (excellent cover)	0.002–0.005
Woods (good cover)	0.01
Woods (fair cover)	0.03
Woods (poor cover)	0.07

[a]Factors can be raised or lowered based on field conditions. For example: pasture fair cover could range from 0.04 to 0.14.

[b]Cover density guide (percentage ground cover including litter:

Excellent	90–100
Good	70–89
Fair	50–69
Poor	30–49
Very poor	15–29

[c]Primary source: USDA Soil Conservation Service, *Guide to Sedimentation Investigations, South Regional Technical Service Area*, Engineering and Watershed Planning Unit *Technical Guide*, No. 12, 1968, p. VII-8. These values are for use in the Musgrave Equation and are not to be confused with those for the Universal Soil Loss Equation which is now being used by the Soil Conservation Service.

history of land use was converted to a composite index of erosional significance or intensity called erosive land use (ELU). The ELU is based primarily on the equations of Musgrave (1947) and Wischmeier and Smith (1965). A relative rate of erosion was assigned to different crops or vegetation types (Table 12.1). This index of erosivity, called the cover factor, is a negative expression of the effectiveness of a particular ground cover in preventing erosion. A composite cover factor was calculated for large areas having more than one land use by weighing the individual cover factors according to the proportion of area in a particular use. This composite ELU intensity permits analysis on a broad scale.

Trimble constructed a map of the Piedmont showing the areal distribution of erosive land use in the Piedmont for 1700, 1770, 1810, 1860, 1920, and 1967 (Figure 12.1). For example, the mean intensity of ELU in 1860 was 38% and in 1920 it was 42%. This means that in 1860 the equivalent of 38% of the area was in row crop and in 1920 it had increased to 48%. The data used were the US Census of Agriculture where possible. The 1967 data were from the conservation needs inventory published by each Soil Conservation Service State Office. Where US Census data were not suitable, Trimble used

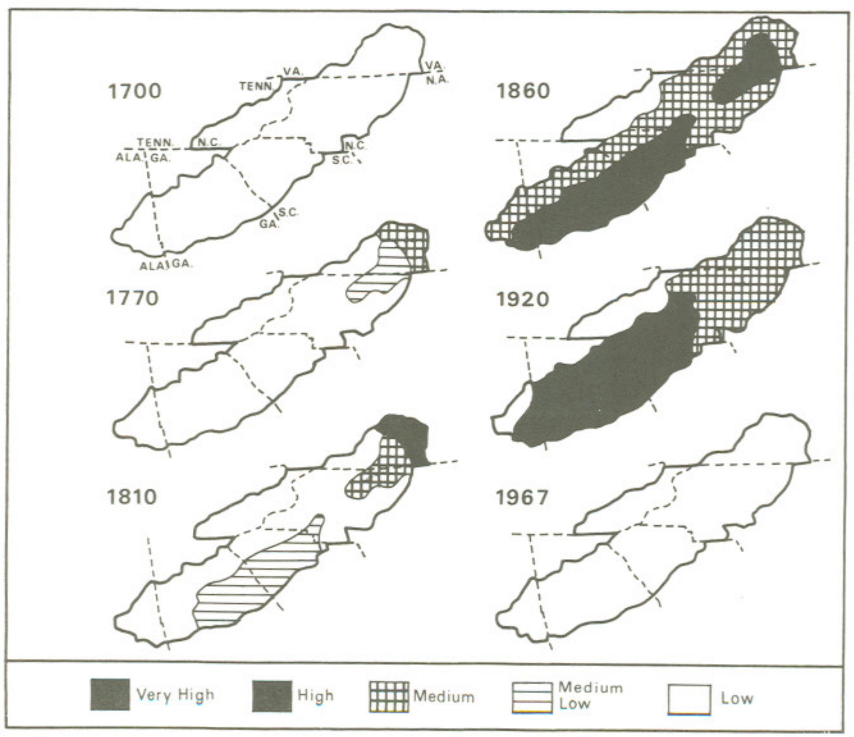

Figure 12.1 Erosive land use, 1700–1967 (Trimble, 1974)

the relationship between ELU population variables

$$\text{ELU} = 17.6 + 0.9\,(\text{density of slave population}) + 0.1(\text{density of non-slaves})$$

to estimate the ELUs before 1860. Trimble (1974) gave a detailed account of how ELUs were calculated and the problems with various parts of the data.

Trimble also estimated the volume of material removed from soils of the Piedmont by a combination of methods. He used the USDA Physical Land Surveys made in the 1930s and 1940s and modern soil surveys published between 1949 and 1967 as the basic data. The 34 surveys used were made at a scale of 1:20 000 or larger and covered 39 160 km^2 of the 142 515 km^2 of the Piedmont.

Average soil-removal estimates were assigned to each erosion class and soil mapping unit by soil scientists experienced in the general area of each survey or those soil scientists who had taken part in the surveys. Estimates were made for the mapping unit in each survey area by two or more soil scientists. It was recognized by Trimble that the numbers assigned are estimates or value judgements but these judgements are based upon thousands of field measurements and observations. Trimble believed the values begin to assume the characteristics of statistical means.

The average depth of soil removed from each survey area was computed from the values assigned to each mapping unit within a survey area. The process was repeated for each of the 34 large-scale surveys used. The information was then expanded to the entire Piedmont for each county by using the Reconnaissance Erosion Surveys completed in 1934 (Lee *et al.*) and 1935. The percentage of each of six erosion classes for the county were used as coefficients in an equation for determining soil loss. The equations were solved for the unknowns by using the estimates of soil loss from each erosion class made by experienced soil scientists. The predicted losses were within 27% of the observed values 65% of the time and within 54% of the observed values about 95% of the time.

By using the above data Trimble calculated the average depth of soil erosion for the entire Piedmont by counties (Figure 12.2). Maps showing the areal distribution of six erosion classes from 1.9 to 12.3 inches (48–312 mm) soil loss were published in both studies.

