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Watersheds of Great Smoky Mountains National Park: A Geographical Information System Analysis

United States Department of the Interior

National Park Service
Southeast Region

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WATERSHEDS OF GREAT SMOKY MOUNTAINS NATIONAL PARK:

A GEOGRAPHICAL INFORMATION SYSTEM ANALYSIS

by Charles R. Parker and David W. Pipes

NATIONAL PARK SERVICE - Southeast Region

Research/Resources Management Report SER-91/01

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ABSTRACT

This report is the first of several describing the natural resources of the Great Smoky Mountains National Park as incorporated in the park's Natural Resources Database. Streams and watersheds are described and illustrated using a geographic information system (GIS). Streams were digitized from U.S. Geological Survey 7.5 minute topographic quadrangle maps. Watersheds comprising at least 5 km^2 were delimited on the maps and also digitized into the GIS. Data on elevation and aspect were derived from the USGS 1:250000-scale Digital Elevation Model for Knoxville and summarized by watershed. The data were analyzed in terms of stream lengths, watershed areas, drainage densities, predominant aspect, and related statistics. Results are presented in tables, figures, and maps for the entire park, the North Carolina and Tennessee sides, and for the 45 watersheds. Those streams not included in a 5 km^2 watershed are treated in separate pages of tables, figures and maps.

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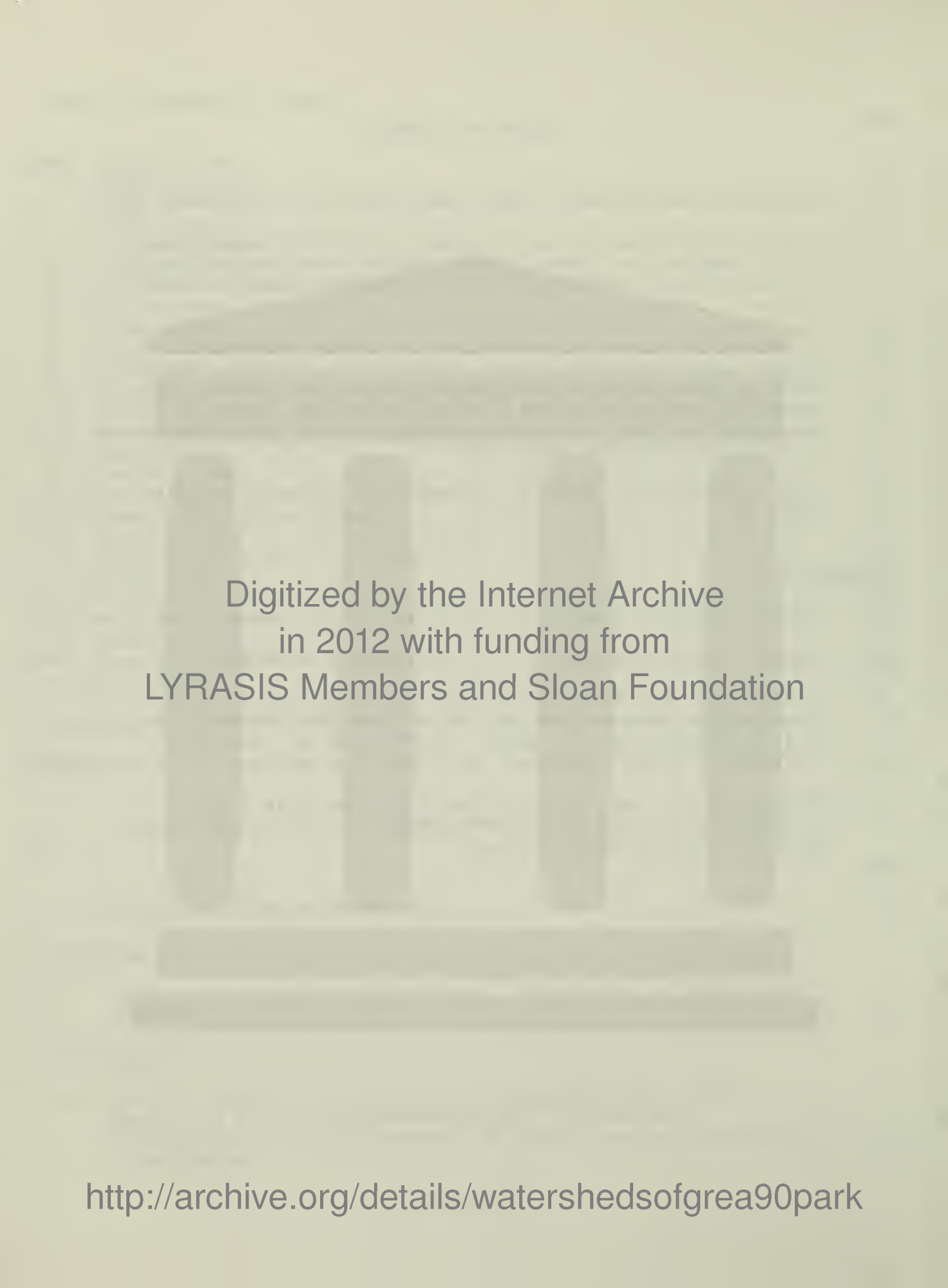


Introduction

This document presents graphic and statistical summaries of the major watersheds of Great Smoky Mountains National Park (GRSM). It is the first of a series of reports summarizing data which have been incorporated into the geographic information system (GIS) of the park. The data in this report represent four of the many themes or data layers in the Natural Resources Database (NRDB) for GRSM. The NRDB is part of a larger effort to acquire and organize data for use by park managers to more efficiently manage the resources under their care, and by scientists to analyze and model the park's ecosystems. This and subsequent reports are designed to serve as references to the major data themes in the NRDB so that potential users will have access to summaries of the information without having to enter the system and learn the specifics of database construction and manipulation. Reports in preparation include forest cover types; disturbance history, including fire history; and geology. Detailed information and analyses are available on request from the GIS Coordinator.

In the past, 28 major watersheds have been recognized (Peine, J.P., C. Pyle, and P.S. White. 1985. Environmental monitoring and baseline data management strategies and the focus of future research in Great Smoky Mountains National Park. SERO R/RM Report SER-76) in GRSM (Fig. 1). These watersheds were defined in such a way that no park land was excluded from a watershed. Hydrologic accuracy was not a primary consideration. However, the Long-Term Ecological Research and Monitoring project and other scientific studies require hydrologically accurate watershed maps for study design and other analyses. For these reasons it became necessary to delimit accurate watersheds and provide descriptions of the basic features of each. In the NRDB, the park's watersheds have their mouth at the point where a stream crosses the park boundary or at the normal pool level of the Tennessee Valley Authority reservoir that a stream flows into. They encompass all lands within an area defined by the ridge lines on the United States Geological Survey's (USGS) 7.5-minute topographic quadrangle maps from

Management Watersheds

Figure 1. Management watersheds, Great Smoky Mountains National Park.

the mouth back to the same point, with a minimum size limitation of 5 km^2. These guidelines resulted in a new map that recognizes 45 watersheds (Fig. 4). Summary statistics of each watershed are given in Table 1. An exception to the 5 km^2 size requirement is White Oak Sinks (4.3 km^2), which was included because of its unique hydrologic and floristic characteristics.

Some streams near the boundary of the park were excluded from the watersheds (see page 21). The largest areas excluded lie between Cosby and the Middle Prong of the Little Pigeon River on the north side of the park and along Fontana Lake on the south side of the park. In these areas, numerous small creeks cross the park boundary or flow into the lake. The boundary line in certain areas follows the middle of the streams for some distance. In addition, lands outside the park boundary are included in certain watersheds, most significantly Abrams Creek. Since the goal was to represent hydrologically accurate watersheds, this was unavoidable. The Abrams Creek watershed includes the area known as Happy Valley up to the ridge line of Chilhowee Mountain. This incorporates 2256.85 ha of non-park land that comprises 11.5% of the Abrams Creek watershed. Other watersheds include smaller portions of non-park land.

The watersheds of Oconaluftee River (West) and Bradley Fork may be treated as separate watersheds, or they may be combined with the small lower segment of the Oconaluftee and be regarded as a single large watershed, Oconaluftee River. The area called Oconaluftee River (Lower) is not a natural watershed and does not represent an independent unit suitable for study. It is included here to permit the option of either combining these three into a larger single watershed or retaining the two natural units for independent analysis. Both options are used in our analyses of themes in this report and will be used in subsequent reports. Similarly, the East, Middle, and West Prongs of the Little River are natural watersheds which may be combined with the portion called Little River (Lower) to form a single watershed that begins at the park boundary and encompasses all three drainages.

Methods

Hardware and Software

GRSM has a commercial GIS package known as ERDAS, which stands for Earth Resources Data Acquisition System. The system in the Science branch of the combined Resource Management and Science Division is implemented on a Dell System 310 computer with a 386 microprocessor, a 387 mathcoprocessor, and a 150 MByte hard drive. Digitizing is done on a GTCO 2436 L digitizing tablet. A comparable system at park headquarters is installed in the Resources Management branch of the division on a Compaq Deskpro 386 similarly equipped. All data discussed in this report are duplicated on the system at headquarters.

Watershed Digitizing

The watersheds were first delimited on USGS topographic maps and then digitized into separate files. For consistency, each watershed boundary was digitized clockwise. Each digitized file was plotted to scale, overlaid on the appropriate topographic maps and checked for accuracy. All watersheds have common boundaries with other watersheds. Since it was impossible to digitize a line exactly the same twice, each common boundary was digitized only once. A program was written using the ERDAS Toolkit that permitted extraction of the desired segments from a file, reversal of the segments' direction if necessary, and insertion into another file. A second program permitted rearrangement of the pieces into the correct sequence, and a third program permitted assembly of the smaller pieces of boundary into one or two large segments that represent the entire watershed boundary. Each watershed was stored in a separate file. Finally, all watersheds were combined into a single watershed file that can be used for thematic analyses. Appendix A lists the watershed boundary data files.

Stream Digitizing

All streams shown on USGS topographic maps were digitized by stream order. Streams having no tributaries are called first-order streams. When two first-order streams come together they form a second-order

stream; when two second-order streams come together they form a third-order stream; and so on. Tributaries of a lower order do not affect the numbering of a higher order stream; i.e., a first-order stream joining a second-order stream will not change the second-order stream to third-order. To achieve maximum flexibility in working with the streams, every tributary and segment of a stream between consecutive tributaries was digitized separately. The streams were plotted to scale and overlaid on the topographic maps to check for accuracy. Corrections were made whenever necessary. Stream segments were stored separately in the data files, and were entered in the files in a manner that ensured that the coordinates of each segment were arranged from the upstream end to the downstream end of the segment. Finally, the individual segments were collected together into an appropriate watershed file. Thus, for example, all streams of the Big Creek watershed were stored in a single file called BIG.DIG, and all streams of the Noland Creek watershed were stored in a file called NOLAND.DIG. These files are listed and summarized in Appendix A along with the watershed boundary files.

Slope, Elevation, and Aspect

Topographic features were derived from USGS 1:250,000-scale elevation data for the region provided by Dr. James Carter, Department of Geography, University of Tennessee. The elevation data for the park and a portion of the surrounding area were extracted from the much larger USGS data set. Slope and aspect were calculated by Dr. Carter during the extraction process and were provided as separate files along with elevation. A nearest-neighbor analysis was used to subsample the three files and convert the data to ERDAS format GIS files. While working with the elevation and aspect data several systematic errors were discovered. These errors are discussed in Appendix B.

Watershed Statistics

Each page of watershed statistics was arranged as follows. The perimeter is given in feet, miles, meters, and kilometers, and is a direct measurement of the length of the watershed boundary. The slope-

corrected area is given in square feet, square miles, acres, square meters, square kilometers, and hectares. **Shape** is a unitless measure that compares the area of the watershed with the area of a circle having the same circumference as the perimeter of the watershed. If the watershed is a perfect circle, then its **shape** would equal 1.0. The larger the difference of **shape** from 1.0, the less circular the watershed. This statistic, also known as shoreline development, is used by limnologists to describe lake morphology. **Elevation** is measured at the lowest point in the watershed, where the stream leaves the park or enters a reservoir, and at the highest peak in the watershed. The measurements were read from topographic maps and are given to the nearest contour interval (nearest 40 feet in most cases) unless a benchmark was available. Normally, the lowest elevations are accurate to the nearest contour interval, whereas the highest elevations are accurate to the nearest foot because the elevation of peaks is usually recorded on topographic maps. **Elevation** is given in both feet and meters. The **Total Length of Streams** was determined from the digitized stream files, and is given in feet, miles, meters, and kilometers. The **Drainage Density** is a measure of the length of streams in the watershed as a function of the area of the watershed. Units are given in either miles stream/mile^2 watershed or km stream/km^2 watershed. The table that follows **Drainage Density** lists the number and total lengths of stream segments by stream order. (The number of segments is equal to the total number of streams only for first-order streams.) Length is given in meters only. For Abrams Creek, Deep Creek, Oconaluftee River (Lower) and Cataloochee Creek, a final measure given was the number and area, in hectares, of **ponds** in the watersheds. These are ponds that are indicated on topographic maps. They are not visible on the watershed maps presented here because they are too small.

The two graphs at the bottom of each watershed statistics page depict the prevailing aspect and the distribution of elevation in the watershed. The aspect is shown as a polar coordinates plot (rosette), in which the number of pixels having a particular orientation is placed an appropriate distance from the center of the circle at an angle that

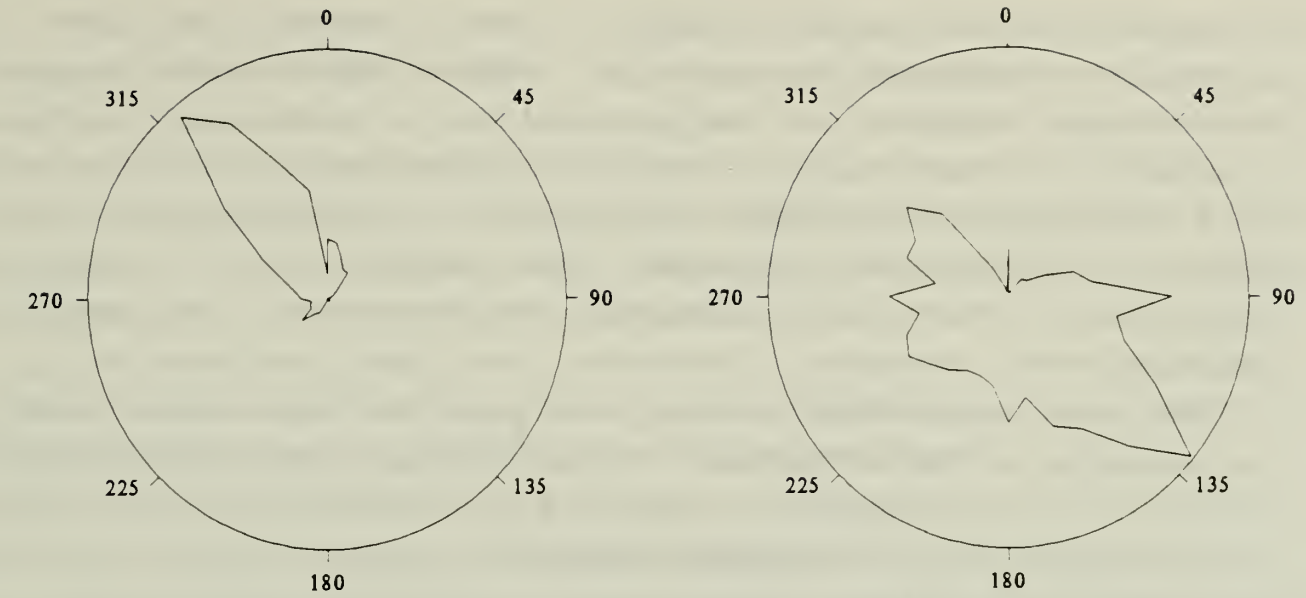


Figure 2. Polar coordinates plots of aspect in Indian Camp Creek (left) and Noland Creek (right) watersheds. Aspect is in 10° increments. Both plots are scaled to have the same radius.

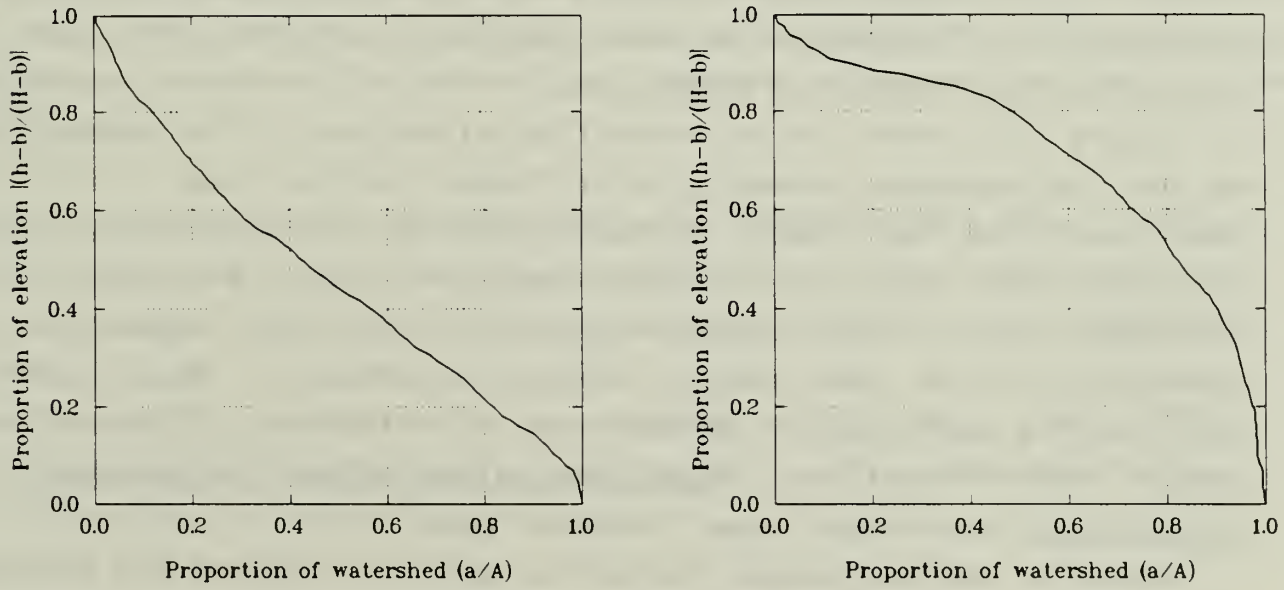


Figure 3. Hypsometric curves of elevation in Middle Prong Little River (left) and West Prong Little River (right). The x-axis of each graph is the proportion of the area of the watershed above or below a given elevation, which is expressed on the y-axis as a proportion of the total range in elevation in the watershed.

corresponds to its aspect. Figure 2 shows rosettes of aspect for watersheds of contrasting orientation. Indian Camp Creek is located in the northeast quadrant of the park and has a predominant northwest orientation. Noland Creek is located on the south side of the park and has a predominant southeast orientation. In comparing the aspect rosettes of different watersheds, the lengths of the spikes are unimportant. The only meaningful comparison is the prevailing direction.

The graph on the right side of each page is a hypsometric curve of the elevation of the watershed. In these graphs, the distribution of elevation in the watershed is depicted as a cumulative curve showing the percentage of the watershed above (or below) a given elevation. The graphs for different watersheds are directly comparable because both axes are standardized. For example, in Fig. 3 the hypsometric curves of Middle Prong Little River and West Prong Little River are plotted side-by-side at identical scales. This was accomplished by converting all elevations into altitudes above the watershed minimums and expressing these as a proportion of the highest elevation above the minimum. The x-axis represents the area of the watershed above a given elevation as a proportion of the total area of the watershed. In contrasting the Middle and West prongs of the Little River, we see from the figure that there is no prevailing elevation in the Middle Prong but that it increases steadily in altitude from the lower to the upper elevations. The West Prong, on the other hand, gains elevation rapidly from the lower end (1.0 on the x-axis) so that over 80% of the watershed (0.8 on the x-axis) is at an elevation above the mid-elevation (0.5 on the y-axis) of the watershed. This manner of depicting the distribution of elevation in watersheds is taken from R. Hammond and P. McCullagh, Quantitative Techniques in Geography: An Introduction, Clarendon Press, Oxford, 1974.

Opposite each watershed statistics page is a map of the watershed and the streams. Each watershed is depicted with north at the top of the page. Scales are not given for the separate watershed maps, but may be inferred from the whole park map on page 13.

The aspect rosettes, elevation hypsographs, and watershed maps were created using SYSTAT/SYGRAPH, a commercial statistics and graphics software package. For the aspect and elevation graphics, data were extracted from the ERDAS GIS files and written to ASCII files accessible by SYSTAT, converted into SYSTAT format and plotted using SYGRAPH. The watershed maps similarly were written in a format acceptable to SYSTAT and converted into SYGRAPH map files. The graphs and the watershed maps were converted to computer graphics metafile (CGM) format. The CGM files were read by WordPerfect 5.1. Sizing and page placement were accomplished within WordPerfect.

