ongoing.

If current trends prevail, the eventual extinction of the native brook trout from Tennessee streams may occur within the next 30 to 50 years. Habitat degradation is not so much the problem it once was, especially on federal lands with protected watersheds. However, encroachment on brook trout habitat by the more aggressive rainbow trout is cause for alarm. Wolfe et al. (1978) and Helfrich et al. (1982) studied agonistic behavior between brook and rainbow trout and generally concluded that brook trout can compete with equal size rainbow trout. However, native Appalachian brook trout tend to be small in size, especially when compared to stocked rainbow trout. Partial eradication of rainbow trout from brook trout streams by electrofishing has resulted in increased standing crops of brook trout (Moore et al. 1984). Whitworth (1980) found that rainbow trout move more than do brook trout and that their overall movement is generally upstream. Although this movement is small over a given period, it is probably consistent from year to year. This, coupled with the generally small size of native brook trout may give some insight as to why brook trout populations have been pushed further and further into their present headwater habitat.

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CRITICAL EROSION AREAS IN KNOXVILLE AND KNOX COUNTY, TENNESSEE

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Abstract

This study was designed to provide a spatial distribution of the critical erosion areas, measure their size and estimate the amount of soil lost in each watershed. Among the thiry-five studied watersheds in Knoxville and Knox County, farming activities predominate the critical area and amount of soil losses. Construction activities in the urbanized and suburbanized basins are the second most important source of erosion. Approximately 10% of the studied area (24,000 acres) can be classified as critical erosion area; 6% of the area represented by intense farming activities, 3% by construction and 1% by road right-of-ways.

Introduction

Excessive soil erosion can result in the loss of prime farm land and the degradation of water quality by causing the siltation of streams, reservoirs, sinkholes and drainage structures, the destruction of aquatic habitats by exclusion of sunlight, limitation of photosynthesis and alteration of the rate of temperature change. All of these affect the feeding, reproduction, movement and food supply of fish. As sediments settle to stream bottom, they contribute to algal blooms and the destruction of bottom-dwelling organisms that provide vital links in the food chain. Additionally, the sediments which result directly from soil erosion commonly have absorbed fertilizers, pesticides, heavy metals and other undesirable pollutants. These absorbed pollutants may be released into the water under certain conditions, contaminating water supplies and creating a danger to public health and aquatic life.

Because of the detrimental effects of sediment on water quality, there is considerable interest in determining the primary sediment sources. Sediments, of course, come from soil erosion which occurs on all natural land surfaces, but erosion can be accelerated when existing protective surface cover (vegetation) is removed or disturbed by man's activities. Areas in Knox County which have greatest soil erosion are generally associated with (1) farming activities; (2) road banks; and (3) construction activities on residential, commercial and industrial sites.

Intense farming may include cropping and grazing practices which alter soil cover, expose the soil and leave it