Trimble used a variety of evidence—such as clear streams, very low ELUs (0.2), and large areas of undisturbed vegetation—as evidence that soil erosion was minor in the Piedmont before European settlement. He probably was correct in his conclusion, but it should be recognized that the Southern Piedmont is an old land mass that has been eroding for several million years. Several geologists, using different techniques, have estimated the average rate of erosion covering several million years for various parts of the United States (Hack, 1978; Judson and Ritter, 1964; Matthews, 1975; Menard, 1961). Most of the estimates are within a range of 4–5 cm per 1000 years for the

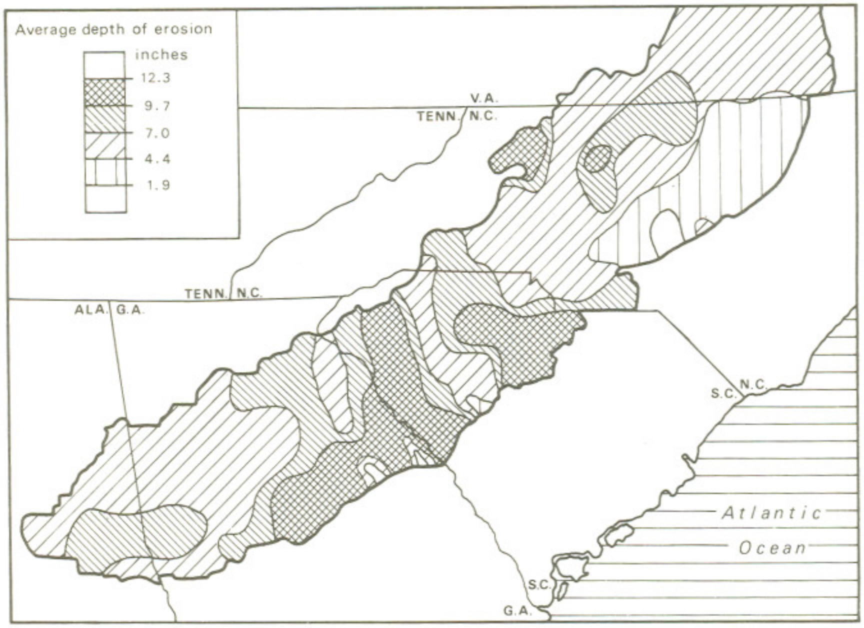

Figure 12.2 Average depths of total erosion (Trimble, 1974)

Piedmont and Applachian region. The low estimates are 0.9–0.4 cm/1000 years for modern erosion of some small watersheds. These rates are the equivalent of 0.75–0.60 t/ha/year, with the low estimates equal to 0.126–0.05 t/ha/year. The high estimates would be difficult to measure by most monitoring techniques and could easily be dismissed as being of no consequence. Yet at 0.75 t/ha/year the land mass of the United States lying above sea level could be moved to the ocean in 11–12 million years (Judson and Ritter, 1964)—only a short part of the time the Southern Piedmont has been exposed to erosion. Other evidence of erosion and deposition in the Piedmont that predates European settlement are the buried soils in alluvium or colluvium in South Carolina that have more northern vegetation pollen, and the radiocarbon dates from wood in alluvium in Georgia that range from 8725 to 425 years before the present (Cain, 1944; Staheli *et al*., 1974, 1977), with sedimentation rates equal to 0.46–2.47 m/1000 years. The problems with average rates of erosion or sedimentation are that we have no idea of the rate during the active cycle, nor do we know how long the cycles lasted.

European settlement started in the Virginia Piedmont in about the year 1700 and was completed in the Alabama Piedmont during the 1830s. The ELU of highest intensity shifted from the north-east to the south-west Piedmont where plantation agriculture, cash crops and slavery predominated.

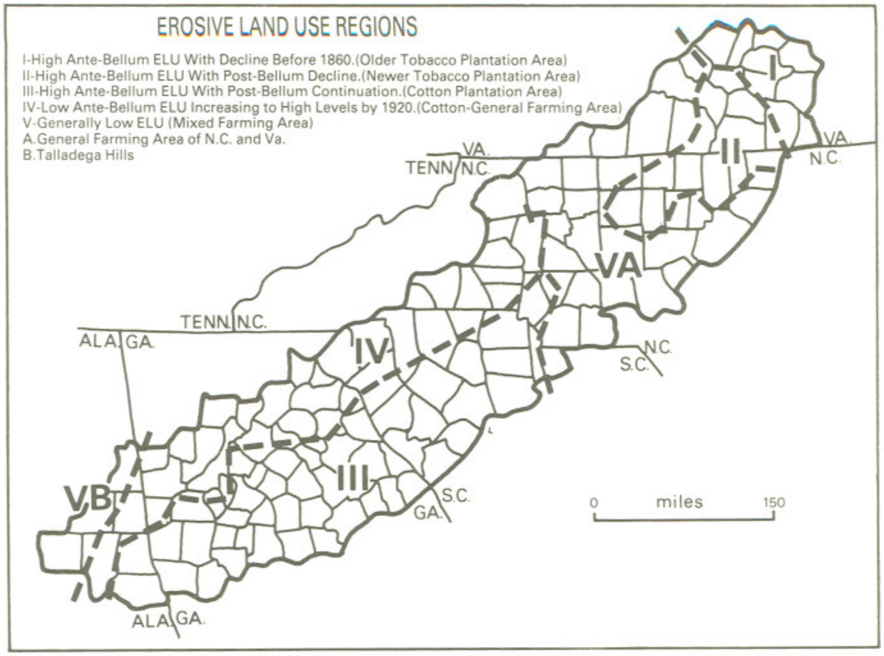

Figure 12.3 Erosive land use regions (Trimble, 1974)

The shifting intensity allowed Trimble to subdivide the Piedmont into five regions (Figure 12.3) that had similar ELU trends through time. These regions are:

Region 1—Old tobacco plantation area: probable high early antebellum ELU with late antebellum decline. 1860 ELU intensity less than 38%.