System Accuracy

Several sources of error place limitations on the reliability of the data presented in this report. The data were digitized from 1:24,000-scale maps. In this process, a map was taped to the digitizing tablet and the features were traced with a cursor, while a button on the cursor was periodically pressed to send coordinates to the computer. For proofing, the data were plotted on a sheet of paper and then placed over the original map for examination on a light table. Errors were corrected either by redigitizing portions of the map or by editing the data file directly. Sources of error in this process included:

1. Registering the map with the digitizing tablet. The digitizing tablet has a resolution of 0.025 mm, or over 1000 lines per inch. This far exceeds the ability of the operator to align the digitizing cursor. Therefore, when setting up each map for digitizing, we accepted a setup that came within 50 meters of the test coordinates. This represented an accuracy of better than 0.5%.

2. Tracing with the cursor. This step requires patience and attention to detail. Not only must the crosshairs of the cursor align properly with the feature being digitized, but the decision of when to press the button to send coordinates to the

computer also affected accuracy. The more curved a line, the more frequently the cursor button must be pressed to record the curves. Thus, the digitizing accuracy was highly operator-dependent. For the most part, however, errors made at this point were caught and corrected in the proofing stage.

3. In plotting a digitized file to check for accuracy, coordinates from the original topographic map must be transferred to the plotter paper, and then these points must be registered with the plotter. Both of these steps are "eyeball" operations with attendant errors. Our estimated accuracy for this step was ±1 mm for each of the 3 registration points.

4. When overlaying the plotted maps on the originals, we checked for errors of omission, excess and incompleteness, as well as registration. The first three types of errors were relatively easy to detect and correct. Missing stream segments were simply digitized and added to the file. Overshoots, in which lines cross rather than meet exactly, and undershoots, in which lines fail to meet, were corrected by editing the file. Registration errors, however, were more difficult or impossible to correct. The digitized path of a stream might follow the mapped stream path closely at first, but become more and more displaced from the mapped path as the stream progressed from one side of the map to the other. Unless displacement was greater than 1.5 mm, we did not correct for it.

5. Errors in the topographic maps. While digitizing the streams, several inconsistencies were discovered. For example, the Mt. LeConte Quadrangle shows a tributary joining Rocky Spur Branch at approximately 2760 ft elevation, immediately after passing under the Roaring Fork Motor Nature Trail. However, Rocky Spur Branch passes under the road and joins the unnamed tributary on the east side of the road. Rocky Spur Branch then flows into Roaring Fork at 2560 ft elevation. Other mapped

streams inconsistent with our knowledge of the field include LeConte Creek and Scratch Britches Creek, and Eagle Rocks Prong and Chapman Prong. A more common error is exemplified by Marks Creek. Marks Creek is shown in the lower left corner of the Gatlinburg Quadrangle at approximately 3560 ft elevation, just below Bearpen Gap. The stream flows southwest to the edge of the map, but is not shown as a stream that continues onto the adjacent Wear Cove Quadrangle. After several trips to the site and after examining aerial photographs of the area, we were able to redraw the Marks Creek area in a manner that more accurately depicts reality than that shown on the topographic maps. The plot of streams shown in the figure of Middle Prong Little River includes the corrected Marks Creek area. This type of problem occurred in several other areas as well, but normally involved a small portion of stream. Most of these discrepancies were corrected without field reconnaissance.

Of these sources of error, the last one -- errors in the topographic maps themselves -- seems the most egregious. Not all of the known discrepancies have been corrected; some of the corrections themselves may be in error; and undoubtedly other errors have not been recognized. Until updated and more accurate topographic maps become available from USGS, we feel that our digitized data of the streams in the park can be considered to be at least as reliable as the original topographic maps, and the measurements made from them represent the best available estimate of the watershed and stream characters for GRSM.

Table 1. Watershed summary statistics.

	Watershed	Area (km^2)	Shape	Elevation Low - High (meters)	Drainage Density (km/km^2)
1	Cosby Creek	27.80	1.68	500 - 1804	2.34
2	Greenbriar Creek	6.73	2.06	546 - 1804	1.88
3	Indian Camp Creek	12.31	1.81	585 - 1942	1.79
4	Dunn Creek	6.71	2.26	634 - 1797	2.26
5	Ramsey Creek	6.04	1.65	475 - 1463	1.65
6	Soak Ash Creek	6.42	1.24	427 - 1219	2.17
7	Copeland Creek	5.45	1.74	390 - 890	1.72
8	Middle Prong Little Pigeon	123.97	1.89	418 - 2018	1.40
9	Dudley Creek	12.79	1.71	451 - 1355	1.64
10	Roaring Fork	18.17	2.03	475 - 2010	1.28
11	Baskins Creek	5.12	2.60	463 - 1378	1.44
12	LeConte Creek	11.37	2.49	475 - 1998	1.38
13	West Prong Little Pigeon	90.35	2.79	402 - 2010	1.37
14	East Prong Little River	159.41	2.56	354 - 2025	1.78
15	Middle Prong Little River	75.21	1.92	354 - 1685	1.53
16	West Prong Little River	45.11	1.74	354 - 1685	1.91
17	Little River (Lower)	3.27	1.83	341 - 719	2.65
	Little River (Combined)	283.00	1.90	341 - 2025	1.74
18	White Oak Sinks	4.33	1.52	518 - 1122	1.57
19	Hesse Creek	30.36	2.34	341 - 1148	2.69
20	Cane Creek	10.79	1.92	372 - 639	1.98
21	Abrams Creek	197.72	2.38	266 - 1684	1.76
22	Panther Creek	28.97	3.15	266 - 1508	1.70
23	Shop Creek	5.81	1.53	266 - 708	1.21
24	Tabcat Creek	15.02	1.80	266 - 843	1.26
25	Parson Branch	20.59	1.49	331 - 1442	1.47
26	Twentymile Creek	41.94	1.41	389 - 1442	1.60
27	Lost Cove Creek	9.46	1.49	521 - 1341	1.85
28	Eagle Creek	59.75	1.75	521 - 1685	1.42
29	Hazel Creek	121.29	1.72	521 - 1616	1.51
30	Pilkey Creek	9.82	1.19	521 - 1463	1.45
31	Chambers Creek	13.91	1.39	521 - 1477	1.68
32	Forney Creek	75.12	1.62	521 - 2025	1.34
33	Noland Creek	56.96	1.93	521 - 2025	1.42
34	Peachtree Creek	5.60	2.16	521 - 1304	1.70
35	Deep Creek	111.60	1.72	549 - 1890	1.35
36	Cooper Creek	11.02	1.69	780 - 1573	1.41
37	Oconaluftee River (Lower)	31.84	2.06	616 - 1540	1.74
38	Oconaluftee River (West)	56.43	1.98	671 - 1895	1.64
39	Bradley Fork	56.52	1.64	671 - 1800	1.42
	Oconaluftee River (Combined)	144.79	1.80	616 - 1895	1.58
40	Raven Fork	54.50	1.63	829 - 1956	1.54
41	Straight Fork	58.11	2.21	780 - 1900	1.26
42	Stillwell Creek	8.36	1.92	853 - 1795	0.97
43	Bunches Creek	14.90	2.09	963 - 1820	1.15
44	Cataloochee Creek	161.26	1.53	707 - 1876	1.48
45	Big Creek	90.29	1.74	474 - 2018	1.66

Figure 4. GRSM watersheds. Numbers correspond to those listed on page 12.

Great Smoky Mountains National Park Streams (Parkwide Totals)

Perimeter:

Feet	960188.12	Miles	181.85
Meters	292665.34	Km	292.67

Area:

Sq Feet	23804016600.	Sq Miles	854.09	Acres	546652.87
Sq Meters	2212183300.	Sq Km	2212.21	Hectares	221224.37

Shape: 3.08

Elevation:

Lowest -	Feet	874.	Meters	266.
Highest -	Feet	6643.	Meters	2025.

Total Length of Streams:

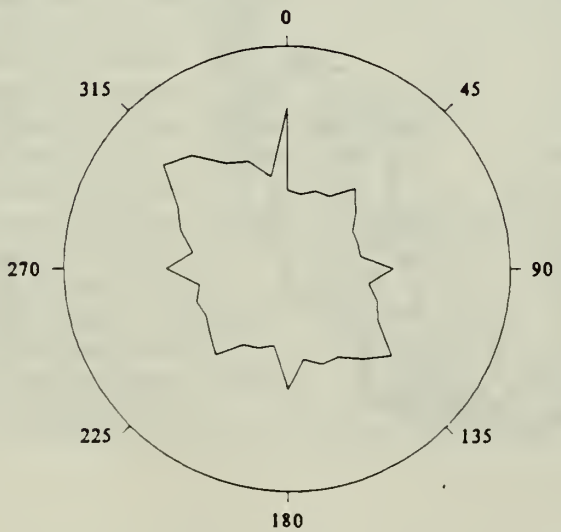
Feet	11169709.10	Miles	2115.47
Meters	3404361.20	Km	3404.36

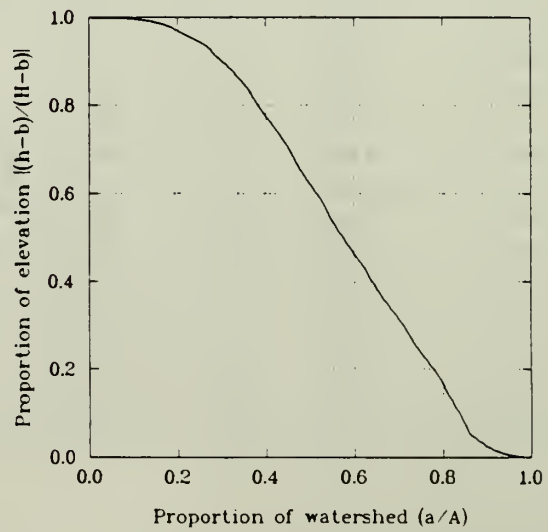
Drainage Density:

Km Stream/Km^2 Watershed 1.54 Miles Stream/Miles^2 Watershed 2.48

Stream Order	Number of Segments	Length (meters)
1	2171	2122364.56
2	1033	703517.12
3	521	313519.04
4	378	201484.98
5	98	61522.91
6	5	1952.59
	Total	3404361.20

Ponds:	5	Hectares	0.80






N

Great Smoky Mountains National Park Streams (Tennessee Side)

Perimeter:

Feet	757835.64	Miles	143.53
Meters	230988.30	Km	230.99

Area:

Sq Feet	10307628000.	Sq Miles	369.91	Acres	236694.28
Sq Meters	958446528.	Sq Km	958.10	Hectares	95816.49

Shape: 4.43

Elevation:

Lowest -	Feet	874.	Meters	266.
Highest -	Feet	6643.	Meters	2025.

Total Length of Streams:

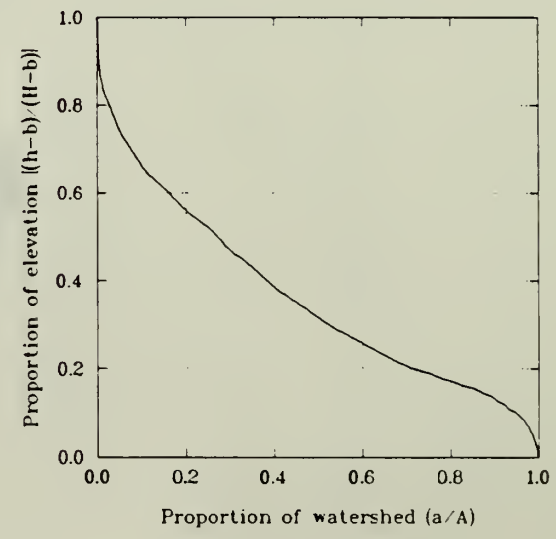
Feet	5454126.88	Miles	1032.98
Meters	1662336.75	Km	1662.34

Drainage Density:

Km Stream/Km² Watershed 1.74 Miles Stream/Miles² Watershed 2.79

Stream Order	Number of Segments	Length (meters)
1	1041	1009299.19
2	520	357744.75
3	237	152115.81
4	178	96340.40
5	71	46836.62
	Total	1662336.75

Ponds: 2 Hectares 0.44

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Great Smoky Mountains National Park Streams (North Carolina Side)

Perimeter:

Feet	841311.55	Miles	159.34
Meters	256431.76	Km	256.43

Area:

Sq Feet	12867174400.	Sq Miles	461.77	Acres	295462.53
Sq Meters	1196304640.	Sq Km	1195.92	Hectares	119604.09

Shape: 4.38

Elevation:

Lowest -	Feet	1086.	Meters	331.
Highest -	Feet	4732.	Meters	1442.

Total Length of Streams:

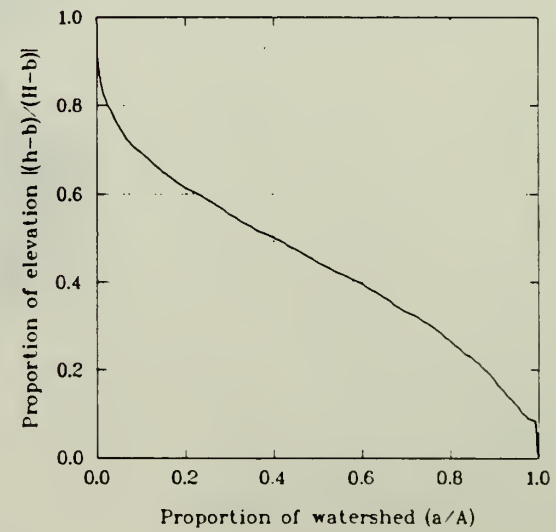
Feet	5721993.46	Miles	1083.71
Meters	1743978.50	Km	1743.98

Drainage Density:

Km Stream/Km² Watershed 1.46 Miles Stream/Miles² Watershed 2.35

Stream Order	Number of Segments	Length (meters)
1	1130	1113065.37
2	513	345772.37
3	284	161403.23
4	200	105144.58
5	27	14686.29
6	5	1952.59
	Total	3387876.75

Ponds: 3 Hectares 0.36




N

Great Smoky Mountains National Park (Streams Outside Named Watersheds)

Total Length of Streams:

Feet	1037713.20	Miles	196.56
Meters	316294.94	Km	316.29

Stream Order	Number of Segments	Length (meters)
1	316	239668.72
2	121	66195.47
3	13	5948.97
5	3	2529.21
6	5	1952.59
	Total	316294.94


N

1. Cosby Creek

Perimeter:

Feet	79495.29	Miles	15.06
Meters	24230.16	Km	24.23

Area:

Sq Feet	299107936.	Sq Miles	10.73	Acres	6868.91
Sq Meters	27797890.	Sq Km	27.80	Hectares	2779.79

Shape: 1.68

Elevation:

Lowest -	Feet	1640.	Meters	500.
Highest -	Feet	5918.	Meters	1804.

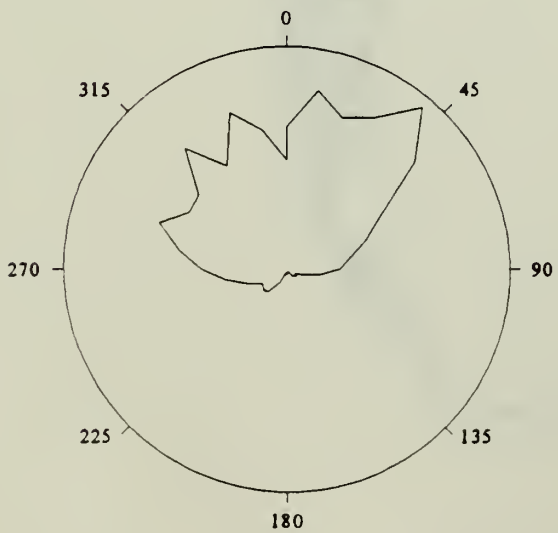
Total Length of Streams:

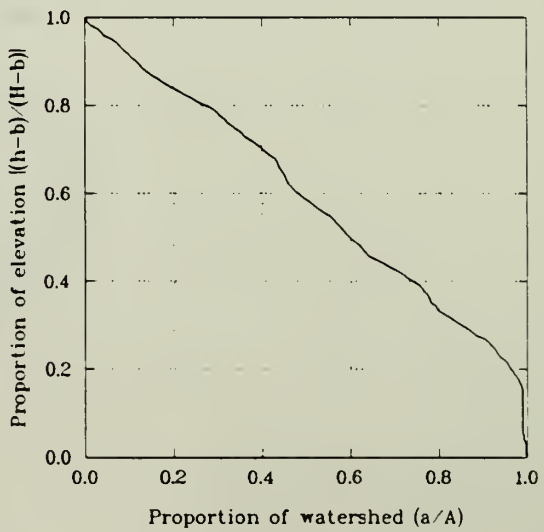
Feet	213664.51	Miles	40.47
Meters	65124.93	Km	65.12

Drainage Density:

Km Stream/Sq Km Watershed 2.34 Miles Stream/Sq Miles Watershed 3.77

Stream Order	Number of Segments	Length (meters)
1	41	38368.91
2	19	15832.16
3	15	8162.37
4	4	2761.51
	Total	65124.93





Watershed 1. Cosby Creek.

2. Greenbriar Creek

Perimeter:

Feet	43342.92	Miles	8.21
Meters	13210.92	Km	13.21

Area:

Sq Feet	72363176.	Sq Miles	2.60	Acres	1661.80
Sq Meters	6725195.	Sq Km	6.73	Hectares	672.52

Shape: 2.06

Elevation:

Lowest -	Feet	1790.	Meters	546.
Highest -	Feet	5918.	Meters	1804.

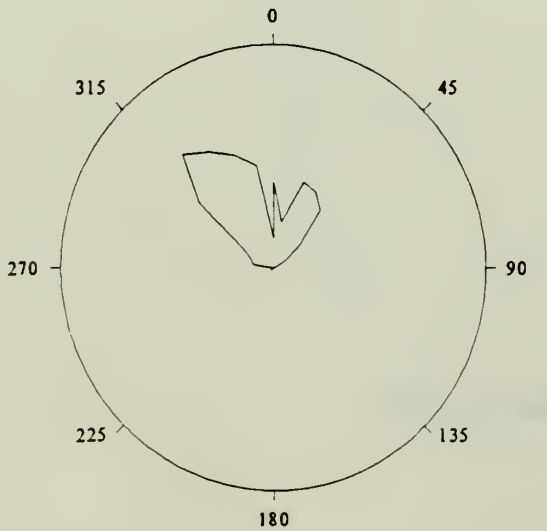
Total Length of Streams:

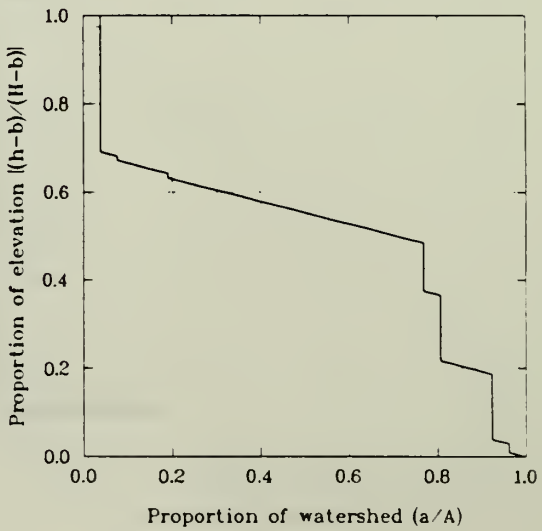
Feet	41485.18	Miles	7.86
Meters	12644.68	Km	12.64

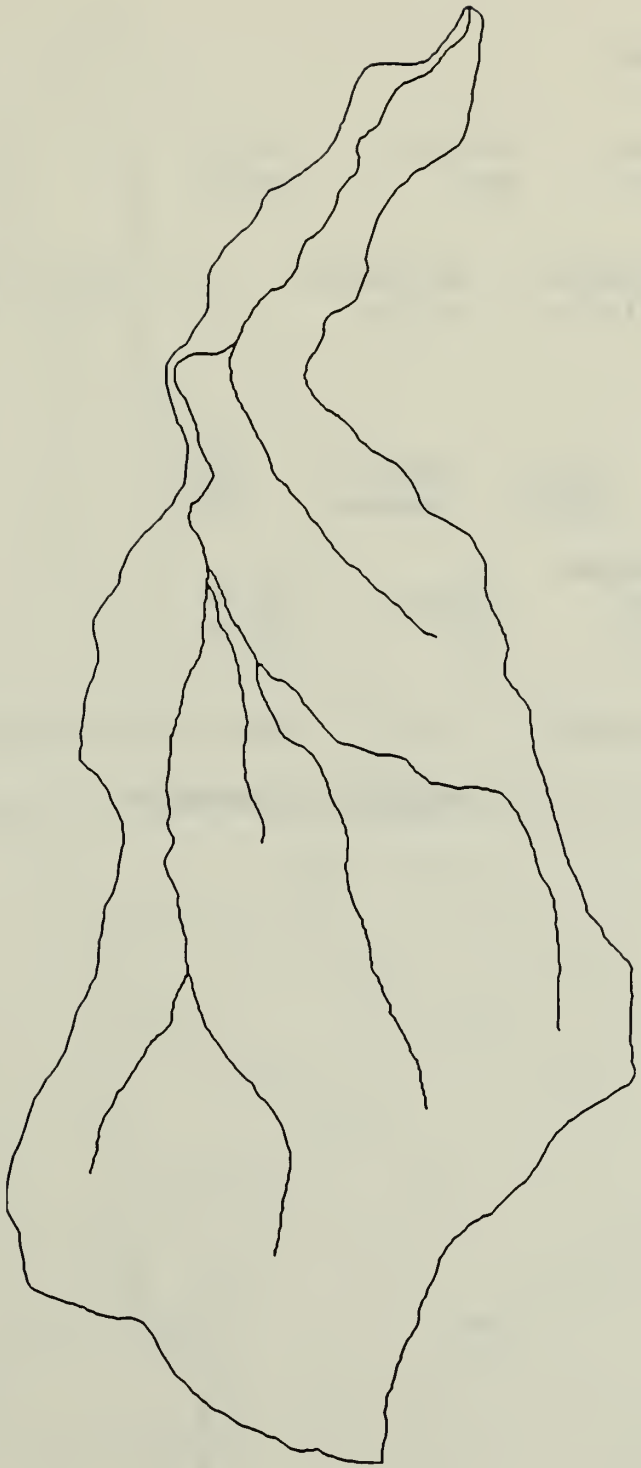
Drainage Density:

Km Stream/Sq Km Watershed 1.88 Miles Stream/Sq Miles Watershed 3.02

Stream Order	Number of Segments	Length (meters)
1	6	8083.78
2	3	1952.17
3	2	2608.73
	Total	12644.68







Watershed 2. Greenbriar Creek.