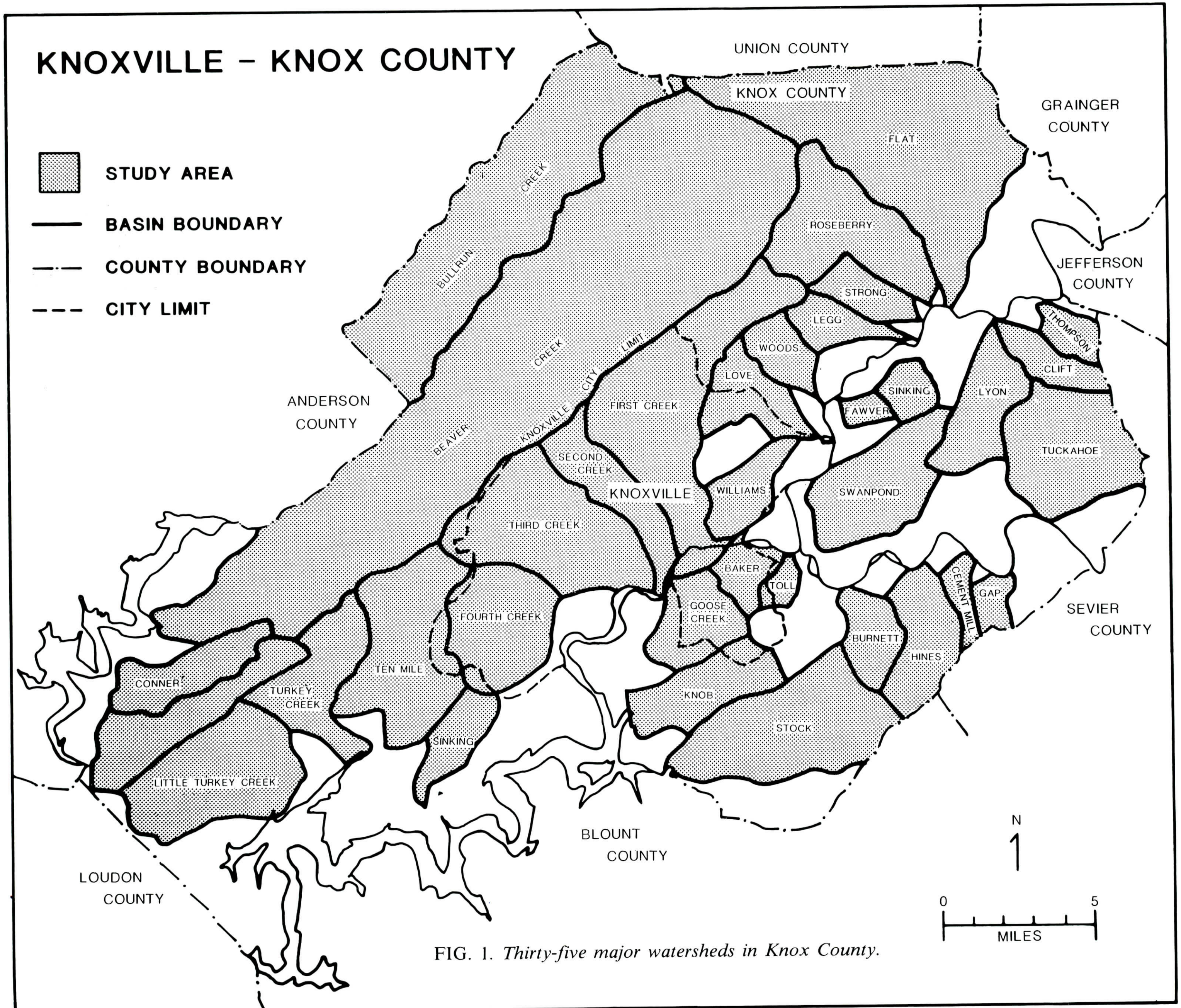

FIG. 1. *Thirty-five major watersheds in Knox County.*

susceptible to erosion. Road right-of-way and construction both involve extensive earth-moving operations. These extensive earth-moving practices disturb the protective ground cover, dislodge and redistribute naturally compact soils and expose more highly erosive soils from the deeper horizons. Therefore, areas in these three categories are treated as critical erosion areas.

The purpose of this study is to define and locate the existing critical erosion areas in Knox County and further to measure the size (in acreage) and calculate the amount of soil loss (in annual tons) from these critical erosion areas by uses and by watersheds.

Study Area

The study area consists of the 35 watersheds (249,099 acres) that cover approximately 75 percent of Knox County (332,132 acres), and includes the majority of those areas that are being impacted by the growth of Knoxville (Fig. 1). Less than one-fourth of the land in Knox County has slopes of less than 15 percent, and it is on this land, primarily in the northern and western portions of the County, that the majority of urban development has occurred. Between 1970 and 1980 Knox County's population grew 16 percent (276,293 to 319,694 persons), land in residential uses doubled, and land in commercial uses increased 150 percent. This has resulted in a net decrease of 12 percent (32,005 acres) in agricultural and idle land (Knoxville/Knox County Metropolitan Plannning Commission, 1980).

Materials and Methods

Topographic maps, aerial photographs and the Knox County Soil Survey served as the three primary data sources for this study. The United States Geological Survey and Tennessee Valley Authority 7.5 minute topographic quadrangle maps of 1:24,000 scale were used to define the thirty-five major watersheds in the county. The topographic maps were also used as base maps for transferring information of identified critical erosion areas.