Region 2—Newer tobacco plantation area: high antebellum ELU (>38%) with postbellum decline (<43%).

Region 3—Cotton plantation area: high antebellum ELU intensity with postbellum continuation (1920 ELU >43%).

Region 4—Cotton—general farming area: low antebellum ELU (<38%) with significant postbellum increase (1920 ELU >43%).

Region 5—Mixed farming area: no definite trends, but with ELU intensities generally remaining at levels below the mean.

Region 1 declined agriculturally before 1860, and by 1860 the greatest ELU was in region 3, the cotton plantation area. Between 1860 and 1920, ELU was medium to high over the Piedmont, although there was a decrease in regions 1 and 2, and a sharp increase in region 4 where cotton cultivation expanded rapidly. High farm tenancy increased the ELU locally. After 1920 the ELU decreased significantly from 22% to 55% and everywhere on the Piedmont was <13%. The decrease in ELU was the result of agricultural decline, change of crop land to forest and pasture, and widespread application of soil conservation practices. Not all effects have been good. The alluvial fills in the headwater valleys are becoming unstable and degrading since the sediment load has decreased (Trimble, 1970).

12.3 CRITIQUE

Trimble used data of variable credibility, completeness and age in reconstructing the erosive land use of the Southern Piedmont from 1700 to 1970. He discussed the problems with these data and assumptions. It is an excellent piece of detective work and synthesis that required imagination and patience to assemble. With present knowledge and data there probably can be few changes of any significance. But as in all studies there are some assumptions that need to be re-examined. The major assumption involves the validity of soil scientists estimating the amount of truncation of a cultivated soil by comparing it to a virgin profile on similar topography. The second assumption is that the 1935 reconnaissance maps accurately represented soil erosion in an area.

The question is not Trimble's approach to measuring erosion, but how accurately can soil scientists estimate the average removal of soil from a mapping unit by comparing it to a virgin or assumed virgin profile? Within the last 30 years it has been difficult to find virgin sites that have much areal extent, so even those few virgin sites remaining may not be representative of the former undisturbed mapping unit. The uneven topography of the Piedmont is another factor, and the surface thickness and textural variations within a virgin area mapping unit have not been documented. It is unusual even on a nearly level Coastal Plain surface to have A horizons (A1 and A2) of uniform thickness across an area because the local soil environment is variable (Daniels, 1967). It would be even more unusual to expect surface thickness and textural uniformity in a gently to moderately rolling landscape shaped by geologic erosion. Local areas of convexity, concavity, runoff and runon on the uplands and valley slopes of the Piedmont should result in localized areas of erosion and deposition even in the undisturbed state. Thus, there is reason to doubt the accuracy of attempts to estimate average soil removal unless considerable detailed work on variations within a mapping unit has been completed. Trimble did not give the documentation, nor can the necessary documentation on surface properties be obtained from the literature.

Although there is ample reason to question the accuracy of an estimated soil loss from a mapping unit by experienced soil scientists, there probably is no better estimate available. Documentation either for or against an accurate estimate is missing. It appears that neither Trimble's approach nor the soil scientists' estimates can be improved upon at the present time. But caution should be exercised in interpreting such data and it should be considered only as a reasonable but rough approximation until other data are available. Authors using these techniques, however, should warn their readers of the possible or probable shortcomings of the approach.

The second assumption—that the reconnaissance and later soil erosion maps accurately represent soil erosion in an area—has been questioned by several, but some authors (Held and Clawson, 1965) feel that these maps are reasonable representatives of the conditions in the field. The Soil Conservation Service completed a reconnaissance soil erosion survey of several states in the early 1930s. No text accompanied these maps and most were published at a scale of 1:500 000. Later the Soil Conservation Service made erosion maps of counties, watersheds and selected project areas (e.g. Stevens *et al*., 1938). A text accompanied the later maps, and soil series as well as erosion were delineated. On both sets of maps the degree of erosion was determined by comparing the soil with a virgin profile on the same topography, or if none were available, then a virgin profile was estimated. A detailed discussion of the criteria used was not given in the later publications, nor were the local variations in surface horizon thickness for each mapping unit. The virgin or assumed virgin profile used to determine the amount of erosion on cultivated soils was not described, so the original thickness of the A horizon is unknown.

The lack of descriptive detail on how the erosion was measured and the absence of documentation of what was used for the uneroded soil of each mapping unit is unfortunate. Today it is nearly impossible for workers to reconstruct or evaluate the changes in an area since the original maps were made and their value has been decreased considerably. Apparently there was considerable editing of the original manuscripts compiled by the field personnel. Stevens (oral communication, 1981) states that detailed descriptions of each map unit were sent in with the maps, both on the original reconnaissance erosion survey and the later surveys. Enough detail was given so that soil differences of slope groups within a series were described. This documentation was not published in the surveys examined; apparently it was eliminated by higher authority during the compilation and publishing process. For many reasons, it is very difficult to publish the basic data collected, and much data giving a detailed insight into the knowledge of the field party is eliminated before publication. (Modern soil survey reports are little different. A map is published, but information needed to help interpret the map 10–30 years after publication is often eliminated or never written.)

The question of how accurately soil scientists can map erosion needs to be discussed because soil scientists operate under some very real restrictions. Modern soil maps are made at scales of 1:20 000 and 1:24 000 and minimum size delineations are about 2 ha (5 acres). Even in the 1:15 840 map scales the minimum delineation is about 0.8 ha. Smaller delineations are discouraged because the symbols must fit within the boundaries of the mapped unit and spot symbols can be lost, eliminated or misplaced during the correlation and compilation process. Estimates of the percentage of inclusions of similar and contrasting soils within a mapping unit are made, but most soil surveys in the United States say little about the variations to be found within an erosional phase. There also has been little published work on the accuracy of mapping erosion phases. Powell and Springer (1965), in a limited study in the Southern Piedmont and using established criteria, stated that erosion was mapped correctly at 77% of their sites investigated. If the work of Powell and Springer is typical of the Piedmont mapping, then the soil scientists are doing an exceptional job. Additional checking is needed to verify this earlier work because most studies of soil variability indicate much more variation in soil properties among morphologically similar pedons than was originally thought (McCormack and Wilding, 1969; Amas and Whiteside, 1975; Bracewell *et al*., 1979; Beckett and Webster, 1971).