3. Indian Camp Creek

Perimeter:

Feet	54949.89	Miles	10.41
Meters	16748.73	Km	16.75

Area:

Sq Feet	132466488.	Sq Miles	4.75	Acres	3042.04
Sq Meters	12311024.	Sq Km	12.31	Hectares	1231.10

Shape: 1.81

Elevation:

Lowest -	Feet	1920.	Meters	585.
Highest -	Feet	6370.	Meters	1942.

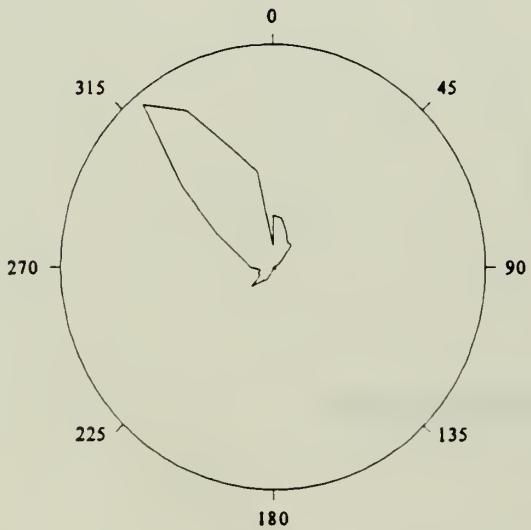
Total Length of Streams:

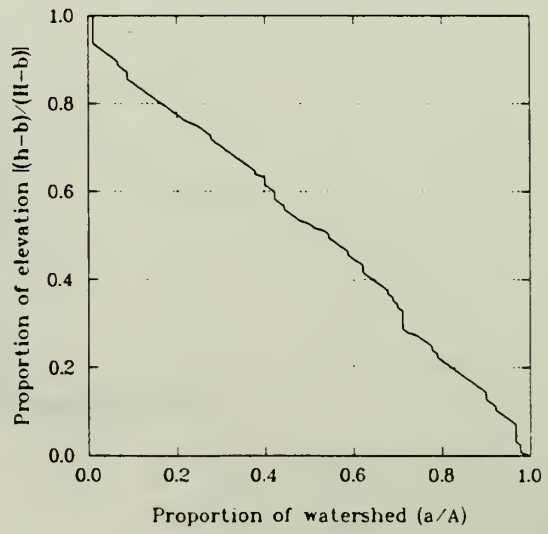
Feet	72166.84	Miles	13.67
Meters	21996.45	Km	22.00

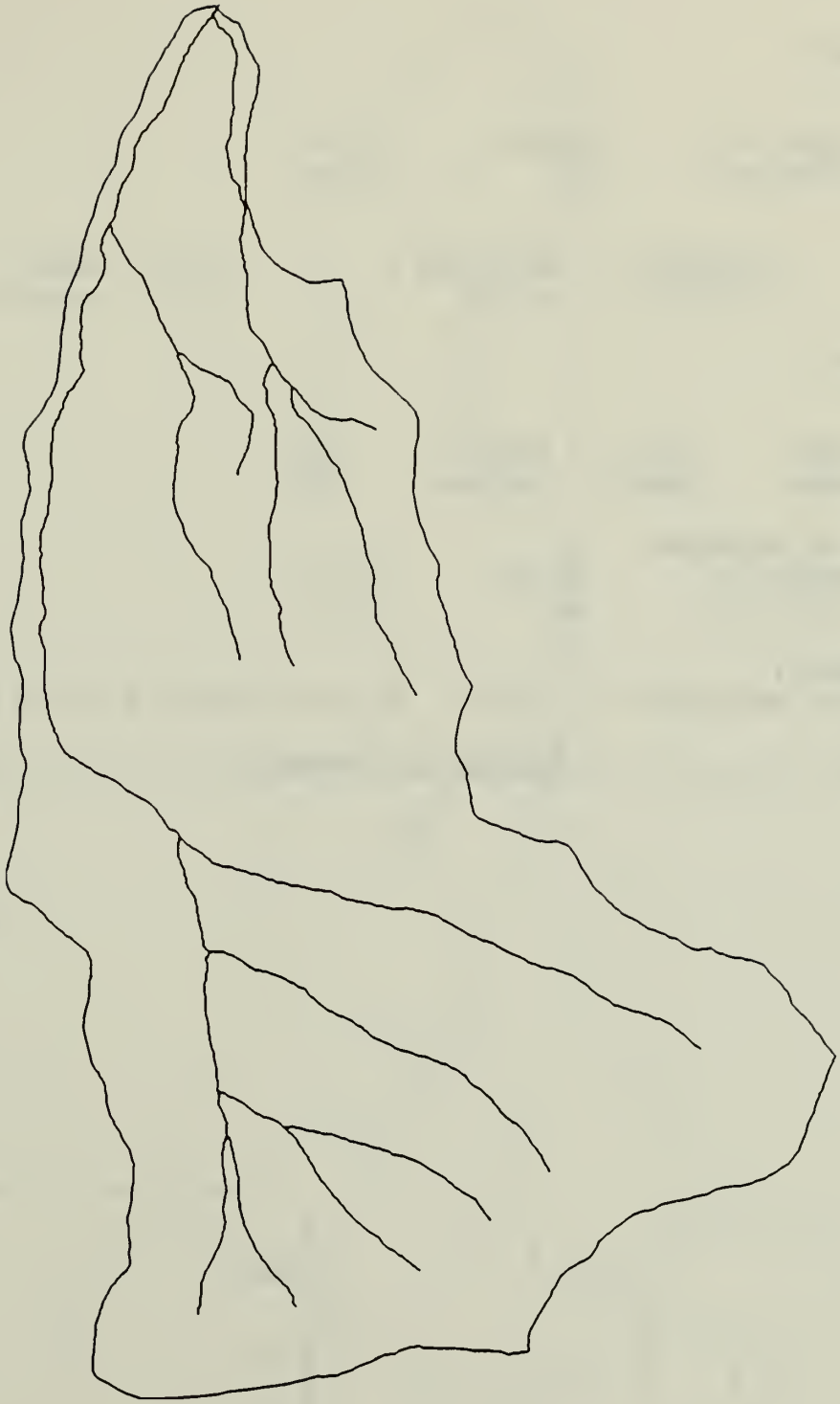
Drainage Density:

Km Stream/Sq Km Watershed 1.79 Miles Stream/Sq Miles Watershed 2.88

Stream Order	Number of Segments	Length (meters)
1	11	13521.19
2	5	3003.46
3	5	5471.81
	Total	21996.45







Watershed 3. Indian Camp Creek.

4. Dunn Creek

Perimeter:

Feet	45326.49	Miles	8.58
Meters	13815.51	Km	13.82

Area:

Sq Feet	72249560.	Sq Miles	2.59	Acres	1659.19
Sq Meters	6714637.	Sq Km	6.71	Hectares	671.46

Shape: 2.26

Elevation:

Lowest -	Feet	2080.	Meters	634.
Highest -	Feet	5895.	Meters	1797.

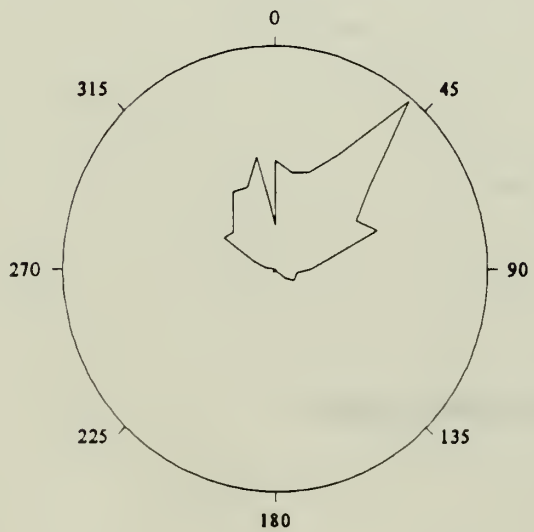
Total Length of Streams:

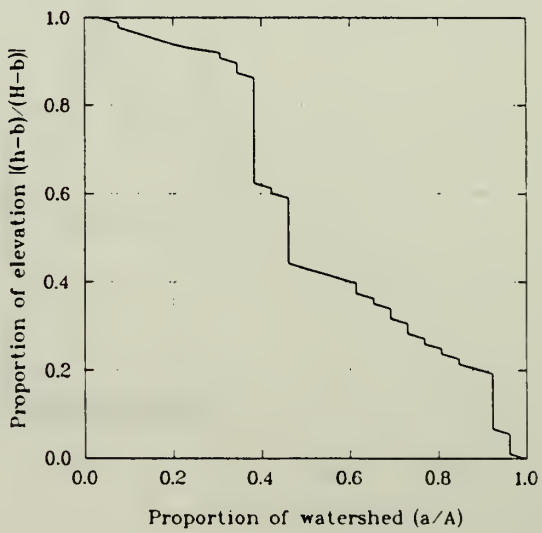
Feet	49799.32	Miles	9.43
Meters	15178.83	Km	15.18

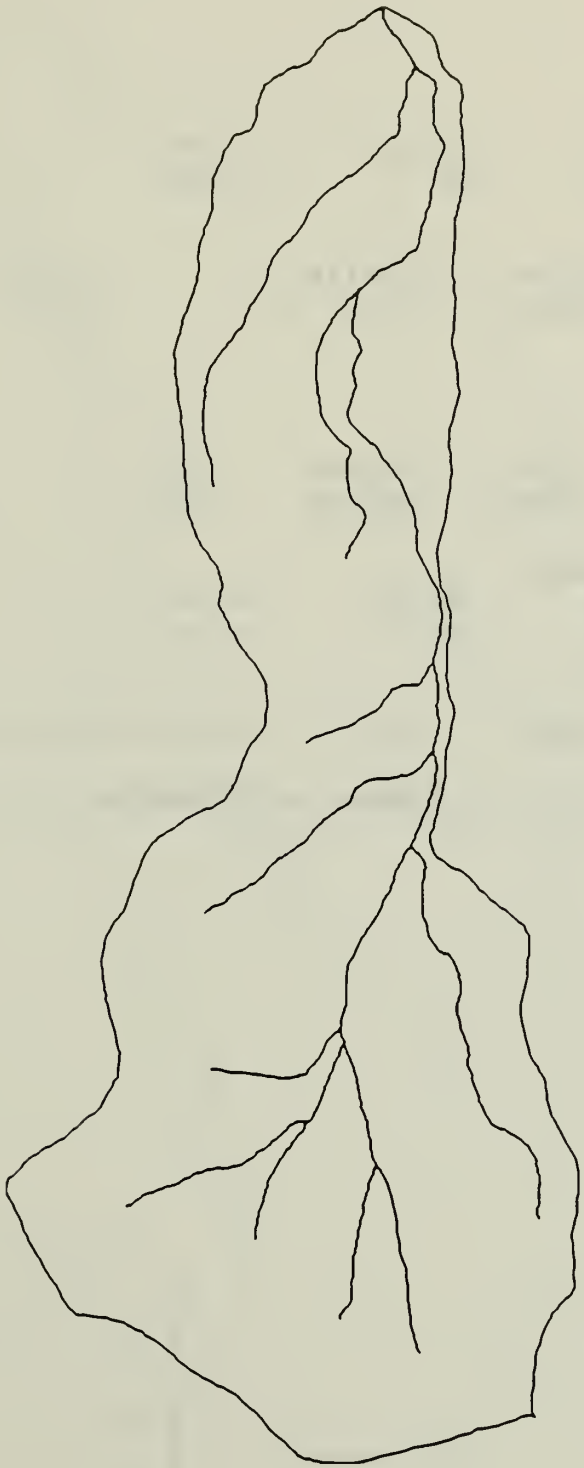
Drainage Density:

Km Stream/Sq Km Watershed 2.26 Miles Stream/Sq Miles Watershed 3.64

Stream Order	Number of Segments	Length (meters)
1	10	9810.55
2	2	838.15
3	7	4530.13
	Total	15178.83







Watershed 4. Dunn Creek.

5. Ramsey Creek

Perimeter:

Feet	36693.25	Miles	6.95
Meters	11184.10	Km	11.18

Area:

Sq Feet	64971116.	Sq Miles	2.33	Acres	1492.04
Sq Meters	6038203.	Sq Km	6.04	Hectares	603.82

Shape: 1.65

Elevation:

Lowest -	Feet	1560.	Meters	475.
Highest -	Feet	4800.	Meters	1463.

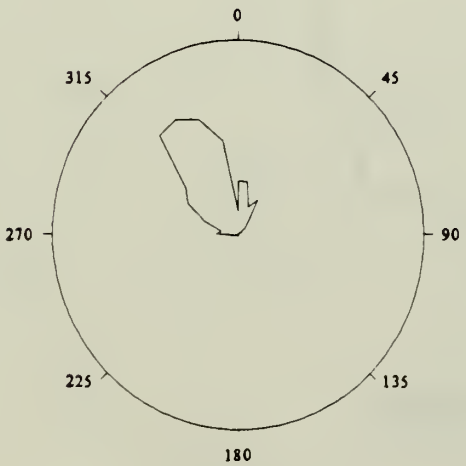
Total Length of Streams:

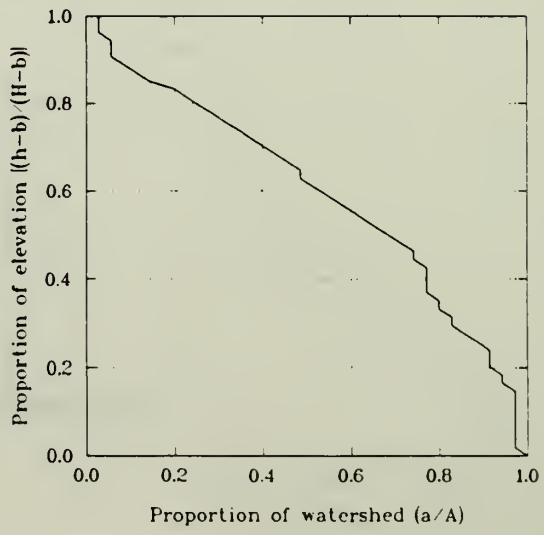
Feet	32746.33	Miles	6.20
Meters	9981.08	Km	9.98

Drainage Density:

Km Stream/Sq Km Watershed 1.65 Miles Stream/Sq Miles Watershed 2.66

Stream Order	Number of Segments	Length (meters)
1	5	5152.95
2	3	4568.13
3	1	260.00
	Total	9981.08





Watershed 5. Ramsey Creek.

6. Soak Ash Creek

Perimeter:

Feet	32852.98	Miles	6.22
Meters	10013.59	Km	10.01

Area:

Sq Feet	69130680.	Sq Miles	2.48	Acres	1587.57
Sq Meters	6424775.	Sq Km	6.42	Hectares	642.48

Shape: 1.24

Elevation:

Lowest -	Feet	1400.	Meters	427.
Highest -	Feet	4000.	Meters	1219.

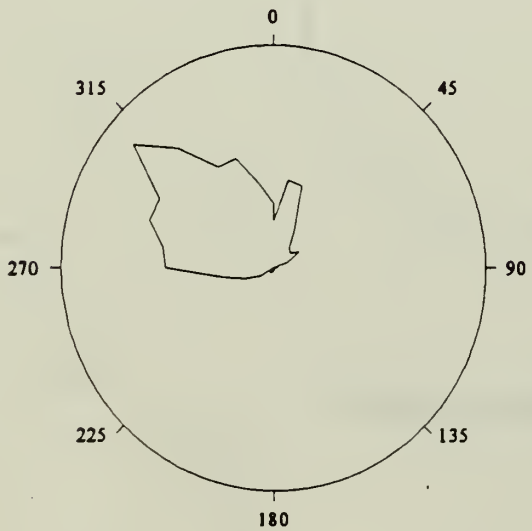
Total Length of Streams:

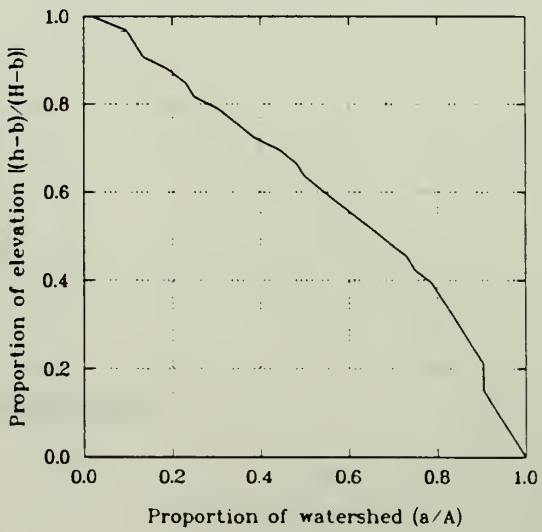
Feet	45787.02	Miles	8.68
Meters	13955.88	Km	13.96

Drainage Density:

Km Stream/Sq Km Watershed 2.17 Miles Stream/Sq Miles Watershed 3.50

Stream Order	Number of Segments	Length (meters)
1	11	8821.52
2	7	4629.53
3	3	504.83
	Total	13955.88





Watershed 6. Soak Ash Creek.

7. Copeland Creek

Perimeter:

Feet	35867.18	Miles	6.79
Meters	10932.32	Km	10.93

Area:

Sq Feet	58694456.	Sq Miles	2.11	Acres	1347.90
Sq Meters	5454868.	Sq Km	5.45	Hectares	545.49

Shape: 1.74

Elevation:

Lowest -	Feet	1280.	Meters	390.
Highest -	Feet	2920.	Meters	890.