The critical erosion areas were identified from aerial photographs and field surveys. The aerial photographs covering the entire county were flown by Continental Aerial Survey in Spring 1977. A Cessna 411 equipped with a Swiss made (Wild RC-9, 3½ inch lenses) camera conducted the mission and the altitude flown was 21,000 feet. The aerial photographs were enlarged (Center Quadrangle) to 1:24,000 scale to match with the USGS and TVA topographic quads. Three categories of critical erosion areas were identified through the aerial photographs and were field checked in November 1980. The identified critical erosion areas were then transferred to the USGS and TVA topographic maps for digitizing (coding) and for final preparation of computer maps.

The erosion potentials (tons/acreage) of 175 soil mapping units of Knox County (USDA, Conservation Service, 1955) were interpreted and calculated from the Universal Soil-Loss Equation (USLE) (Jent, et. al., 1967).

$$A = RKLSCP$$

Where:

A - Annual soil loss in tons/acre;

R - Rainfall intensity factor (assumed to be 200);

K - Soil erodibility factor (obtained from soil interpretation sheets);

LS - Length and slope factor (assumed a slope length of 100 feet and an average slope for each soil map unit); and

CP - Cropping and conservation practice factor (a value of 1.0 was used for the critical erosion areas which assumes no cropping [bare] and no conservation practices [worst management]).

Maps of identified critical erosion areas and erosion potentials were generated by TVA's computer using TVA's version "IMGRID" program and a grid-cell system of 2.68 acres per cell. The erosion potential map was then divided into four classes: (1) low (less than 50 Tons/Acre); (2) moderate (50-100 Tons/Acre); (3) high (100-200 Tons/Acre); and (4) very high (greater than 200 Tons/Acre). Determination of the size of each critical erosion area and its potential soil loss was accomplished via computer map-

TABLE 1. *Acreage of critical erosion areas by watersheds in Knox County, Tennessee*

		Critical Erosion Areas	
Watershed	Size (Acres)	Acres	Percent
Beaver Creek	57,381	4,974	9
Bullrun Creek	25,993	3,374	13
Flat Creek	20,284	1,924	10
First Creek	13,788	670	5
Stock Creek	12,223	1,809	15
Third Creek	10,711	913	9
Ten Mile Creek	10,256	554	5
Roseberry Creek	9,176	635	7
Swanpond Creek	7,343	485	7
Turkey Creek	7,072	1,088	15
Tuckahoe Creek	6,683	1,034	16
Fourth Creek	6,490	337	5
Hickory Creek	5,491	879	16
Hines Creek	5,322	777	15
Love Creek	4,853	447	9
Lt. Turkey Creek	4,684	809	17
Second Creek	4,422	322	7
Conner Creek	4,306	755	18
Lyon Creek	4,078	246	6
Knob Creek	3,926	244	6
Woods Creek	2,621	228	9
Burnett Creek	2,334	370	16
Goose Creek	2,302	172	8
Sinking Creek	2,133	179	8
Legg Creek	2,079	147	7
Baker Creek	1,999	174	9
Clift Creek	1,921	32	2
Sinking Creek	1,884	19	1
Williams Creek	1,774	45	3
Strong Creek	1,656	129	8
Cement Mill Creek	1,281	131	10
Fawver Creek	758	86	11
Toll Creek	753	86	1
Thompson Creek	573	29	5
Gap Creek	536	27	5
TOTAL	249,099	24,136	10

ping techniques that combined the four classes of erosion potential with the three types of critical erosion areas.

RESULTS

In general, the intense farming erosion areas are concentrated in north, east and south Knox County. Road right-of-way erosion predominated in current interstate contruction segments such as I-640, I-40 and I-75 in Second Creek and Third Creek watersheds and on state and county highway right-of-ways. Critical construction erosion areas were primarily distributed in urban and suburban watersheds. Because of the Center City redevelopment, construction and site preparation for the 1982 World's Fair in lower Second Creek and other related construction activities, the First Creek, Second Creek and Third Creek watersheds had the greatest percentage of erosion from construction areas. Fourth Creek, Ten Mile Creek and Turkey Creek watersheds also have a high percentage of construction area erosion because of the development concentrated in these areas of west Knox County. West Knox County has less physical constraints to development, the topography is relatively gentle, soil is moderately deep and percolates well and central sewerage is generally available for waste water disposal. In addition, easy access provided by Kingston Pike and I-40 W serve to make this area a major development corridor.