One reason to doubt the accuracy of mapping erosion is the fact that most Piedmont soil mapping units subject to erosion have an uneven topography and contain both erosional and depositional slopes or segments. Delineating a reasonably pure unit is very difficult, especially at the smaller scales. Unpublished data by Stone (1981) indicates the variation in surface characteristics within the same mapping unit in the Piedmont of North Carolina. The sites chosen were mapped as severely eroded Cecil, a Typic Hapludult, yet surface textures of the Ap within the delineations ranged from clay loam 75–100 mm thick to sandy loam up to about 450 mm thick. Corn yields in 1981 appear to be directly related to plow layer characteristics and micro landscape position. The lowest yields were on thin clay loam Ap horizons on convex ridge crests and noses, and the highest yields on sandy loam Ap horizons less than 380 mm thick on concave valley slopes. The yield variation in bushels per hectare per plot within fields composed of one mapping unit was as shown in Table 12.2.

Langdale *et al*. (1979) published data supporting the yield variations in eroded mapping units found by Stone. The test site was a 1.3 ha (3.2 acres) watershed mapped as eroded Cecil, but the test plots were eroded and moderately eroded Cecil plus a soil in local alluvium. Corn yields on severely and moderately eroded Cecil and the local alluvium were, respectively, 2226, 4674 and 6429 kg/ha (or 36, 75 and 92 bushels per acre) over three growing seasons. Corn grain and dry matter production were related positively to soil depth above the Bt horizon. Yields increased until the Bt horizon was about 40 cm from the land surface. A 40% yield reduction occurred when 15 cm of topsoil was eroded or the depth to the Bt was reduced from 40 to 25 cm. Similar results were found by Adams (1949). The only problem with trying to

Table 12.2 Corn yields in Stone's study

Location	Average yield (bu/acre)	Yield range (bu/acre)	Standard deviation (bu/acre)	Growing season rainfall (mm)	Rainfall (% >25 mm/hour)
Wake Co.	42	22–77	12	152	20
Rockingham Co.	76	35–139	24	254	50
Davidson Co.	106	81–131	14	178	50
Yadkin Co.					
1	156	71–200	27	203	28
2	153	100–199	25	203	32

1 US bushel = 35.2391 dm^3.
1 acre = 0.405 ha.

extrapolate Langdale *et al.*'s data is that the plots were not all Cecil soil nor did each plot have the same landscape position and configuration. Only one plot was moderately eroded and three were in local alluvium. The micro-environment was not the same on all plots, especially the plots on the concave sites on the lower slopes and those in local alluvium. But the variable yields found by Langdale *et al.* are probably typical for the gently sloping Cecil uplands and mapping units. Within the uplands the more productive sites are usually too small for a soil surveyor to delineate the different soils. At scales of 1:20 000 the entire watershed studied by Langdale *et al.* has less area than the smallest delineation allowed by modern surveys.

The data of Stone and Langdale *et al.* are indicative of the probable variations within a soil mapping unit in the Piedmont. The areal extent of the inclusion of other erosional phases within the mapping units and their influence on map unit production needs to be carefully documented.

12.4 PRESENT SOIL PRODUCTIVITY

Many kinds of soils are found in the Southern Piedmont, but one of the most common is the Cecil series derived from acid rocks, usually schists and gneiss, and its associate the Appling series, usually found on granites. These two soil series are still used for agriculture in the Piedmont and their present productivity can give an indication of changes in productivity over time.

The US agricultural censuses have been reasonably accurate since about 1860 (Trimble, 1974), but yields per acre are available only since about 1880 (Table 12.3). The average yields of corn harvested for grain in several southern Piedmont counties are given in Table 12.3. The average volume of soil lost by erosion as estimated by Trimble (1975) is given for each county. If soil erosion affects soil productivity, then we should expect lower production from severely eroded counties than from less severely eroded counties in the same state. The productivity loss should be large in South Carolina and Georgia between 1860 and 1920 because these are the areas of most erosive land use during these periods (Trimble, 1974: Figures 1, 3). But average corn yields in all counties remained nearly constant from 1879 to about 1954 in Georgia and South Carolina. Table 12.3 suggests that yields in North Carolina did not increase much until about 1929, although annual yield data (Table 12.4 and Figure 12.4) show that corn yields increased from a range of 11–14 bushels per acre starting about 1900 to a range of 18–20 bushels per acre by 1920. The increase was a result of 4-H Corn Clubs and educational programmes (Krantz and Chandler, 1954). Data in Table 12.4 show a large increase in North Carolina corn yields in the 1950s, probably as a result of suitable hybrids and an intensive educational programme that increased fertilizer use and helped install other practices (*ibid*). The increase in average corn yields in South Carolina and Georgia counties did not take place until the 1960s (Table 12.3).

If one looks only at average county yields, there apparently is no loss in productivity even in the severely eroded counties. Technology has increased the average yield per acre considerably during the period of record. But there has been a large decrease in corn acreage in all counties (Table 12.3), and the decrease in corn acreage in the Georgia counties could be interpreted as little more than transfer of corn acreage to the better soils.