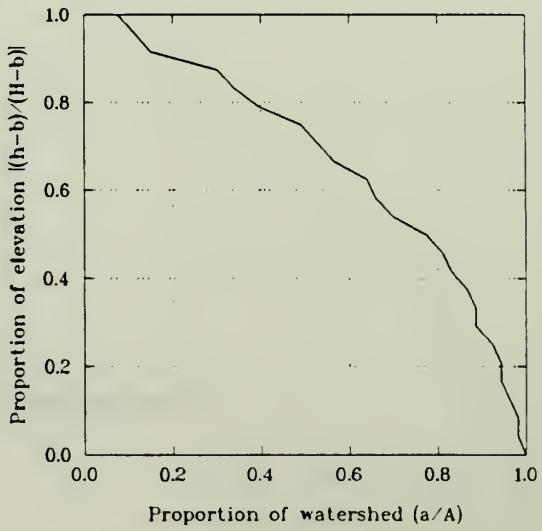
Total Length of Streams:

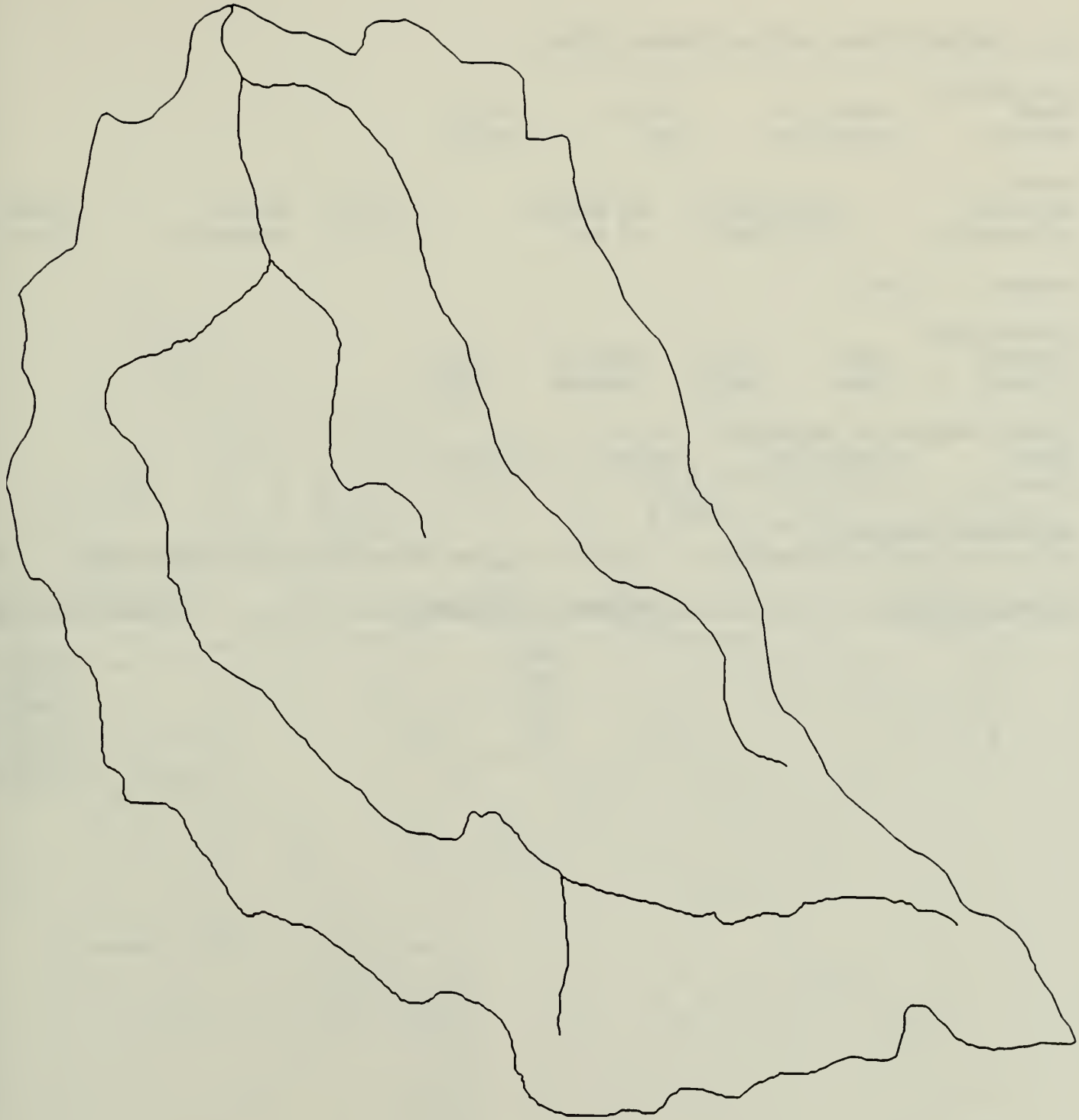
Feet	30738.82	Miles	5.82
Meters	9369.19	Km	9.37

Drainage Density:

Km Stream/Sq Km Watershed 1.72 Miles Stream/Sq Miles Watershed 2.76

Stream Order	Number of Segments	Length (meters)
1	4	5689.17
2	3	3680.03
	Total	9369.19





Watershed 7. Copeland Creek.

8. Middle Prong Little Pigeon River

Perimeter:

Feet	178052.94	Miles	33.72
Meters	54270.54	Km	54.27

Area:

Sq Feet	1334015490.	Sq Miles	47.87	Acres	30636.59
Sq Meters	123975000.	Sq Km	123.97	Hectares	12397.86

Shape: 1.89

Elevation:

Lowest -	Feet	1370.	Meters	418.
Highest -	Feet	6621.	Meters	2018.

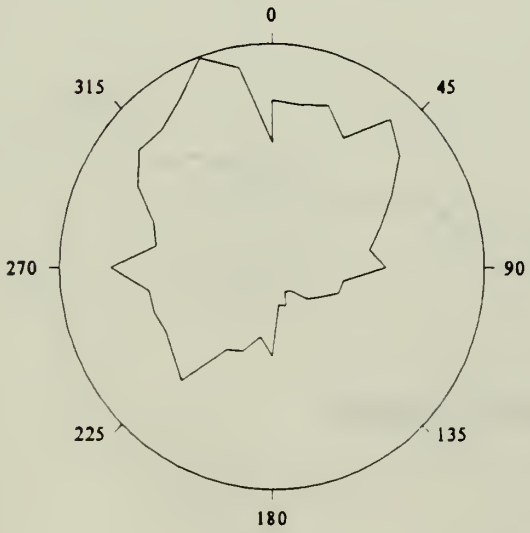
Total Length of Streams:

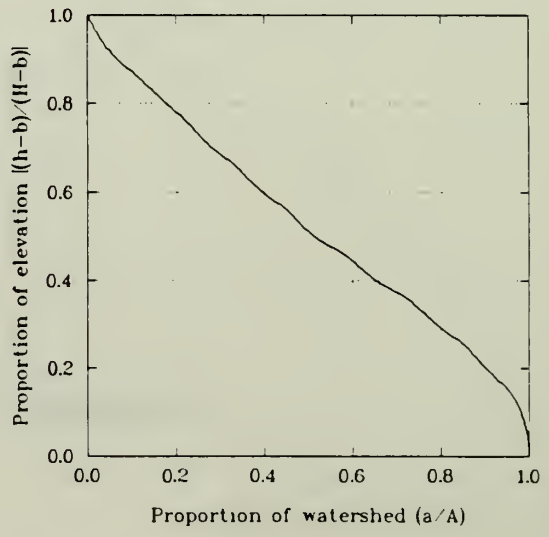
Feet	569891.02	Miles	107.95
Meters	173702.75	Km	173.70

Drainage Density:

Km Stream/Sq Km Watershed 1.40 Miles Stream/Sq Miles Watershed 2.26

Stream Order	Number of Segments	Length (meters)
1	96	99483.25
2	52	43952.68
3	22	13859.93
4	16	10921.84
5	11	5485.08
	Total	173702.75





Watershed 8. Middle Prong Little Pigeon River.

9. Dudley Creek

Perimeter:

Feet	54328.62	Miles	10.29
Meters	16559.36	Km	16.56

Area:

Sq Feet	137667696.	Sq Miles	4.94	Acres	3161.50
Sq Meters	12794413.	Sq Km	12.79	Hectares	1279.44

Shape: 1.71

Elevation:

Lowest -	Feet	1480.	Meters	451.
Highest -	Feet	4445.	Meters	1355.

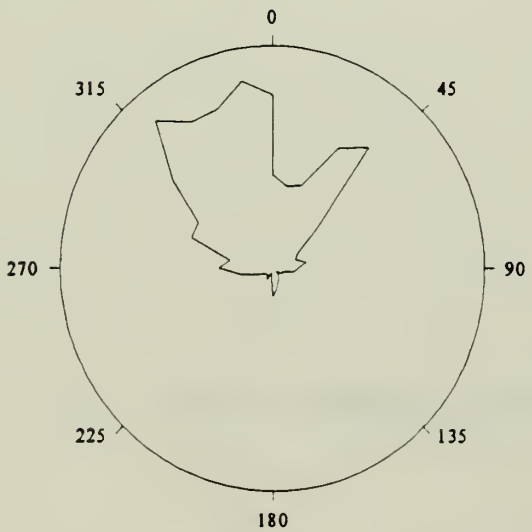
Total Length of Streams:

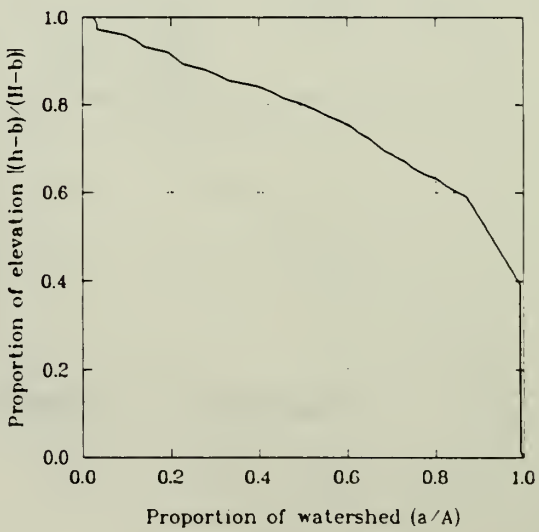
Feet	68756.11	Miles	13.03
Meters	20956.86	Km	20.96

Drainage Density:

Km Stream/Sq Km Watershed 1.64 Miles Stream/Sq Miles Watershed 2.64

Stream Order	Number of Segments	Length (meters)
1	11	11649.75
2	3	5401.33
3	6	3905.78
	Total	20956.86





Watershed 9. Dudley Creek.

10. Roaring Fork

Perimeter:

Feet	70721.14	Miles	13.39
Meters	21555.80	Km	21.56

Area:

Sq Feet	195522160.	Sq Miles	7.02	Acres	4490.11
Sq Meters	18171208.	Sq Km	18.17	Hectares	1817.12

Shape: 2.03

Elevation:

Lowest -	Feet	1560.	Meters	475.
Highest -	Feet	6593.	Meters	2010.

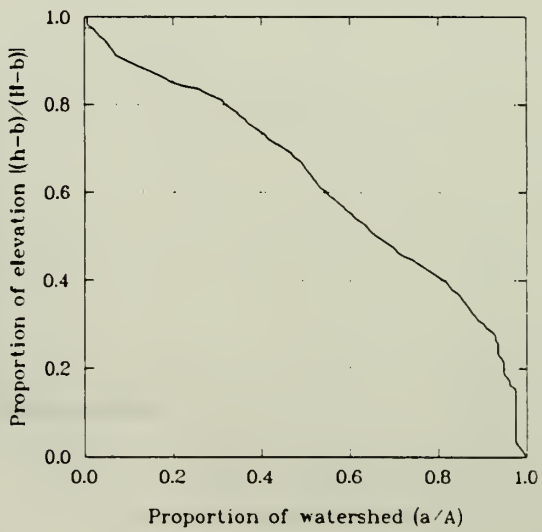
Total Length of Streams:

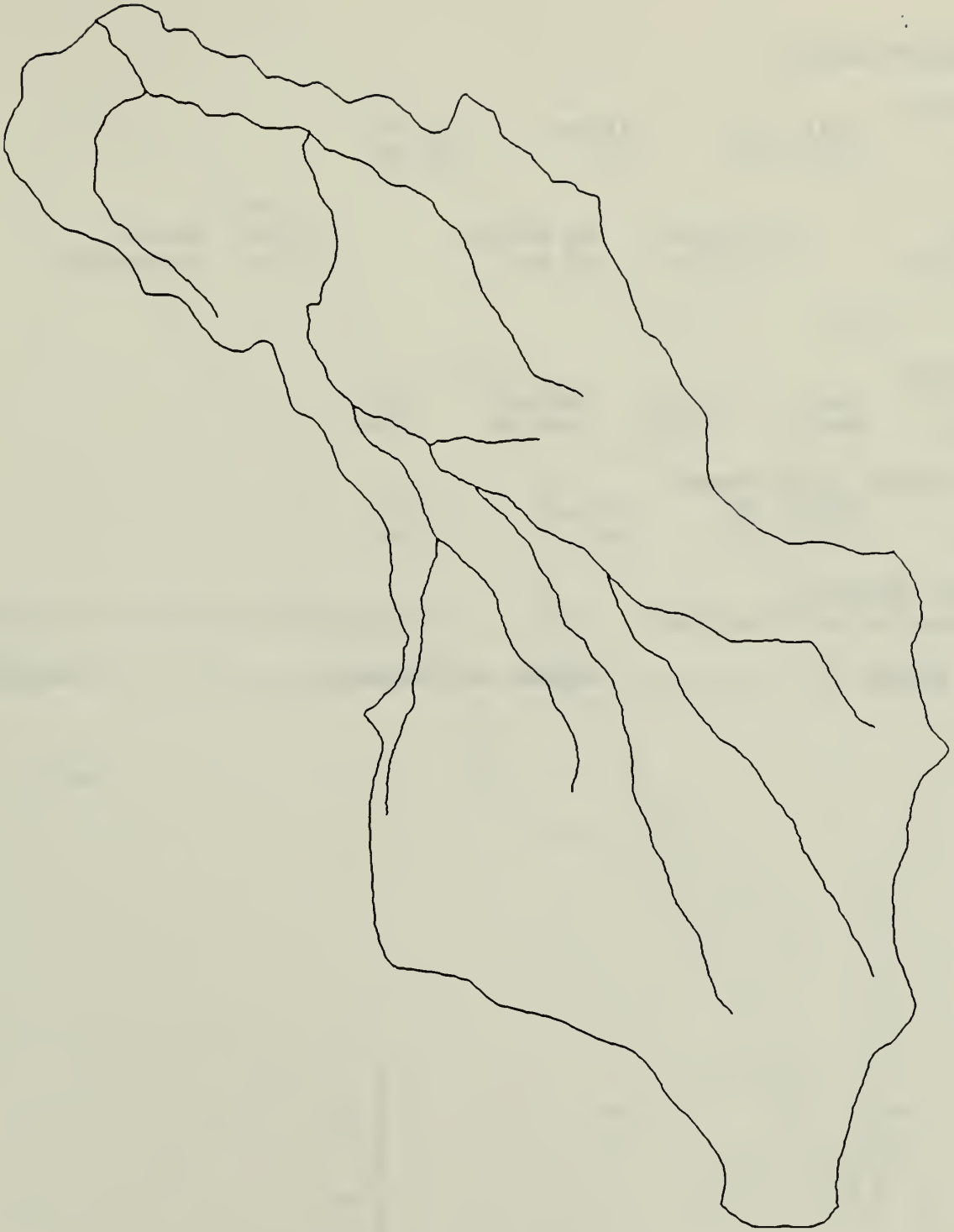
Feet	76183.90	Miles	14.43
Meters	23220.85	Km	23.22

Drainage Density:

Km Stream/Sq Km Watershed 1.28 Miles Stream/Sq Miles Watershed 2.06

Stream Order	Number of Segments	Length (meters)
1	8	16894.36
2	4	2871.00
3	3	3455.49
	Total	23220.85





Watershed 10. Roaring Creek.

11. Baskins Creek

Perimeter:

Feet	42447.10	Miles	8.04
Meters	12937.88	Km	12.94

Area:

Sq Feet	55113224.	Sq Miles	1.98	Acres	1265.66
Sq Meters	5122040.	Sq Km	5.12	Hectares	512.20

Shape: 2.60

Elevation:

Lowest -	Feet	1520.	Meters	463.
Highest -	Feet	4520.	Meters	1378.

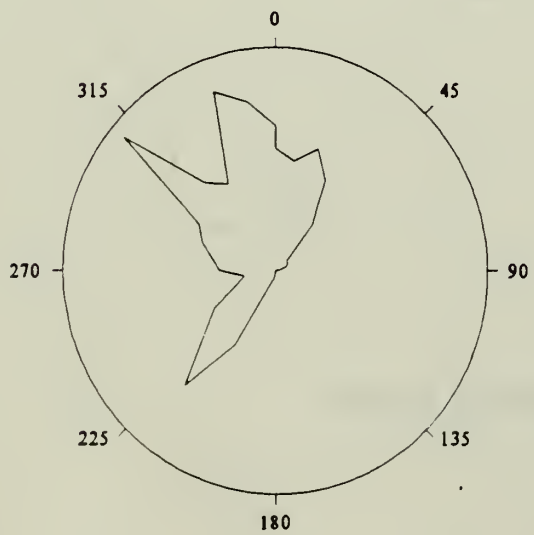
Total Length of Streams:

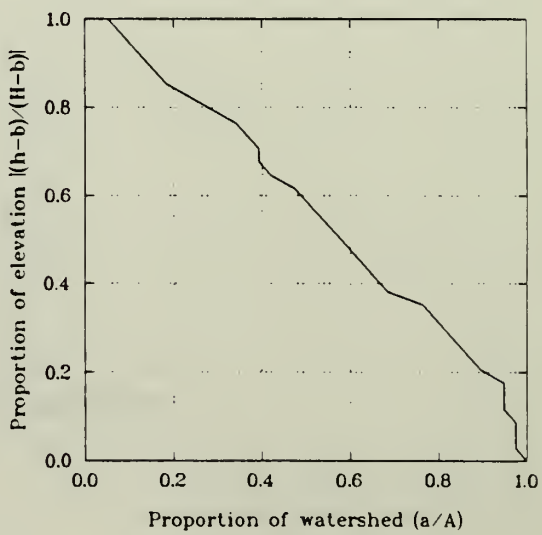
Feet	24270.18	Miles	4.60
Meters	7397.55	Km	7.40

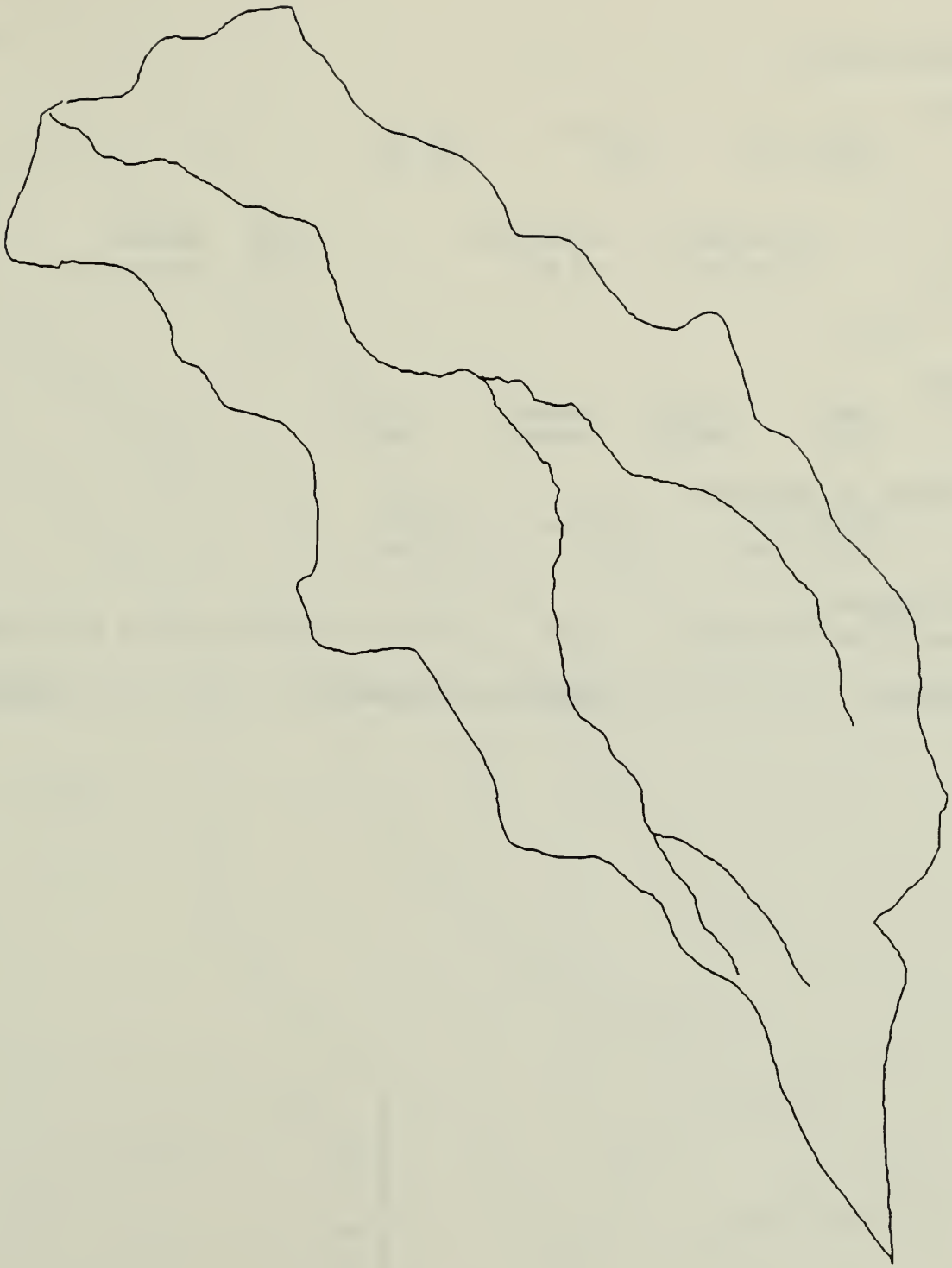
Drainage Density:

Km Stream/Sq Km Watershed 1.44 Miles Stream/Sq Miles Watershed 2.32

Stream Order	Number of Segments	Length (meters)
1	3	3449.63
2	2	3947.92
	Total	7397.55







Watershed 11. Baskins Creek.