The potential soil losses were derived using the Universal Soil Loss Equation. Since slope is one of the most significant determinants of erosion potential, the erosion potential map is similar to slope distribution map with some modifications due to other parameters such as soil erodibility and cropping and conservation practices. Soils with very high erosion potential are located on ridges and steep slopes. Low erosion potential soils are generally distributed on gentle slopes and flat bottom land. The erosion potential map provides semi-quantitative soil loss rates for four erosion potential classes. This map and the map of critical erosion areas can be matched to generate a matrix map showing the existing critical erosion areas by use and by erosion potential classes. Table 1 shows the acreage of critical erosion areas in each of the study watersheds. In the thirty-five studied watersheds, the average percentage of critical erosion sites is 24,000 acres. Beaver Creek has the largest area of critical erosion sites (4,974 acres), followed by Bullrun Creek (3,374 acres), Flat Creek (1,924 acres), Stock Creek (1,809 acres), Turkey Creek (1,088 acres) and Tuckahoe Creek (1,034 acres). Table 2 shows the acreage of critical erosion areas by use. The predominant critical erosion areas are those resulting from agricultural or intense farming uses which comprise 60% (14,500 acres) of the total identified critical erosion areas (24,000 acres). Construction areas make up 30% and road right-of-way accounted for 10% of the total critical erosion areas. Bullrun Creek had the largest amount of critical erosion areas on highway right-of-way (536 acres). Beaver Creek had the largest amount of construction site erosion areas (1,470 acres) while Ten Mile Creek had the highest percentage (94%) of construction site erosion areas (522 acres).

TABLE 2. *Critical erosion areas by uses in part of Knox County, Tennessee*

Watershed	Criti-Erosion Area/Acres	Critical Agricultural Erosion		Critical R-O-W Erosion		Critical Construction Erosion	
		Acres	Percent	Acres	Percent	Acres	Percent
Beaver Creek	4,974	3,280	66	225	4	1,469	30
Bullrun Creek	3,374	2,554	75	536	16	284	9
Flat Creek	1,924	1,603	83	107	6	214	11
First Creek	670	349	52	29	4	292	44
Stock Creek	1,809	1,369	76	239	13	201	11
Third Creek	913	24	3	278	30	611	67
Ten Mile Creek	554	27	5	5	1	522	94
Roseberry Creek	635	453	71	51	8	131	21
Swanpond Creek	485	295	61	51	10	139	29
Turkey Creek	1,088	196	18	147	13	745	69
Tuckahoe Creek	1,034	688	66	236	23	110	11
Fourth Creek	337	67	20	51	15	219	65
Hickory Creek	879	584	66	83	10	212	24
Hines Creek	777	439	56	126	17	212	27
Love Creek	447	150	34	77	17	220	49
Lt. Turkey Creek	809	547	67	48	6	214	27
Second Creek	321	16	5	144	45	161	50
Conner Creek	755	691	91	11	1	53	8
Lyon Creek	246	118	48	19	7	109	45
Knob Creek	243	153	63	53	22	37	15
Woods Creek	227	99	43	8	4	120	53
Burnett Creek	369	142	38	75	20	152	42
Goose Creek	171	56	33	0	0	115	67
Sinking Creek	179	72	40	40	22	67	38
Legg Creek	147	80	55	8	5	59	40
Baker Creek	174	112	65	0	0	62	35
Clift Creek	32	21	67	0	0	11	33
Sinking Creek	18	16	86	0	0	2	14
Williams Creek	45	24	53	8	17	13	30
Strong Creek	128	85	67	24	19	19	14
Cement Mill Creek	131	21	16	64	49	46	35
Fawver Creek	85	37	44	8	9	40	47
Toll Creek	85	72	84	5	6	8	10
Thompson Creek	29	29	100	0	0	0	0
Gap Creek	26	10	40	3	10	13	50
TOTAL	24,136	14,485	60	2,763	11	6,887	29

TABLE 3. *Predicted tons of annual soil losses of critical erosion areas by uses and watersheds in part of Knox County, Tennessee.*