Soil Conservation Service soil scientists have estimated average crop yields under a high level of management for a number of years. The yields are not measured but are determined for each mapping unit through discussions with land owners and operators, the experience of the local conservationist and extension agent. For the time collected, the estimated yields are probably reasonable for the soil mapping unit in the county. The estimates are quickly outdated by changes in technology, although the relative yield differences among mapping units probably hold for a few years. Table 12.5 lists the soil survey report's estimated yields for Cecil and Appling mapping units, slope and surface texture phases, in four counties. The sandy loam phases are the least eroded, or at least have the highest predicted yields, and the clay loam phases usually have lost the A horizon and the underlying B is now the plough layer. In most counties the yields on eroded phases, or the soils with the finest textured plough layer, were estimated to be 20–25% less than similar soils with a coarser textured surface. Although subject to criticism, these data indicate that mapping units with B horizon for the plough layer have lower yields than similar mapping units with some thickness of sandy loam surface remaining. The yield reductions for the mapping unit as estimated in soil survey reports are about one-half the reduction suggested by Langdale *et al*. (1979) and Adams (1949) for similar soils. The researchers were looking at plot data and the estimates are for mapping units that usually have inclusions.

Unpublished data compiled in 1964 by W. W. Stevens, former State

Table 12.3 Corn yields in the Southern Piedmont from 1879 to 1978

State:	Georgia				South Carolina						North Carolina					
County:	Baldwin		Harris		Edgefield		Fairfield		Greenville		Catawba		Person		Wilkes	
	A[a]	B[b]	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Average depth erosion (cm)[c]	>31.2		11.4–17.8		>31.2		>31.2		11.4–17.8		11.4–17.8		4.8–11.2		>31.2	
Year																
1879	17.6	7	26.9	9	67.8	8	40.3	9	52.6	11	21.2	17	19.4	12	34.9	14
1890	13.3	10	24.3	11	68.0	10	34.1	9	53.5	12	24.3	13	18.8	12	40.8	13
1899	22.6	7	29.5	11	38.3	8	40.4	20	63.5	10	27.8	14	21.3	16	44.5	14
1909	18.6	10	26.0	10	36.7	11	35.1	9	57.2	11	30.9	14	20.9	15	44.3	14
1919	23.3	10	28.9	10	33.8	15	36.2	11	58.0	12	25.9	15	20.7	15	40.7	16
1924	16.9	9	21.5	12	27.7	12	25.5	10	50.1	15	19.4	14	16.5	11	38.5	15
1929	15.9	–	12.1	15	22.6	10	20.2	10	39.9	7	19.1	19	19.1	18	42.5	21
1934	21.6	7	25.2	9	29.0	8	22.5	6	54.9	12	21.8	18	19.2	16	37.6	18
1940	19.4	8	20.7	7	23.4	11	22.0	10	46.1	16	19.4	20	23.1	21	31.5	22
1945	16.3	11	11	13	22.5	17	16.7	14	46.2	18	16.8	26	20.1	26	27.9	27
1949	8.5	16	8.3	13	19.0	16	11.2	14	29.2	20	13.3	30	18.3	31	19.3	35
1954	8.7	10	4.9	10	12.9	10	4.8	9	14.2	11	8.1	20	17.5	20	11.3	22
1959	5.0	24	2.9	18	7.1	22	3.1	20	7.3	25	7.8	36	13.5	30	8.4	37
1964	0.7	31	0.7	30	3.3	24	1.2	31	4.3	38	4.5	49	10.0	42	2.7	47
1969	1.6	41	0.5	36	1.4	40	0.4	31	1.6	35	4.7	53	7.1	54	4.3	63
1974	2.6	34	1.6	47	0.8	33	0.2	56	2.9	54	5.8	63	8.2	60	4.3	77
1978	2.5	41	0.7	32	0.7	23	0.3	33	4.4	44	4.5	57	7.1	53	5.2	73

[a] Acres ×1000 (1000 acres = 405 ha).
[b] Yield in bu/acre (1 US bushel = 35.24 dm^3).
[c] From Trimble (1975).

Table 12.4 Yield (in bushels/acre) and acreage of corn harvested for grain in three North Carolina counties[a]

Year	Catawba		Person		Wilkes	
	Acres	Yield	Acres	Yield	Acres	Yield
1879	21 248	17	19 372	12	34 865	14
1890	24 275	13	18 776	12	40 760	13
1899	27 837	14	21 292	16	44 466	14
1909	30 936	14	20 897	15	44 281	14
1919	25 917	15	20 724	15	40 711	16
1925	20 250	14	17 260	11	35 970	15
1926	20 010	18	21 350	18	37 230	20
1927	20 340	18	21 650	19	32 850	18
1928	20 160	17	21 470	16	32 910	19
1929	18 800	18	20 950	19	33 680	21
1930	21 460	17	22 170	15	38 480	11
1931	21 810	18	26 060	20	41 790	19
1932	20 400	12	22 210	12	37 830	18
1933	20 680	13	24 180	16	40 300	18
1934	21 640	18	21 150	16	36 760	18
1935	22 860	19	21 360	16	35 740	19
1936	20 560	17	20 540	19	32 360	20
1937	18 310	20	19 970	20	30 340	20
1938	19 090	20	21 660	19	31 880	22
1939	19 760	20	21 350	19	35 070	21
1940	18 860	20	21 640	21	30 910	22
1941	18 490	21	20 690	21	30 150	20
1942	17 010	23	21 080	21	26 060	19
1943	17 950	21	22 020	20	27 180	25
1944	17 500	26	21 000	20	26 900	27
1945	16 100	26	19 500	26	21 800	27
1946	1 500	29	20 000	26	2 300	27
1947	14 900	31	18 600	28	20 700	33
1948	16 430	30.5	19 290	32.3	21 800	36
1949	15 230	30.4	18 380	30.9	19 500	35.1
1950	13 890	31.3	19 090	35.2	17 540	36.7
1951	13 730	31.3	18 140	28.3	15 980	37.5
1952	13 400	21.7	18 300	22.5	15 300	23.4
1953	12 400	21.6	18 100	17.4	13 800	27.9
1954	18 800	20.0	17 700	20.6	11 600	23.2
1955	9 900	34.1	16 200	28.7	11 600	41.1
1956	9 400	27.0	15 400	34.0	9 200	37.8
1957	7 400	32.4	15 100	21.0	9 100	43.3
1958	6 700	37.5	14 700	36.0	9 200	43.0
1959	8 650	36.0	14 400	29.6	9 200	36.7
1960	7 900	41	14 400	36	7 650	49
1961	7 500	40	10 650	37	7 900	45
1962	6 650	37	9 200	40	5 850	49
1963	8 050	40	11 300	35	5 950	46
1964	8 350	49	11 000	42	5 550	47