12. LeConte Creek

Perimeter:

Feet	61890.76	Miles	11.72
Meters	18864.30	Km	18.86

Area:

Sq Feet	122302976.	Sq Miles	4.39	Acres	2808.65
Sq Meters	11366441.	Sq Km	11.37	Hectares	1136.64

Shape: 2.49

Elevation:

Lowest -	Feet	1560.	Meters	475
Highest -	Feet	6555.	Meters	1998.

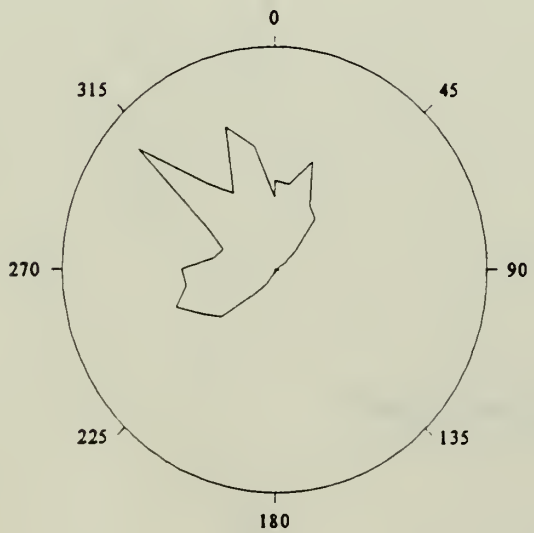
Total Length of Streams:

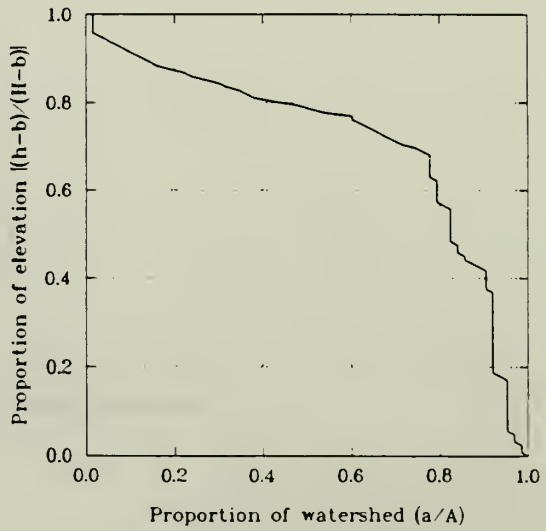
Feet	51339.22	Miles	9.73
Meters	15648.19	Km	15.65

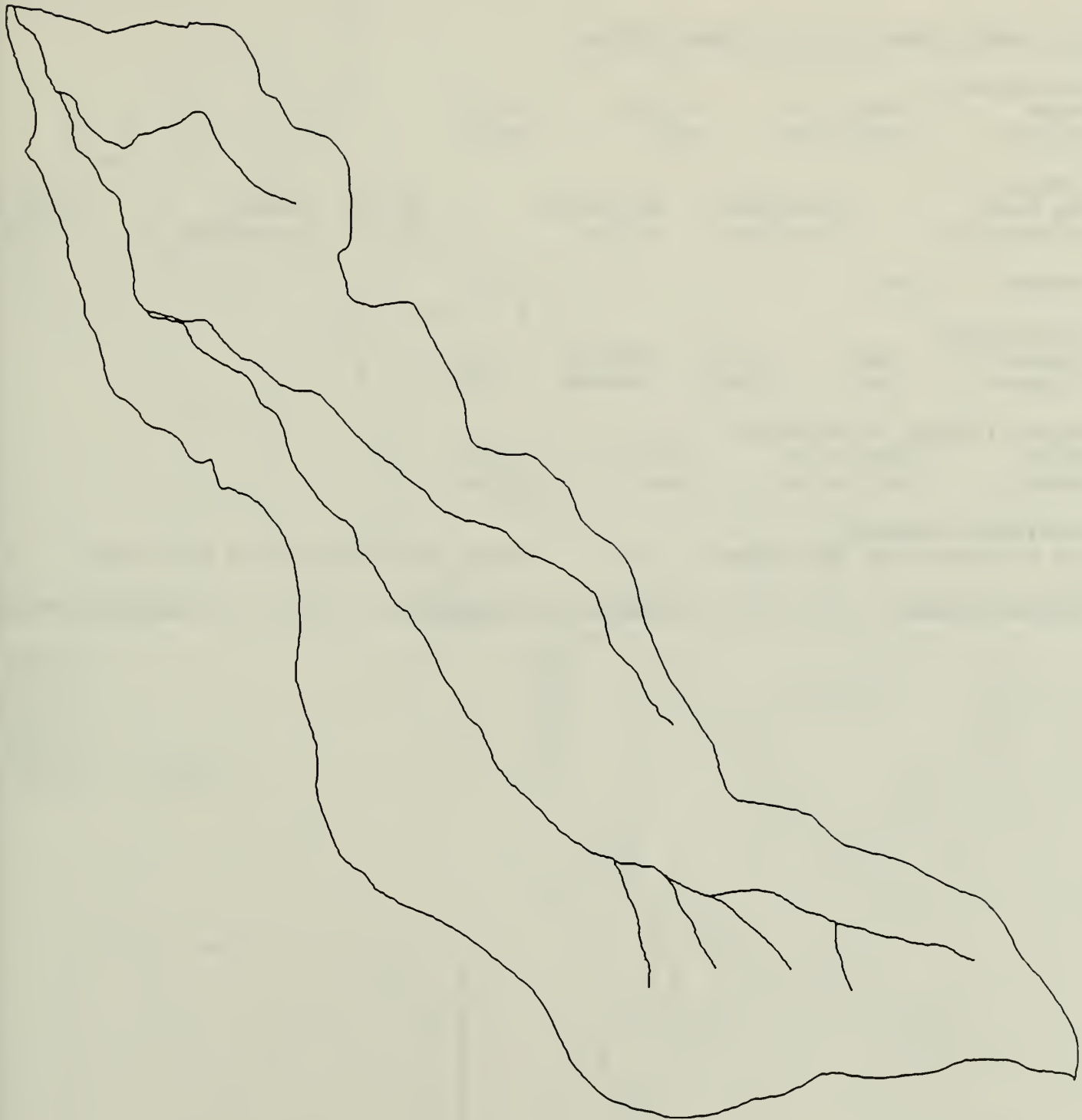
Drainage Density:

Km Stream/Sq Km Watershed 1.38 Miles Stream/Sq Miles Watershed 2.22

Stream Order	Number of Segments	Length (meters)
1	7	8514.06
2	6	7134.14
	Total	15648.19







Watershed 12. LeConte Creek.

13. West Prong Little Pigeon River

Perimeter:

Feet	184621.08	Miles	34.97
Meters	56272.50	Km	56.27

Area:

Sq Feet	972167616.	Sq Miles	34.88	Acres	22325.95
Sq Meters	90347616.	Sq Km	90.35	Hectares	9034.92

Shape: 2.79

Elevation:

Lowest -	Feet	1320.	Meters	402.
Highest -	Feet	6593.	Meters	2010.

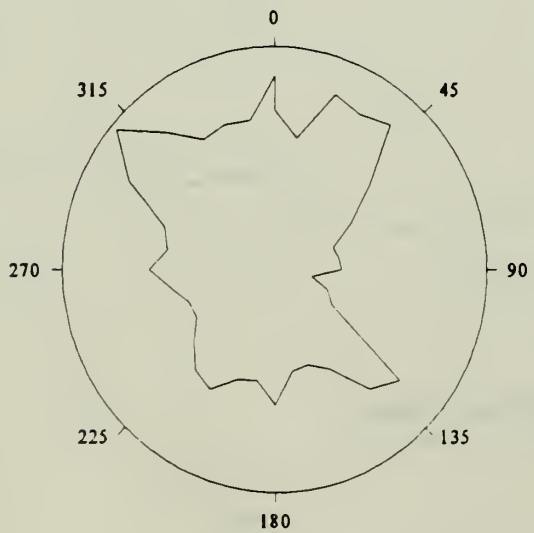
Total Length of Streams:

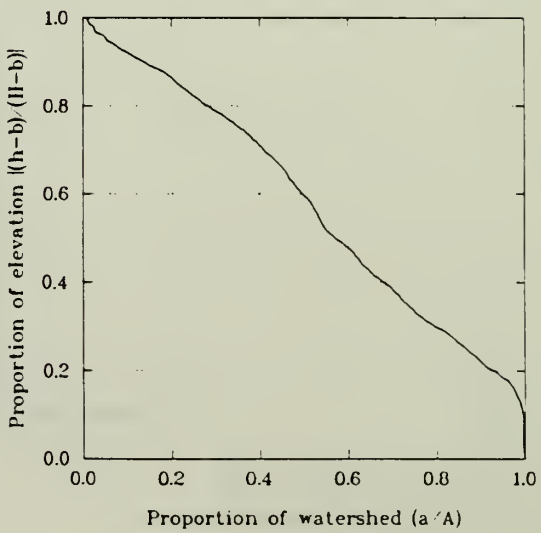
Feet	407338.07	Miles	77.16
Meters	124156.62	Km	124.16

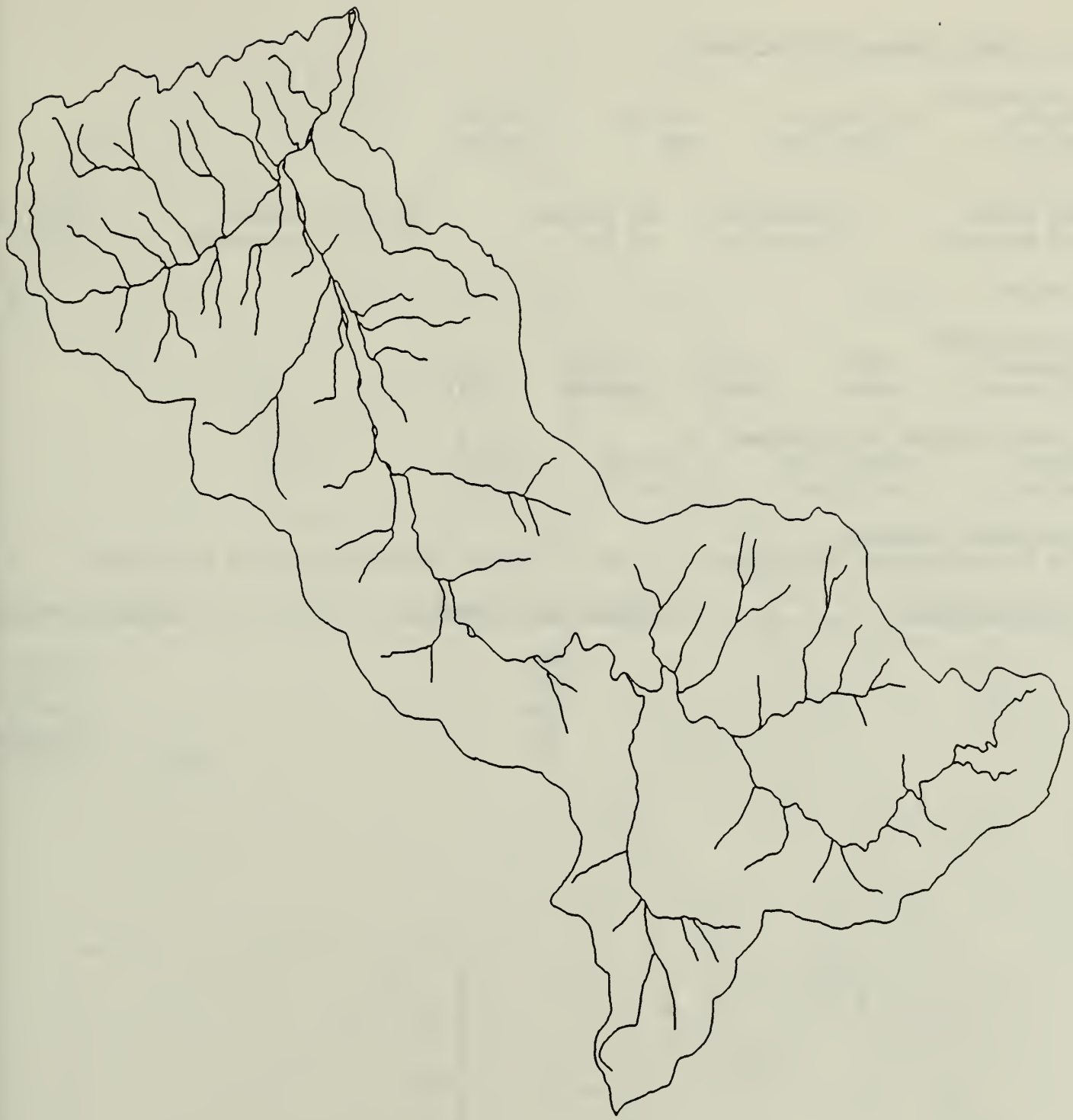
Drainage Density:

Km Stream/Sq Km Watershed 1.37 Miles Stream/Sq Miles Watershed 2.21

Stream Order	Number of Segments	Length (meters)
1	72	74286.02
2	37	23134.96
3	12	9349.38
4	38	14359.67
5	9	3026.63
	Total	124156.62







Watershed 13. West Prong Little Pigeon River.

14. East Prong Little River

Perimeter:

Feet	235149.40	Miles	44.54
Meters	71673.54	Km	71.67

Area:

Sq Feet	1715268610.	Sq Miles	61.55	Acres	39391.46
Sq Meters	159402544.	Sq Km	159.41	Hectares	15941.04

Shape: 2.56

Elevation:

Lowest -	Feet	1160.	Meters	354.
Highest -	Feet	6643.	Meters	2025.

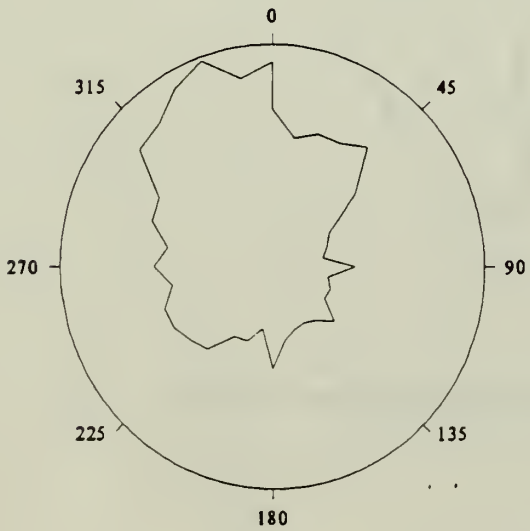
Total Length of Streams:

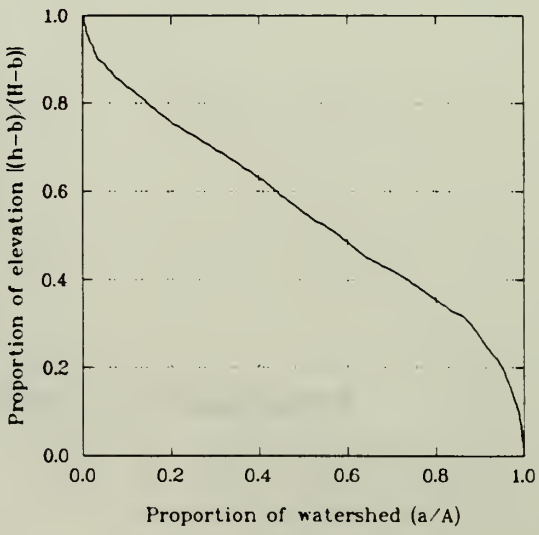
Feet	929361.06	Miles	176.02
Meters	283255.43	Km	283.26

Drainage Density:

Km Stream/Sq Km Watershed 1.78 Miles Stream/Sq Miles Watershed 2.86

Stream Order	Number of Segments	Length (meters)
1	174	178001.73
2	90	51409.57
3	26	16953.57
4	68	36890.56
	Total	283255.43





Watershed 14. East Prong Little River.

15. Middle Prong Little River

Perimeter:

Feet	139981.90	Miles	26.51
Meters	42666.48	Km	42.67

Area:

Sq Feet	809290176.	Sq Miles	29.04	Acres	18584.95
Sq Meters	75209968.	Sq Km	75.21	Hectares	7521.14

Shape: 2.02

Elevation:

Lowest -	Feet	1160.	Meters	354.
Highest -	Feet	5527.	Meters	1685.

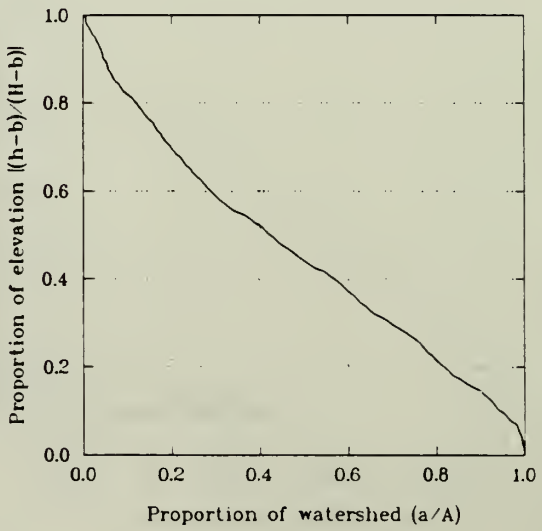
Total Length of Streams:

Feet	378442.52	Miles	71.69
Meters	115349.26	Km	115.35

Drainage Density:

Km Stream/Sq Km Watershed 1.61 Miles Stream/Sq Miles Watershed 2.59

Stream Order	Number of Segments	Length (meters)
1	75	69403.23
2	34	22075.23
3	23	12905.40
4	3	2331.70
5	14	8633.64
	Total	115349.26



Watershed 15. Middle Prong Little River.

16. West Prong Little River

Perimeter:

Feet	103085.97	Miles	19.52
Meters	31420.60	Km	31.42

Area:

Sq Feet	485440928.	Sq Miles	17.42	Acres	11147.98
Sq Meters	45115008.	Sq Km	45.11	Hectares	4511.55

Shape: 1.74

Elevation:

Lowest -	Feet	1160.	Meters	354.
Highest -	Feet	5527.	Meters	1685.

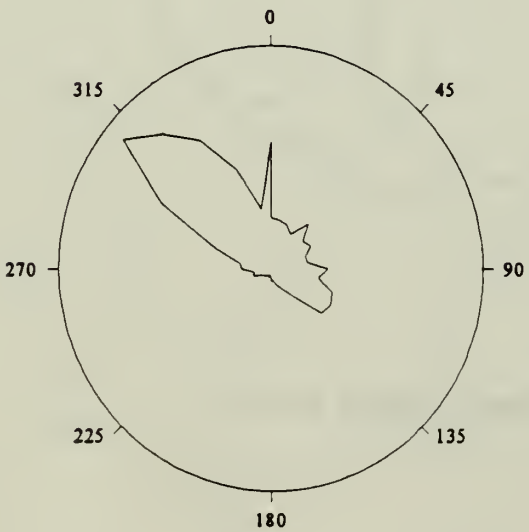
Total Length of Streams:

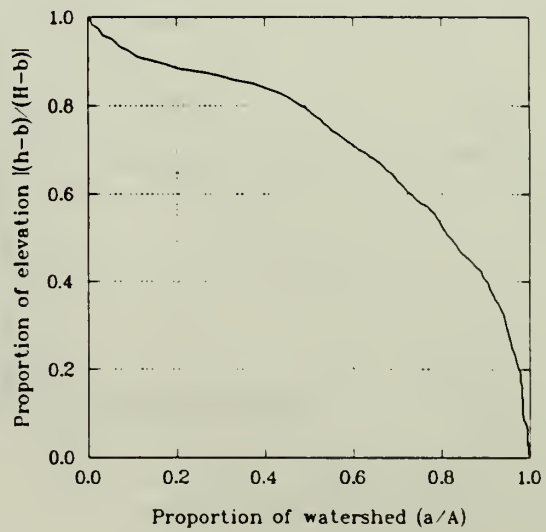
Feet	282989.39	Miles	53.60
Meters	86250.96	Km	86.25

Drainage Density:

Km Stream/Sq Km Watershed 1.91 Miles Stream/Sq Miles Watershed 3.08

Stream Order	Number of Segments	Length (meters)
1	58	51873.44
2	30	15411.16
3	23	15965.00
4	3	3001.36
	Total	86250.96





Watershed 16. West Prong Little River.