Watershed	Critical Soil Erosion Tons	Critical Agricultural Erosion Tons	Critical R-O-W Erosion Tons	Critical Construction Erosion Tons
Beaver Creek	389,088	264,114	21,416	103,558
Bullrun Creek	409,477	319,598	65,732	24,147
Flat Creek	162,287	139,188	8,927	14,172
First Creek	45,581	23,857	1,702	20,022
Stock Creek	158,112	118,641	20,960	18,511
Third Creek	77,068	2,170	25,388	49,510
Ten Mile Creek	31,997	1,723	389	29,885
Roseberry Creek	54,366	37,139	4,942	12,285
Swanpond Creek	92,260	17,149	3,966	71,145
Turkey Creek	67,595	15,871	9,412	42,312
Tuckahoe Creek	86,663	57,652	18,487	10,524
Fourth Creek	20,006	4,663	3,744	11,599
Hickory Creek	74,064	53,013	4,060	16,991
Hines Creek	74,306	42,146	15,515	16,645
Love Creek	34,315	12,537	5,612	16,166
Lt. Turkey Creek	59,882	43,679	4,355	11,848
Second Creek	17,664	1,104	7,343	9,217
Conner Creek	80,349	75,600	986	3,763
Lyon Creek	17,900	8,134	1,560	8,206
Knob Creek	18,934	12,068	5,183	1,683
Woods Creek	15,568	7,469	745	7,354
Burnett Creek	28,735	10,599	4,663	13,513
Goose Creek	13,794	7,448	-	6,346
East Sinking Creek	14,679	5,360	3,846	5,473
Legg Creek	10,666	4,181	474	6,011
Baker Creek	15,772	10,910	-	4,862
Clift Creek	3,431	1,780	-	1,651
Sinking Creek	2,112	1,873	-	239
Williams Creek	3,578	2,316	595	667
Strong Creek	7,860	5,684	1,635	541
Cement Mill Creek	5,400	1,321	490	3,589
Fawver Creek	5,443	1,986	536	2,921
Toll Creek	1,851	1,436	126	289
Thompson Creek	2,198	2,198	-	-
Gap Creek	933	308	46	579
TOTAL	2,103,934	1,314,875	242,835	546,224

The largest watershed in the County, Beaver Creek, also had the largest acreage of agricultural erosion areas (3,280 acres).

The tons of soil lost annually from critical erosion areas by type of use and watershed was calculated from the size of crictical erosion areas multiplied by tons/acre of soil loss for each soil mapping unit. The predicted loss of soil from critical erosion areas by type of use for each watershed is shown in Table 3. Total soil losses from the 35 watersheds exceed two million tons per year. More than one million tons of this annual soil loss comes from agricultural land and more than half a million tons are coming from construction sites. Almost one quarter of a million tons of the annual soil loss is attributable to road right-of-way banks. Bullrun Creek had the highest total soil loss (409,477 tons/yr) of all the watersheds. This watershed's high annual soil loss is primarily a result of intense farming and agricultural activities in the basin. Some urbanized and suburbanized watersheds such as Third Creek, Ten Mile Creek, Turkey Creek, Fourth Creek and Second Creek lose more soil from construction activities than from agriculture. The smallest watershed, Gap Creek, has annual soil losses of almost one thousand tons. Eight of the studied watersheds had annual soil losses between 1500 and 8000 tons. These watersheds are relatively small in size. Twenty-two of the watersheds had annual soil losses between 10,000 and 95,000 tons.

Conclusion

Soil erosion has been identified as one of the most significant water pollution sources in the nationwide 208 Water Management Study. However, specific questions regarding the soil erosion problem have not been appropriately addressed. These questions include: (1) Where are the critical soil erosion areas? (2) Approximately how many acres of these critical erosion areas are located in each watershed? and (3) How many tons of soil are lost annually from these critical erosion areas in each watershed? This study attempted to answer these questions by using computer mapping techniques to tabulate the acreage of critical erosion areas and compute the tons of soil lost in each watershed. The results of this study provide valuable information to local government officials and the USDA Soil Conservation District and will enable them to focus their limited resources on solving the most significant soil erosion problems.

This study is concentrated on soil losses from critical erosion areas which are related to, but different from, sedmentation yields to streams. Therefore, soil losses can not predict the sediment yield of streams or their water quality; it can only be used as an indirect indicator of a stream's potential sediment load. Lack of continuous stream water quality data on siltation and sedimentation prohibits conclusive quantitative testing and correlation between water quality and the amount of soil loss derived using the Universal Soil Loss Equation. More gauging stations are needed to measure sediment in streams in order to monitor soil losses and to determine more accurately the impact of soil losses from critical erosion areas on present water quality.

Acknowledgment

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