Table 12.4 (*contd*)

Year	Catawba Acres	Catawba Yield	Person Acres	Person Yield	Wilkes Acres	Wilkes Yield
1965	8 450	55	10 500	45	5 900	60
1966	9 600	40	11 100	25	6 350	45
1967	9 100	55	11 500	55	7 300	65
1968	8 700	50	10 950	45	7 350	60
1969	7 600	53	8 750	54	7 000	63
1970	5 750	26	9 650	41	7 750	48
1971	5 250	44	8 950	36	6 250	60
1972	4 800	53	7 800	58	2 650	62
1973	5 800	64	8 600	61	2 900	78
1974	7 050	63	9 300	60	4 000	77
1975	7 070	58	9 510	60	5 540	70
1976	6 050	58	11 000	46	7 650	75
1977	7 000	18	9 500	25	6 000	44
1978	6 000	57	9 000	53	5 100	73
1979	5 700	82	8 300	60	5 920	78
1980	5 650	63	9 300	44	6 250	37

[a]From NC Dept. Agriculture, Division of Agricultural Statistics, Raleigh, NC, and US Agricultural Censuses.

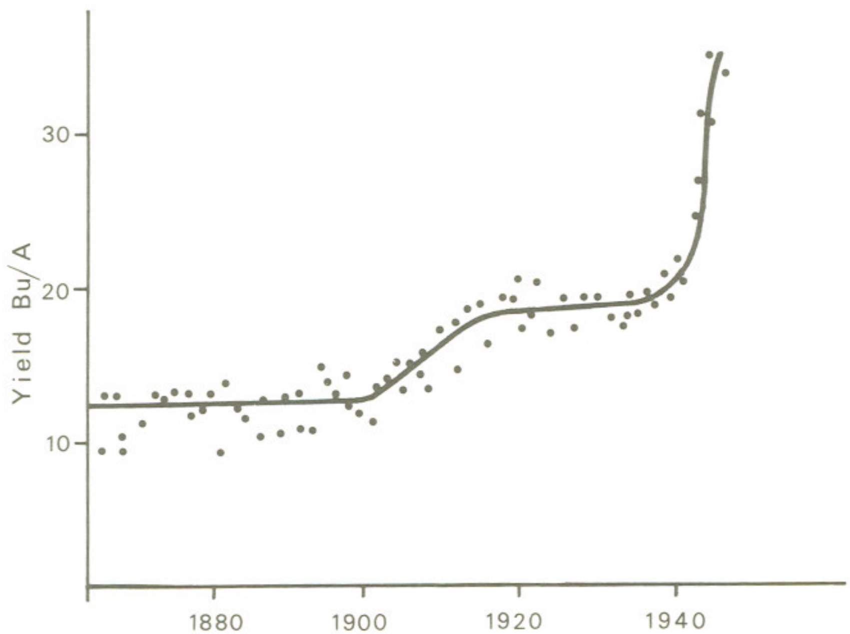

Figure 12.4 Corn yields in North Carolina (Krantz and Chandler, 1954)

Table 12.5 Corn yield estimates for Piedmont soils

Series and phase	Catawba, NC, 1975		Wake, NC, 1970		Greenville SC, 1975		Baldwin, GA, 1976	
	Y[a]	A[b]	Y	A	Y	A	Y	A
Appling								
2–6% sandy loam	90	4.9	73	3.2	80	12.1	–	–
Sandy loam eroded	–	–	68	7.1	–	–	–	–
6–10% sandy loam	–	–	65	4.6	70	2.5	–	–
Sandy loam eroded	80	2.8	60	8.1	–	–	–	–
Cecil								
2–6% sandy loam	–	–	–	–	90	56.4	95	7.9
Sandy loam eroded	90	37.7	–	–	–	–	–	–
Clay and sandy clay	–	–	–	–	–	–	–	–
loam	70	1.5	–	–	65	2.6	70	2.6
6–10% sandy loam	–	–	–	–	80	64.0	90	5.2
Sandy loam eroded	80	36.6	–	–	–	–	–	–
Clay and sandy clay	–	–	–	–	–	–	–	–
loam	60	6.3	–	–	55	11.0	60	8.0

[a]Yield in bu/acre (1 US bushel = 35.24 dm^3).
[b]Acres ×1000 (1000 acres = 504 ha).

Resource Conservationist, Soil Conservation Service, Raleigh, North Carolina, show the effect of surface thickness on stand (Table 12.6). Only a small part of the data are shown to illustrate the relationships. The stands were measured for 100 feet (30.5 m) of row by experienced agronomists. The soils were identified by soil scientists or other qualified personnel.

The relationship between stand (Y) and topsoil thickness (X) for Cecil is $R^2 = 0.6616$ ($R = 0.8195$) and for Appling $R^2 = 0.5449$ ($R = 0.7429$); both correlations are statistically significant. Although there are several criticisms of these data that can be raised, they clearly illustrate the difficulty in 1964 of obtaining a satisfactory stand on soils with little or no coarse textured surface horizon. Technology still has not solved the problem of producing a uniform seed bed in the variable surface textures of the Piedmont and is one of the problems restricting corn yields in the area (oral communication, G. Naderman, 1982). The yields on the plots with small plant populations would be low even if hybrids producing 2 or 3 ears per stalk were grown under high fertility levels (Kamprath *et al*., 1973). Present recommendations are for populations of 20 000 plants per acre for modern hybrids that produce only one ear.