17. Little River (Lower)

Perimeter:

Feet	28481.90	Miles	5.39
Meters	8681.28	Km	8.68

Area:

Sq Feet	35149048.	Sq Miles	1.26	Acres	807.19
Sq Meters	3266640.	Sq Km	3.27	Hectares	326.66

Shape: 1.83

Elevation:

Lowest -	Feet	1120.	Meters	341.
Highest -	Feet	2360.	Meters	719.

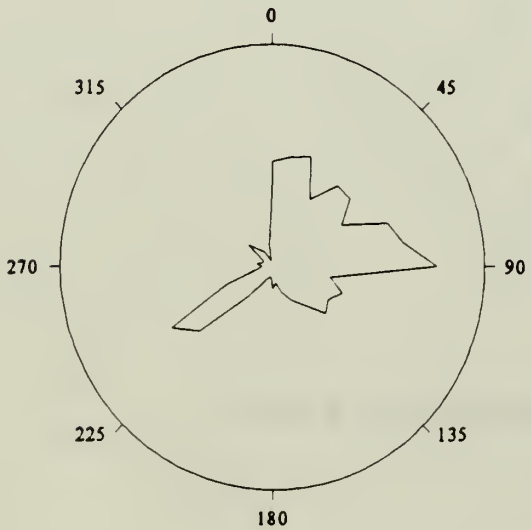
Total Length of Streams:

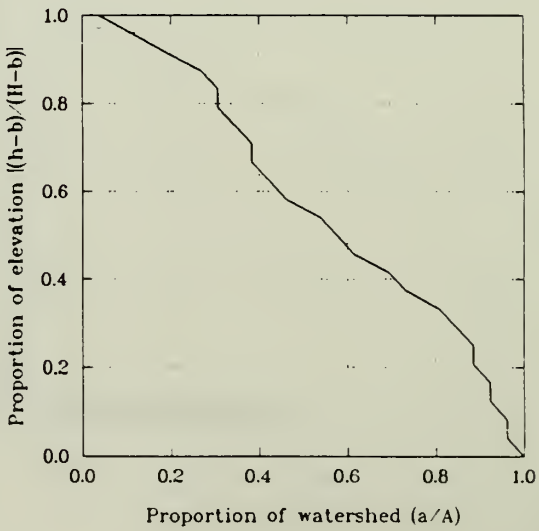
Feet	28441.11	Miles	5.39
Meters	8668.85	Km	8.67

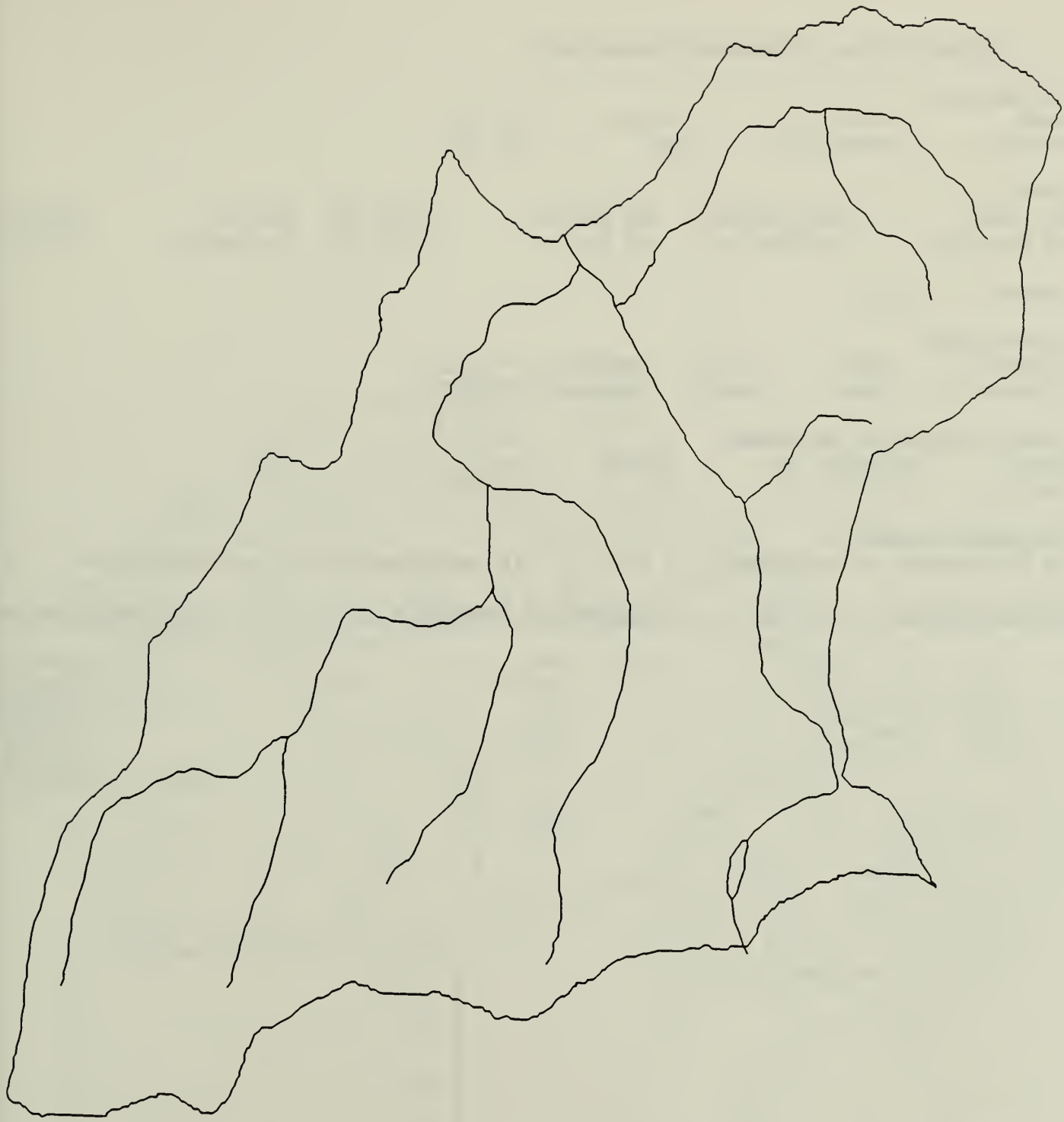
Drainage Density:

Km Stream/Sq Km Watershed 2.65 Miles Stream/Sq Miles Watershed 4.28

Stream Order	Number of Segments	Length (meters)
1	7	4534.94
2	4	2251.69
5	8	1882.21
	Total	8668.85







Watershed 17. Little River (Lower).

Little River (Combined Watershed)

Perimeter:

Feet	269658.68	Miles	51.07
Meters	82191.97	Km	82.20

Area:

Sq Feet	3045148762.	Sq Miles	109.26	Acres	69931.58
Sq Meters	282994160.	Sq Km	283.00	Hectares	28300.34

Shape: 1.90

Elevation:

Lowest -	Feet	1120.	Meters	341.
Highest -	Feet	6643.	Meters	2025.

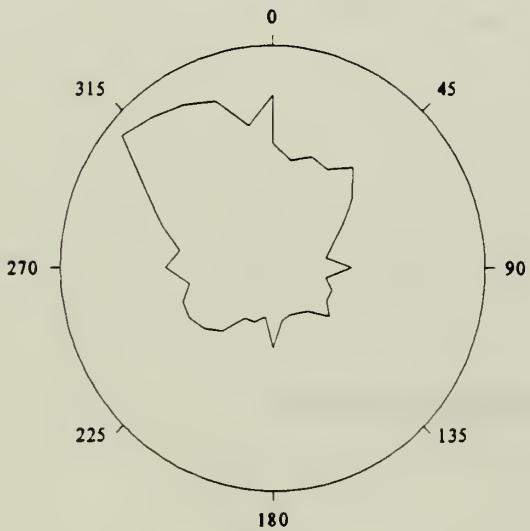
Total Length of Streams:

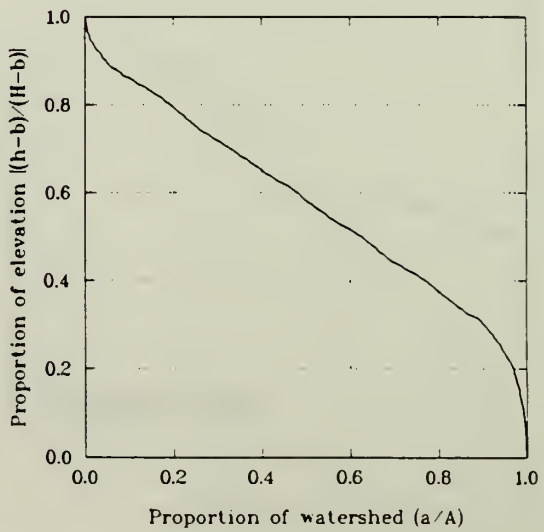
Feet	1619256.00	Miles	306.69
Meters	493525.16	Km	493.52

Drainage Density:

Km Stream/Sq Km Watershed 1.74 Miles Stream/Sq Miles Watershed 2.81

Stream Order	Number of Segments	Length (meters)
1	314	303813.41
2	155	91147.64
3	72	45823.96
4	74	42223.62
5	22	10515.85
	Total	493525.16





Little River (Combined Watershed).

18. White Oak Sinks

Perimeter:

Feet	29842.80	Miles	5.65
Meters	9096.09	Km	9.10

Area:

Sq Feet	46615212.	Sq Miles	1.67	Acres	1070.50
Sq Meters	4332265.	Sq Km	4.33	Hectares	433.23

Shape: 1.52

Elevation:

Lowest -	Feet	1700.	Meters	518.
Highest -	Feet	3680.	Meters	1122.

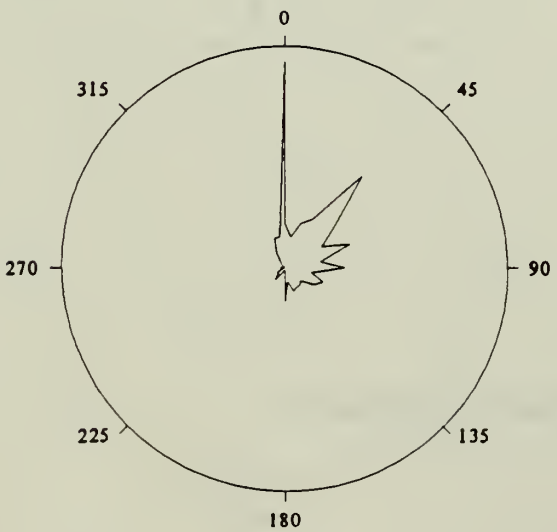
Total Length of Streams:

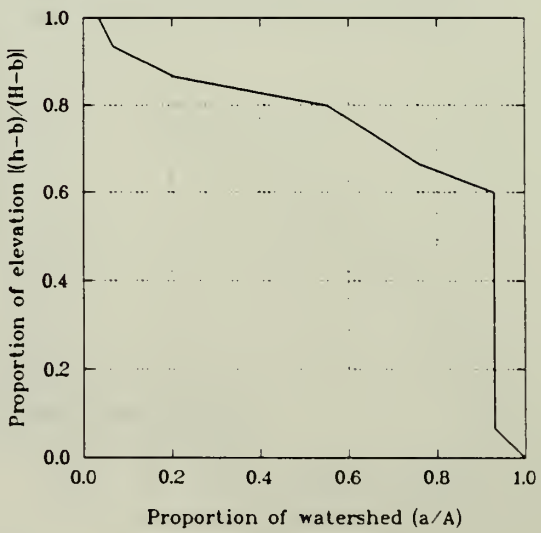
Feet	22288.98	Miles	4.22
Meters	6793.68	Km	6.79

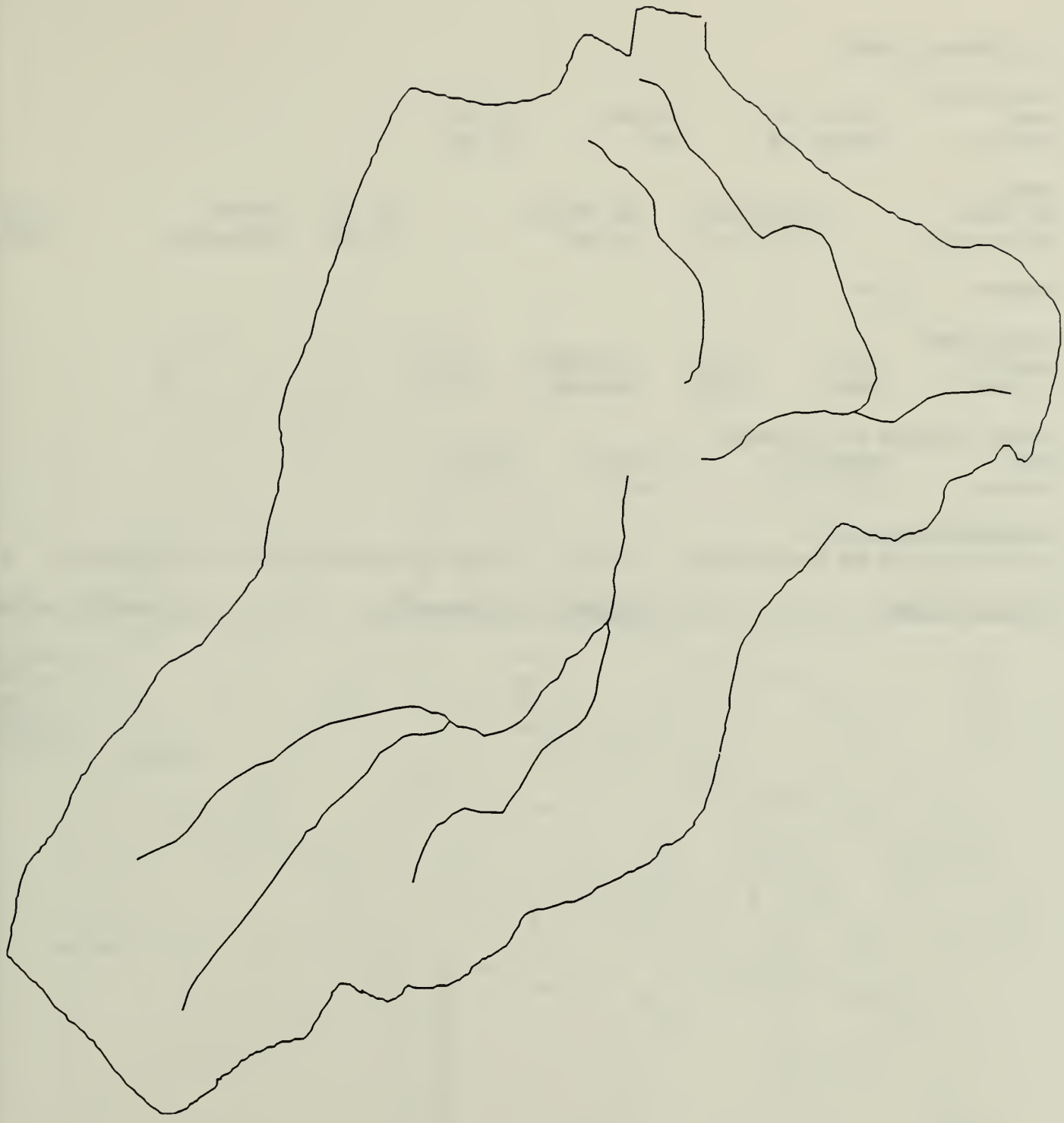
Drainage Density:

Km Stream/Sq Km Watershed 1.57 Miles Stream/Sq Miles Watershed 2.53

Stream Order	Number of Segments	Length (meters)
1	6	5401.38
2	3	1392.30
	Total	6793.68







Watershed 18. White Oak Sinks.

19. Hesse Creek

Perimeter:

Feet	97966.99	Miles	18.55
Meters	29860.34	Km	29.86

Area:

Sq Feet	326636000.	Sq Miles	11.72	Acres	7501.11
Sq Meters	30356242.	Sq Km	30.36	Hectares	3035.66

Shape: 2.34

Elevation:

Lowest -	Feet	1120.	Meters	341.
Highest -	Feet	3765.	Meters	1148.

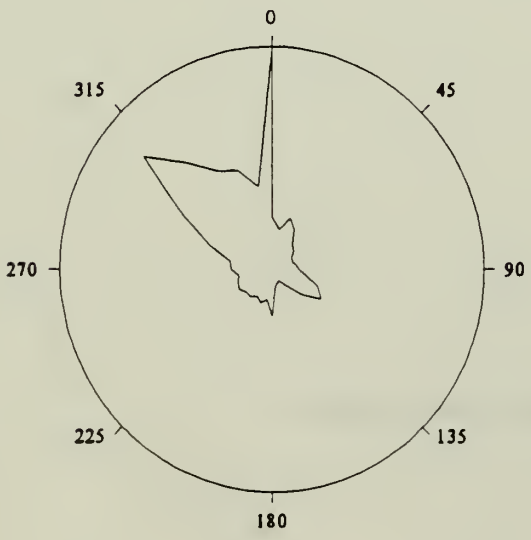
Total Length of Streams:

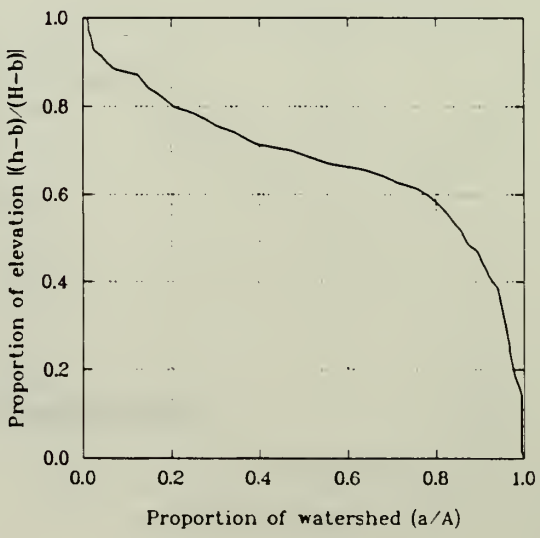
Feet	268305.77	Miles	50.82
Meters	81775.61	Km	81.78

Drainage Density:

Km Stream/Sq Km Watershed 2.69 Miles Stream/Sq Miles Watershed 4.34

Stream Order	Number of Segments	Length (meters)
1	74	48046.88
2	41	19478.01
3	17	6576.68
4	14	7674.03
	Total	81775.61





Watershed 19. Hesse Creek.

20. Cane Creek

Perimeter:

Feet	52887.70	Miles	10.02
Meters	16120.17	Km	16.12

Area:

Sq Feet	116100400.	Sq Miles	4.17	Acres	2666.22
Sq Meters	10790058.	Sq Km	10.79	Hectares	1079.00

Shape: 1.92

Elevation:

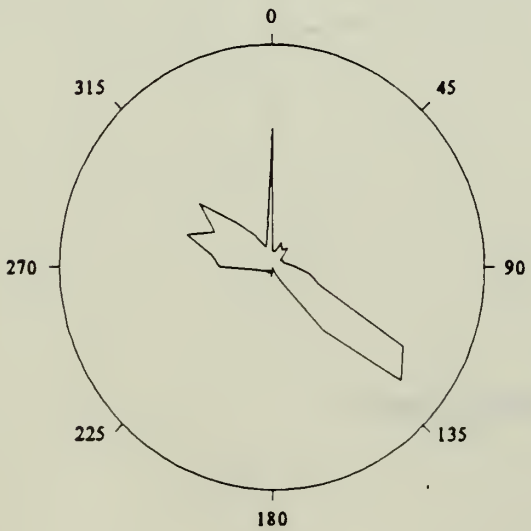
Lowest -	Feet	1220.	Meters	372.
Highest -	Feet	2097.	Meters	639.

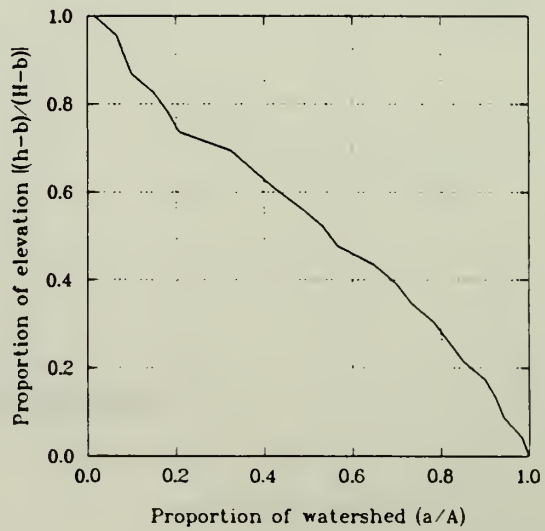
Total Length of Streams:

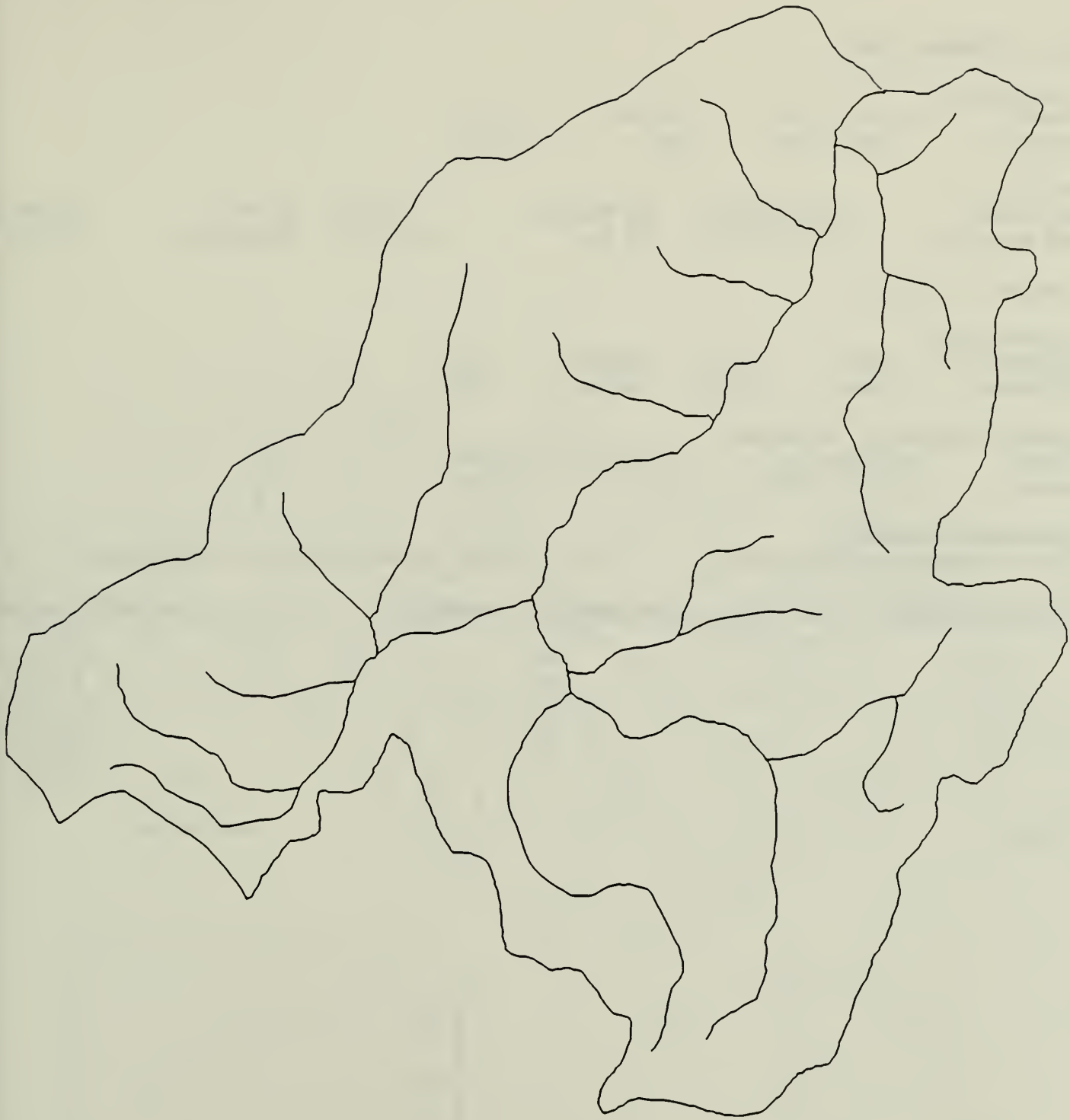
Feet	70140.60	Miles	13.29
Meters	21378.85	Km	21.38

Drainage Density:
Km Stream/Sq Km Watershed 1.98 Miles Stream/Sq Miles Watershed 3.19

Stream Order	Number of Segments	Length (meters)
1	17	14231.62
2	9	3450.15
3	2	1007.17
4	5	2689.91
	Total	21378.85







Watershed 20. Cane Creek.

21. Abrams Creek

Perimeter:

Feet	252006.36	Miles	47.73
Meters	76811.54	Km	76.81

Area:

Sq Feet	2127486460.	Sq Miles	76.33	Acres	48854.75
Sq Meters	197705872.	Sq Km	197.72	Hectares	19771.40

Shape: 2.38

Elevation:

Lowest -	Feet	874.	Meters	266.
Highest -	Feet	5527.	Meters	1684.

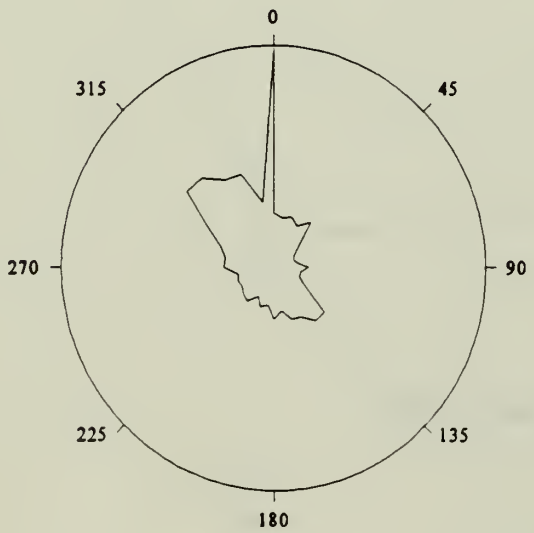
Total Length of Streams:

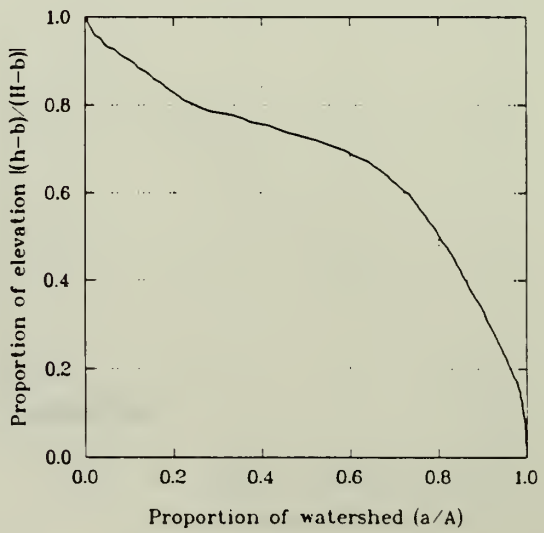
Feet	1141707.16	Miles	216.28
Meters	347992.28	Km	347.99

Drainage Density:

Km Stream/Sq Km Watershed 1.76 Miles Stream/Sq Miles Watershed 2.83

Stream Order	Number of Segments	Length (meters)
1	183	199117.39
2	93	72156.41
3	43	31717.14
4	27	15709.82
5	30	29291.33
	Total	347992.28
Ponds:	2	Hectares 0.44





Watershed 21. Abrams Creek.

22. Panther Creek

Perimeter:

Feet	111071.98	Miles	21.04
Meters	33854.74	Km	33.85

Area:

Sq Feet	311706400.	Sq Miles	11.18	Acres	7158.27
Sq Meters	28968750.	Sq Km	28.97	Hectares	2896.90

Shape: 3.15

Elevation:

Lowest -	Feet	874.	Meters	266.
Highest -	Feet	4949.	Meters	1508.

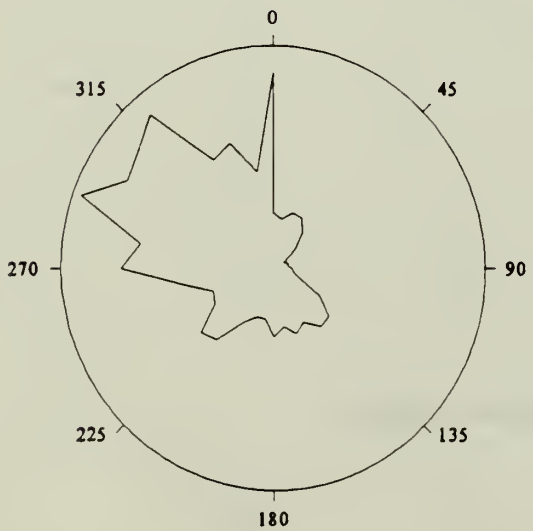
Total Length of Streams:

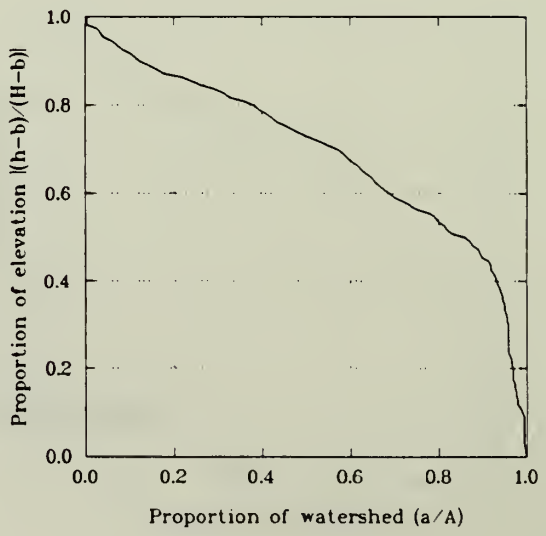
Feet	161948.68	Miles	30.67
Meters	49359.55	Km	49.36

Drainage Density:

Km Stream/Sq Km Watershed 1.70 Miles Stream/Sq Miles Watershed 2.74

Stream Order	Number of Segments	Length (meters)
1	27	30402.10
2	10	6215.67
3	16	12741.78
	Total	49359.55





Watershed 22. Panther Creek.

23. Shop Creek

Perimeter:

Feet	34628.93	Miles	6.56
Meters	10554.90	Km	10.55

Area:

Sq Feet	62561452.	Sq Miles	2.24	Acres	1436.71
Sq Meters	5814256.	Sq Km	5.81	Hectares	581.43

Shape: 1.53

Elevation:

Lowest -	Feet	874.	Meters	266.
Highest -	Feet	2324.	Meters	708.

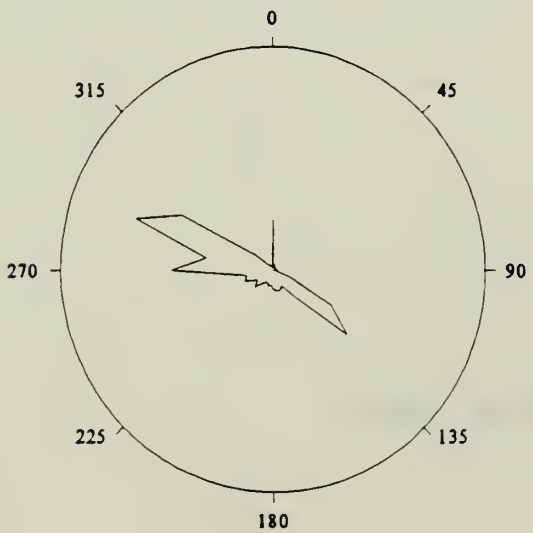
Total Length of Streams:

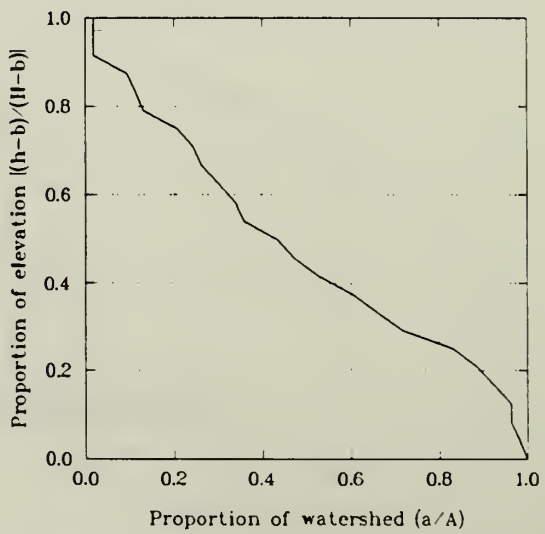
Feet	23042.13	Miles	4.36
Meters	7023.24	Km	7.02

Drainage Density:

Km Stream/Sq Km Watershed 1.21 Miles Stream/Sq Miles Watershed 1.95

Stream Order	Number of Segments	Length (meters)
1	3	5411.31
2	2	1611.93
	Total	7023.24





Watershed 23. Shop Creek.

24. Tabcat Creek

Perimeter:

Feet	60508.91	Miles	11.46
Meters	18443.12	Km	18.44

Area:

Sq Feet	161667760.	Sq Miles	5.80	Acres	3712.65
Sq Meters	15024958.	Sq Km	15.02	Hectares	1502.50

Shape: 1.80

Elevation:

Lowest -	Feet	874.	Meters	266.
Highest -	Feet	2767.	Meters	843.

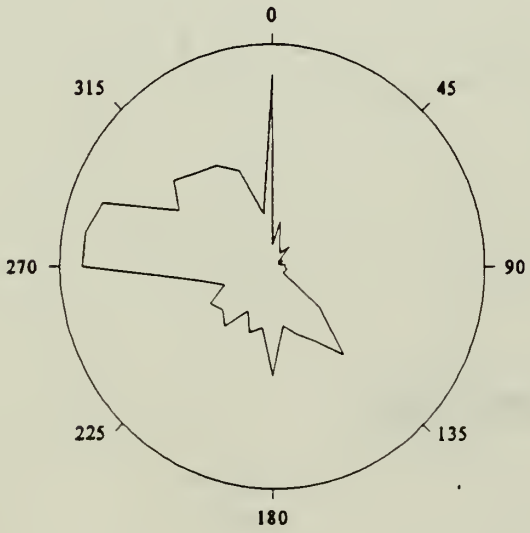
Total Length of Streams:

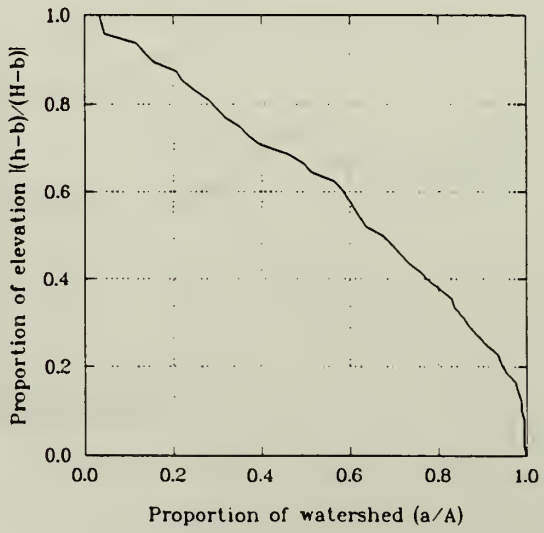
Feet	61847.88	Miles	11.72
Meters	18851.23	Km	18.85

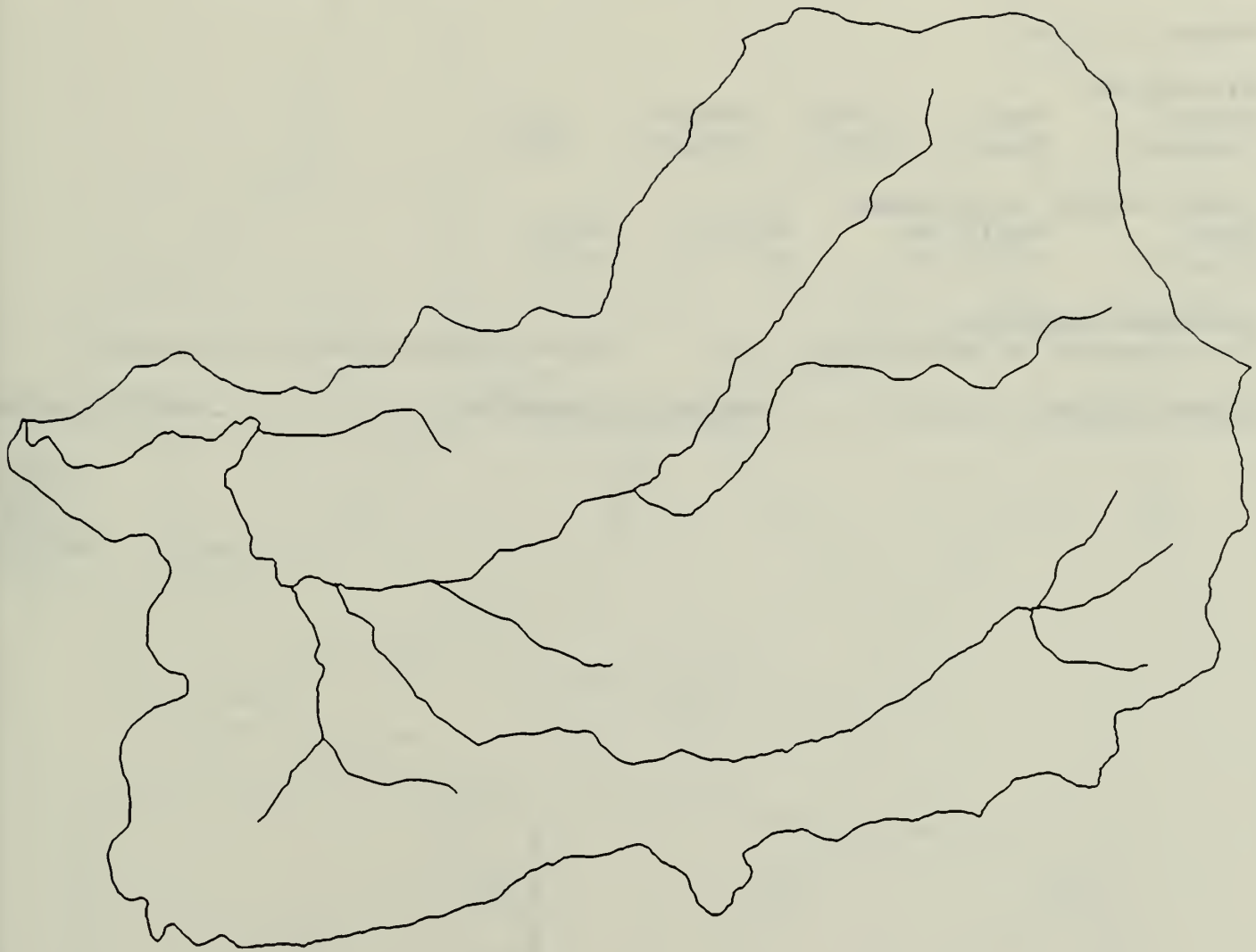
Drainage Density:

Km Stream/Sq Km Watershed 1.26 Miles Stream/Sq Miles Watershed 2.02

Stream Order	Number of Segments	Length (meters)
1	9	10223.92
2	5	6082.95
3	3	2544.36
	Total	18851.23







Watershed 24. Tabcat Creek.

25. Parson Creek

Perimeter:

Feet	64444.29	Miles	12.21
Meters	19642.62	Km	19.64

Area:

Sq Feet	221520192.	Sq Miles	7.95	Acres	5087.15
Sq Meters	20587352.	Sq Km	20.59	Hectares	2058.75

Shape: 1.49

Elevation:

Lowest -	Feet	1086.	Meters	331.
Highest -	Feet	4732.	Meters	1442.

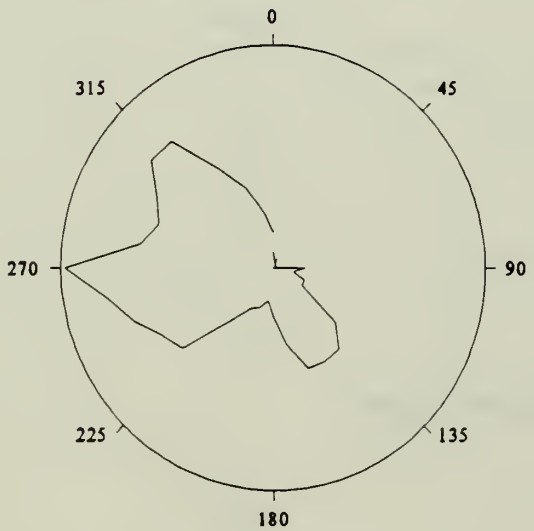
Total Length of Streams:

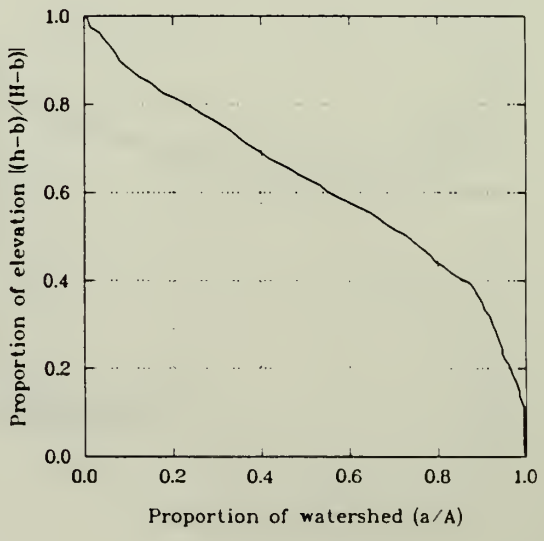
Feet	99411.99	Miles	18.83
Meters	30300.77	Km	30.30

Drainage Density:

Km Stream/Sq Km Watershed 1.47 Miles Stream/Sq Miles Watershed 2.37

Stream Order	Number of Segments	Length (meters)
1	19	21461.27
2	11	6006.53
3	7	2832.96
	Total	30300.77





Watershed 25. Parson Branch.