If there is any region in the United States where soil erosion should have a maximum effect on soil productivity it would be in the Southern Piedmont. The soils (Ultisols), or most of them, were and are acid, nutrient-poor mineral soils formed from saprolite that has lost most of its weatherable minerals. The

Table 12.6 Relationship among surface thickness and corn stand (unpublished data from W. W. Stephens)

	Topsoil (plough layer) thickness (inches)				
	0	0–2	2–4	4–6	6–8
Cecil					
No. of plots	8	21	35	27	12
Plants/acre					
r	124–5977	1084–6973	996–7845	5479–10 958	7845–12 453
$\bar{X}$	2241	2864	4358	7721	10 585
Appling					
No. of plots	4	16	36	38	43
Plants/acre					
r	0–3985	0–5479	0–7222	2247–10 460	4483–12 826
$\bar{X}$	1120	1618	3985	6102	7721
White Store					
No. of plots	0	11	21	12	11
Plants/acre					
r		1245–5728	2490–6849	4109–7721	5479–8966
$\bar{X}$		3362	4732	5603	6724
Creedmore					
No. of plots	5	24	32	31	35
Plants/acre					
r	747–2490	373–12 951	2739–10 460	1743–10 958	4732–12 453
$\bar{X}$	1245	4607	6102	6973	7596

r = range; $\bar{X}$ = mean.

A1 horizons were thin. The underlying B horizons are usually clay, most are acid and have kaolinitic or mixed 2:1–1:1 clay minerals. The clay B horizons with the most favourable physical properties are always described as sticky or slightly sticky, plastic or slightly plastic when wet. In soils developed from basic rock, the B horizons are sticky and plastic and it is a common statement that you may have 30 minutes or an hour when ploughing is favourable; otherwise it is too wet or too dry. The plastic B horizons do not produce good seed beds under most conditions.

The soils of the Southern Piedmont have been farmed for at least 200 years and many have been severely eroded, or at least the B horizon is exposed in some areas. If Trimble's 1975 estimate of the volume of soil removed is correct, many areas have eroded well into the B horizon. Yet crop yields are improving, and since about 1870 or 1880 held at rather constant levels during periods of erosive land use (Tables 12.3, 12.4, 12.5 and Figures 12.1, 12.2, 12.4). Improved technology can account for the increase in average yields, although soils with thin plough layers of fine-textured material still produce less than the thicker slightly coarser surface horizons (Tables 12.5 and 12.6). Similar relationships occur in other southern Piedmont counties with published soil surveys during the last 10 years.

Trimble's 1975 data suggest that in severely eroded areas such as Baldwin County, Georgia, most of the soils should have clay loam plough layers because more than 30 cm of soil has been removed by erosion (Figure 12.2). The 1976 Baldwin County, Georgia, soil survey report suggests otherwise (Table 12.5). Similar relationships occur in other counties with published soil surveys during the last 10–20 years (Tables 12.7 and 12.8). In the Southern Piedmont surveys examined, about 75% of the Appling, Cecil and Madison soils on slopes from 2% to 10% still have sandy loam surfaces. In both Abbeville and Edgefield Counties, South Carolina, where Trimble predicted >31.2 to 24.6 cm of erosion, the majority of the soils have sandy loam surfaces (Table 12.8). Only Morgan and Walton Counties, Georgia, have more area of sandy clay loam or clay loam surfaces in the 2–10% slope groups of Cecil, Appling and Madison than sandy loam (Table 12.8). Walton County

Table 12.7 Total acreage (×1000 acres) of Appling, Cecil and Madison soil series with sandy clay loam or clay loam surface[a]

Soil series and phase Number of counties	ALA 3	GA 18	SC 9	NC 8	VA 3	Totals 41
Appling						
SL 2–6[b]	9.5	130.5	81.7	140.1	20.8	382.6
SL 6–10	32.0	97.5	30.0	65.4	12.1	237.0
SCL 6–10	16.7	17.3	–	0.3	1.3	35.6
Cecil						
SL 2–6	4.8	301.0	353.5	140.4	31.3	831.0
SL 6–10	13.2	228.3	273.7	140.1	23.4	678.7
SCL-CL 2–6	2.8	84.6	35.6	122.9	4.8	250.7
SCL-CL 6-10	30.1	287.3	77.1	55.2	18.8	468.5
Madison						
SL 2–6	4.2	52.9	25.6	8.7	1.9	93.3
SL 6–10	36.3	84.8	45.7	16.6	1.7	185.1
SCL 2–6	1.1	7.1	2.1	0.4	0.9	11.6
SCL 6–10	36.5	51.1	16.0	2.3	2.2	108.1
Totals	187.2	1342.4	941.0	692.4	119.2	3282.2

[a]From soil surveys published since 1959.
[b]Slope groups.
SL = sandy loam; SCL = sandy clay loam; CL = clay loam.
1000 acres = 405 ha.

Table 12.8 Percentage of Appling, Cecil and Madison soils on 2–6% and 6–10% slopes with sandy loam and sandy clay loam or clay loam surface horizons

Location	Approx. average soil loss (cm)[a]	Total acres (×1000)	Sandy loam (%)	Sandy clay loam and clay loam (%)
Georgia				
Banks, 1971	24.4–18.0	33.3	55.0	45.0
Barrow, 1977	24.4–18.0	59.9	77.1	22.9
Clarke, 1968	24.4–11.4	25.6	82.0	18.0
Clayton, 1979	17.8–11.4	43.0	85.1	14.9
Coweta, 1980	17.8–11.4	137.9	79.6	20.4
Fayette, 1979	17.8–11.4	93.5	72.5	27.5
Gwinett, 1967	17.8–11.4	74.4	89.1	10.9
Hall, 1977	24.4–18.0	46.6	53.2	46.8
Heard, 1980	17.8–11.4	45.3	68.9	21.1
Henry, 1979	17.8–11.4	126.2	72.8	27.2
Jackson, 1977	24.4–18.0	113.7	50.6	49.4
Meriwether, 1965	24.4–11.4	112.1	53.3	46.7
Morgan, 1962	31.2–18.0	72.6	37.2	62.8
O'Conee, 1968	24.4–11.4	42.1	83.6	16.4
Spalding, 1964	17.8–11.4	80.6	52.3	47.7
Stephens, 1971	24.4–11.4	17.0	54.1	45.9
Troup, 1980	24.4–18.0	100.1	71.1	28.9
Walton, 1964	17.8–11.4	118.5	43.0	57.0
Alabama				
Celeburne, 1979	17.8–11.4	4.8	100.0	0.0
Chambers, 1959	24.4–11.4	107.8	48.0	52.0
Randolph, 1967	17.8–11.4	74.6	58.3	41.7
Virginia				
Charlotte, 1974	17.8–11.4	101.2	73.2	26.8
Chesterfield, 1978	17.8–11.4	3.8	100.0	0.0
Henrico, 1975	17.8–11.4	14.2	93.7	6.3
South Carolina				
Abbeville, 1980	>31.2–24.6	91.3	91.4	8.6
Anderson, 1979	–	265.2	96.6	3.4
Edgefield, 1981	>31.2–24.6	49.9	99.5	0.5
Greenville, 1975	24.4–11.4	159.4	90.3	9.7
Greenwood, 1980	31.2–18.0	63.3	77.4	22.6
Laurens, 1975	24.4–11.4	167.6	78.1	21.9
McCormack, 1980	31.2–24.6	14.2	97.2	2.8
Union, 1975	>31.2–24.6	63.9	99.5	0.5
York, 1965	24.4–11.4	66.2	58.0	42.0
North Carolina				
Catawba, 1975	17.8–11.4	102.2	92.3	7.7
Durham, 1976	11.2– 4.8	6.5	100.0	0.0

Table 12.8 (*contd*)

Location	Approx. average soil loss (cm)[a]	Total acres (×1000)	Sandy loam (%)	Sandy clay loam and clay loam (%)
Forsyth, 1976	31.2–11.4	57.0	90.0	10.0
Iredell, 1964	22.9–11.4	1·31.4	88.4	11.6
Mecklenburg, 1980	17.8–11.4	122.2	3.4	96.6
Orange, 1977	17.8– 4.8	22.5	100.0	0.0
Vance, 1980	11.2– 4.8	71.1	57.9	42.1
Wake, 1970	11.2– 4.8	179.5	97.5	2.5

was predicted to have lost 17.8–11.43 cm and Morgan County 31.2–18.0 cm of soil by Trimble (1975).

Data in Tables 12.7 and 12.8 seemingly contradict the data of Trimble's that large volumes of soils have been eroded from the soils of the southern Piedmont. Large areas still retain a sandy loam surface that is at least grossly similar to the original surface. Trimble's estimate of soil loss is probably the best available using current information. Therefore, we must ask whether modern cultural practices are developing sandy loam plough layers from the underlying or upslope clay B horizons at a rate approximately equal to the loss of surface, or whether our interpretations of the Universal Soil Loss Equation grossly over-estimate the amount of material removed from a field. The upland Piedmont landscape is a combination of gentle concave and convex slopes, so erosion and deposition of material can occur within a few square metres. Modern cultural practices expose the B horizon at the surface where it can be dispersed by raindrop impact and aggregates moved downslope. The large and heavy equipment now in use, too, is capable of mixing the sandy surface and the clayey B horizon to a much greater extent than the light mule-drawn equipment of a few years ago.

Is it possible that erosional and depositional processes in cultivated fields in the Piedmont have reached a pseudo-equilibrium so that continued erosion does not change the present field relations much even though it may remove the original Ap horizon and a large part of the B horizon? Are the areas of Cecil and similar soils with clay loam surfaces the zone of most active removal and the adjacent lower areas with sandy clay loam to sandy loam surfaces the zone of transport and deposition? Are the gentle interfluves of the upland maintaining a sandy loam surface because the fines exposed by ploughing are being partially dispersed by raindrop impact and removed by runoff, as well as clayey aggregates being moved downslope as bed-load?

The idea that erosion will remove all of an A horizon, and leave only a fine textured B horizon at the surface, should be carefully examined in light of estimates of erosion and the conditions that actually exist. The variations in colour of a freshly ploughed Cecil soil that has been cultivated for nearly 200 years is convincing evidence that we either over-estimate the amount of erosion, or other processes are maintaining a sandy loam surface over much of the upland landscape developed from acid igneous rocks.

Is it also possible that we are over-predicting the amount of material removed from a field when we interpret erosion by the Universal Soil Loss Equation? This equation predicts the amount of erosion, but does not account for sorting and local deposition. It is an estimate of the amount of material moved, but not necessarily from the field. In most interpretations an annual soil loss of 10 tons per acre (25 t/ha) is interpreted as meaning the movement of that much material from the field. This claim is not made for the equation.

12.5 SUMMARY AND SPECULATION

There is little doubt that erosion since European settlement has changed the soils of the Southern Piedmont. These changes have resulted in lower soil productivity using the same technology, yet with modern technology the loss in productivity from erosion is minor compared with the large advances in yields produced by better hybrids, cultural practices and fertilizer applications. Productivity today, as measured by corn yields, is larger than at any time since European settlement. Problems—such as poor stands, as a result of unfavourable seed beds—exist but there appears to be little evidence that suggests continued erosion will reduce soil productivity to zero or even much below present levels. In most of the Southern Piedmont the saprolite is several feet thick, and except for a lower permeability to water it probably has physical properties more conducive to high soil productivity using present technology than the clay B horizons of the soils. There is also a suggestion that erosional and cultural processes may help maintain a relatively favourable surface horizon over much of the area on slopes of 10% or less. When one considers the low natural fertility of most Piedmont soils, the maintenance of a favourable rooting zone may be more important than maintaining the original surface layer of low fertility.

If it becomes necessary to again cultivate large areas of the Southern Piedmont, present technology should maintain productivity at a higher level than was possible at any time in the past. Erosion since European settlement has damaged soil productivity but not irreversibly. Without modern technology, however, soil productivity would soon decrease somewhere near the levels of the late 1800s or early 1900s, largely because the soil and underlying materials usually have low inherent fertility.

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