26. Twentymile Creek

Perimeter:

Feet	89289.80	Miles	16.91
Meters	27215.53	Km	27.22

Area:

Sq Feet	451252832.	Sq Miles	16.19	Acres	10362.84
Sq Meters	41937596.	Sq Km	41.94	Hectares	4193.76

Shape: 1.41

Elevation:

Lowest -	Feet	1276.	Meters	389.
Highest -	Feet	4732.	Meters	1442.

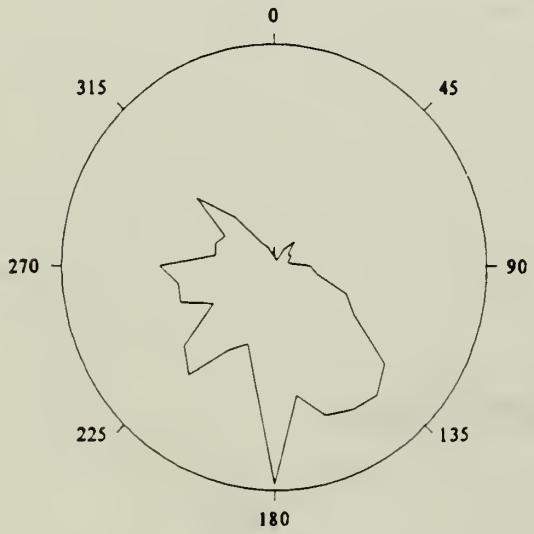
Total Length of Streams:

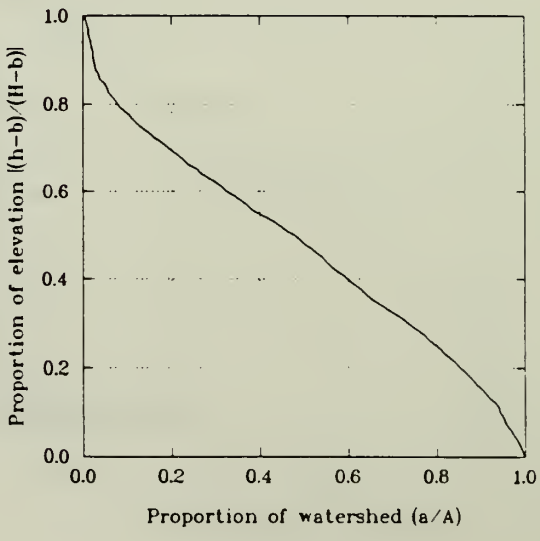
Feet	220476.29	Miles	41.76
Meters	67201.16	Km	67.20

Drainage Density:

Km Stream/Sq Km Watershed 1.60 Miles Stream/Sq Miles Watershed 2.58

Stream Order	Number of Segments	Length (meters)
1	48	43030.70
2	19	12550.33
3	22	8759.03
4	6	2861.09
	Total	67201.16





Watershed 26. Twentymile Creek.

27. Lost Cove Creek

Perimeter:

Feet	43740.94	Miles	8.28
Meters	13332.24	Km	13.33

Area:

Sq Feet	101831856.	Sq Miles	3.65	Acres	2338.54
Sq Meters	9463924.	Sq Km	9.46	Hectares	946.39

Shape: 1.49

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	4400.	Meters	1341.

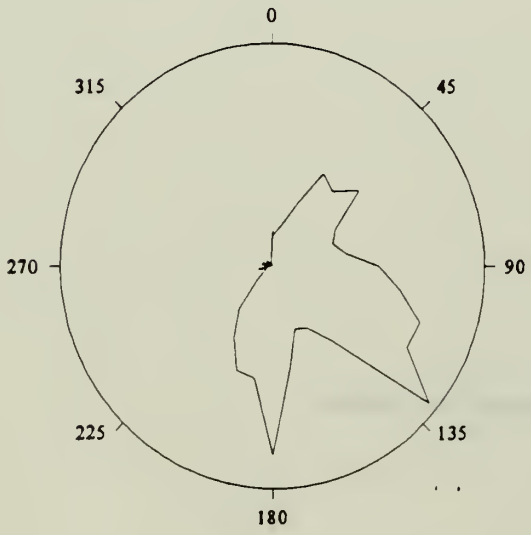
Total Length of Streams:

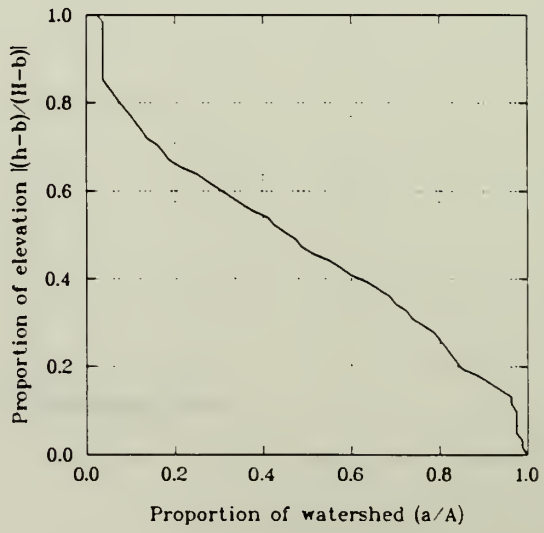
Feet	57507.33	Miles	10.89
Meters	17528.23	Km	17.53

Drainage Density:

Km Stream/Sq Km Watershed 1.85 Miles Stream/Sq Miles Watershed 2.98

Stream Order	Number of Segments	Length (meters)
1	14	11634.72
2	9	3714.86
3	4	2178.65
	Total	17528.23





Watershed 27. Lost Cove Creek.

28. Eagle Creek

Perimeter:

Feet	119087.88	Miles	22.55
Meters	36297.98	Km	36.30

Area:

Sq Feet	642919616.	Sq Miles	23.07	Acres	14764.19
Sq Meters	59749564.	Sq Km	59.75	Hectares	5975.01

Shape: 1.75

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	5527.	Meters	1685.

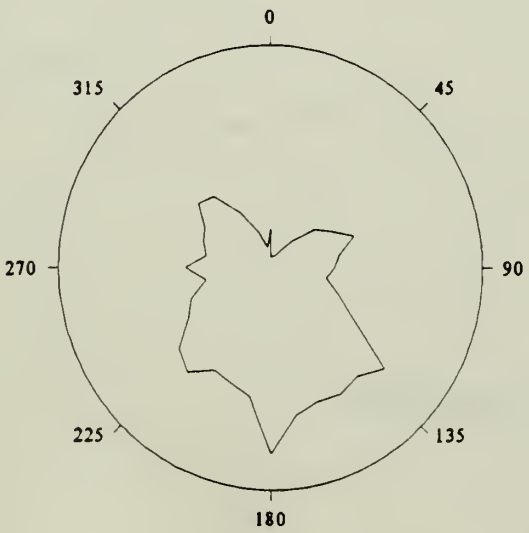
Total Length of Streams:

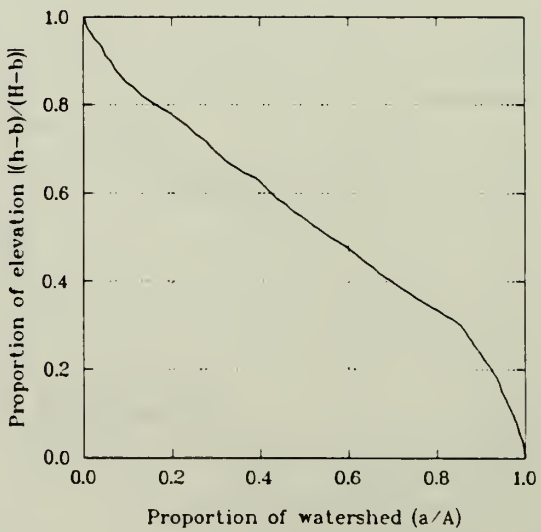
Feet	277471.28	Miles	52.56
Meters	84573.23	Km	84.57

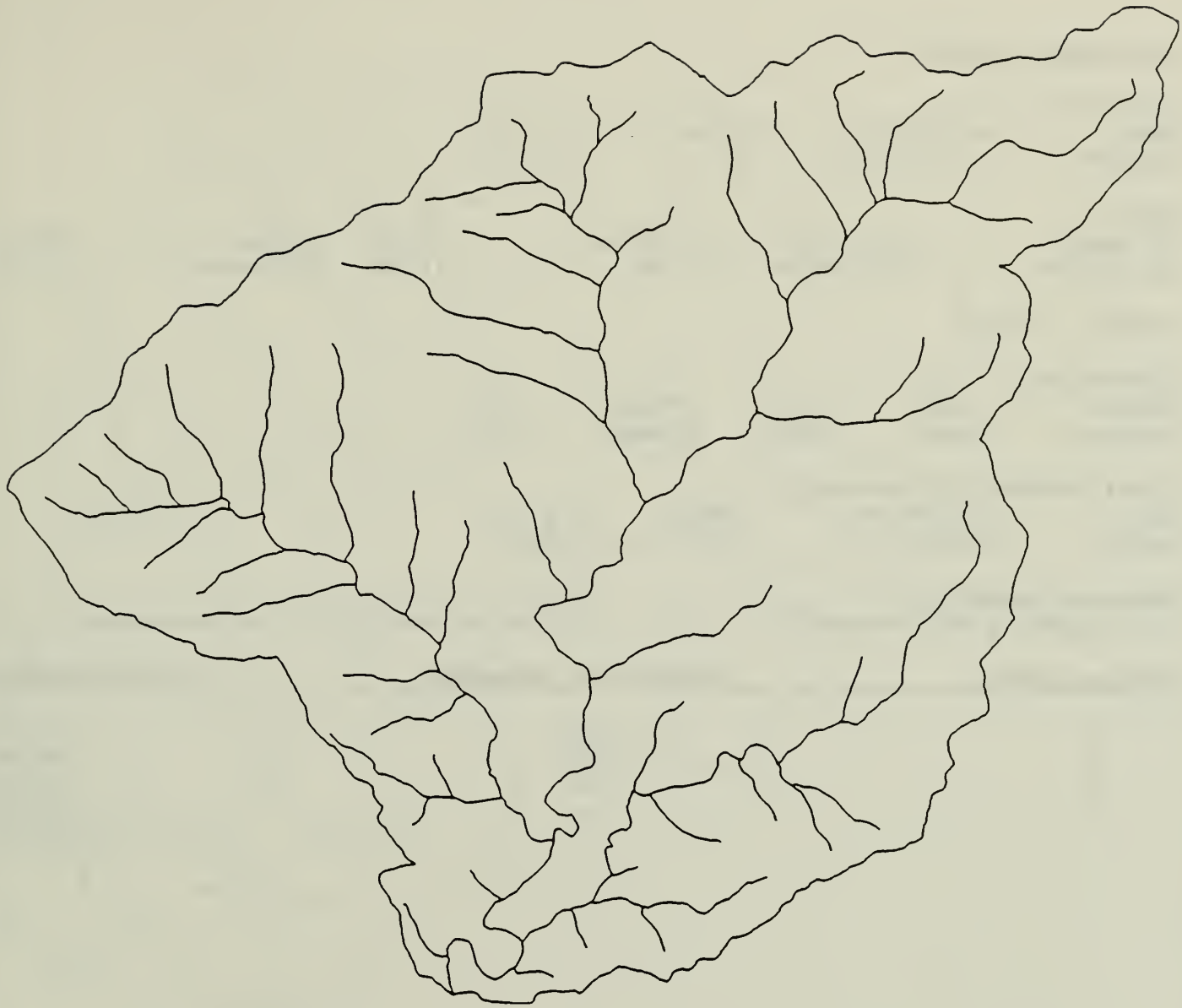
Drainage Density:

Km Stream/Sq Km Watershed 1.42 Miles Stream/Sq Miles Watershed 2.28

Stream Order	Number of Segments	Length (meters)
1	49	54487.95
2	26	13118.72
3	14	9083.91
4	8	7882.68
	Total	84573.23







Watershed 28. Eagle Creek.

29. Hazel Creek

Perimeter:

Feet	167799.87	Miles	31.78
Meters	51145.40	Km	51.15

Area:

Sq Feet	1305171840.	Sq Miles	46.83	Acres	29973.83
Sq Meters	121290576.	Sq Km	121.29	Hectares	12129.70

Shape: 1.72

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	5320.	Meters	1616.

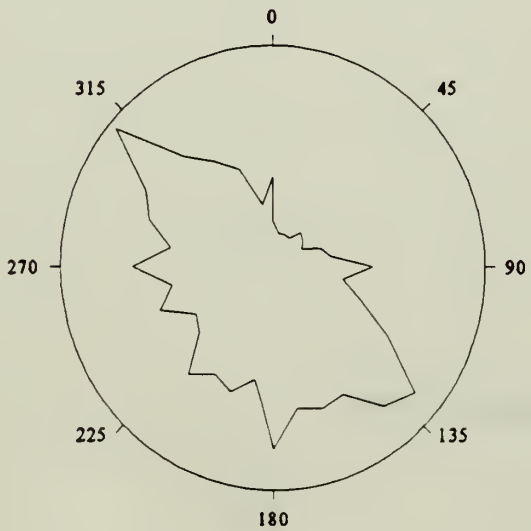
Total Length of Streams:

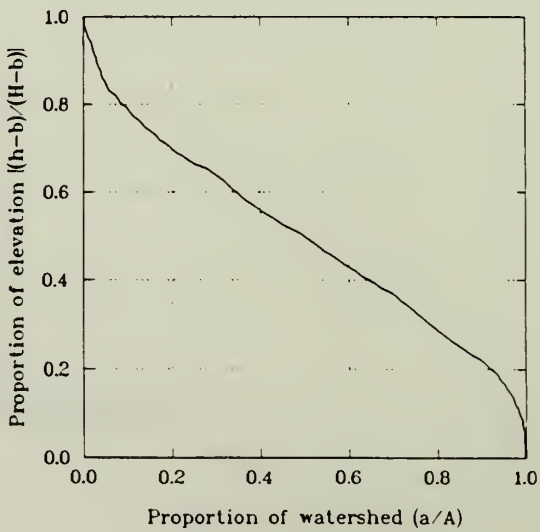
Feet	599269.40	Miles	113.52
Meters	182657.28	Km	182.66

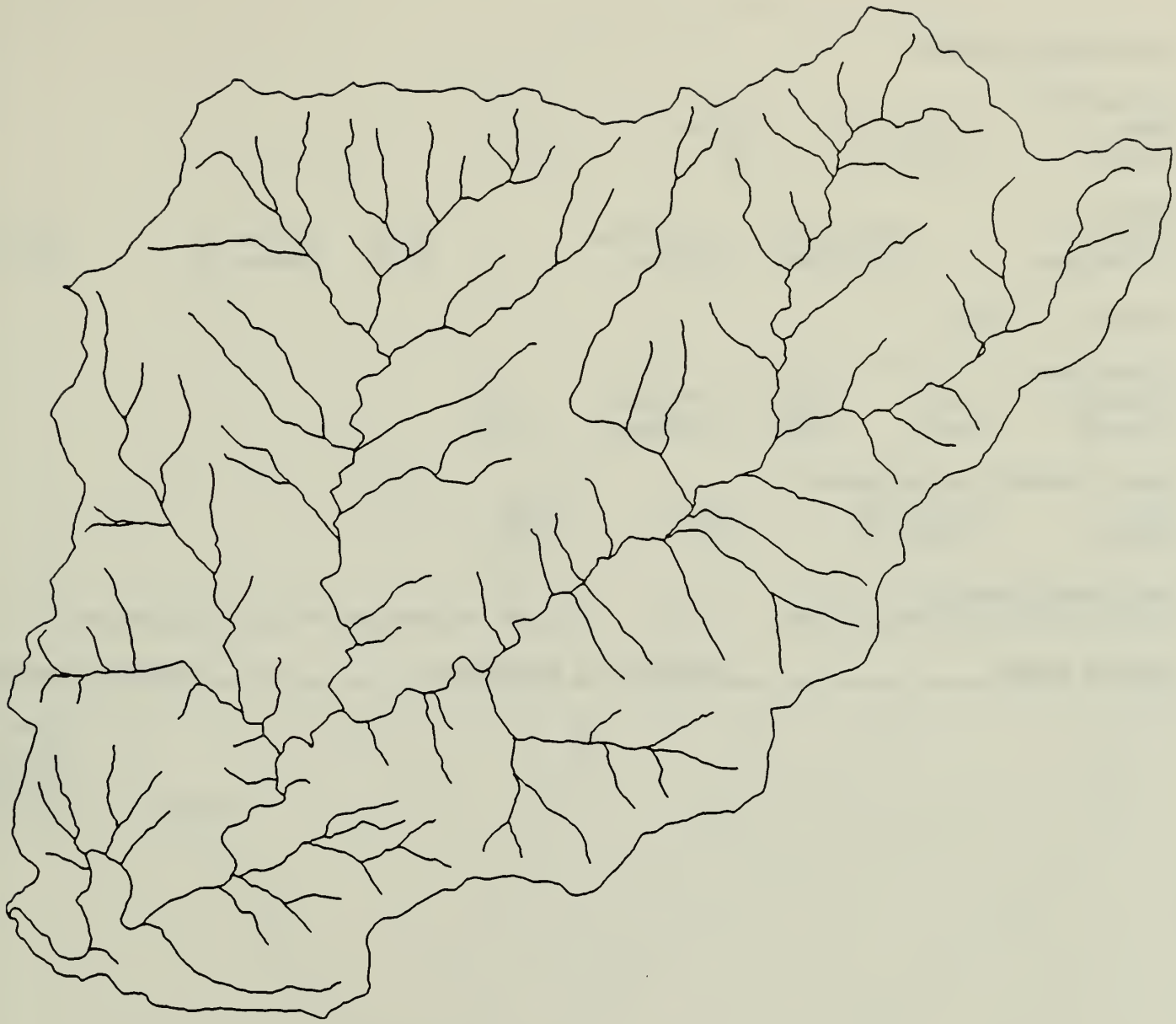
Drainage Density:

Km Stream/Sq Km Watershed 1.51 Miles Stream/Sq Miles Watershed 2.42

Stream Order	Number of Segments	Length (meters)
1	102	114398.91
2	48	34508.52
3	36	22042.53
4	16	11707.35
	Total	182657.28







Watershed 29. Hazel Creek.

30. Pilkey Creek

Perimeter:

Feet	39721.56	Miles	7.52
Meters	12107.13	Km	12.11

Area:

Sq Feet	105710568.	Sq Miles	3.79	Acres	2427.61
Sq Meters	9824400.	Sq Km	9.82	Hectares	982.44

Shape: 1.19

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	4800.	Meters	1463.

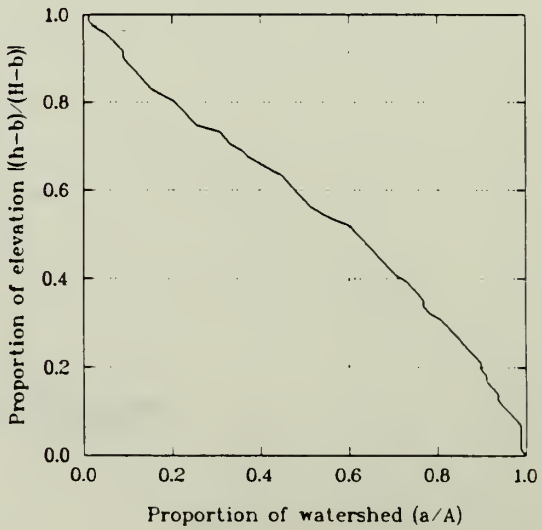
Total Length of Streams:

Feet	46739.84	Miles	8.86
Meters	14246.30	Km	14.25

Drainage Density:

Km Stream/Sq Km Watershed 1.45 Miles Stream/Sq Miles Watershed 2.34

Stream Order	Number of Segments	Length (meters)
1	8	10543.73
2	6	3397.81
3	1	304.76
	Total	14246.30



Watershed 30. Pilkey Creek.

31. Chambers Creek

Perimeter:

Feet	51175.58	Miles	9.69
Meters	15598.32	Km	15.60

Area:

Sq Feet	149655264.	Sq Miles	5.37	Acres	3436.78
Sq Meters	13908508.	Sq Km	13.91	Hectares	1390.85

Shape: 1.39

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	4845.	Meters	1477.

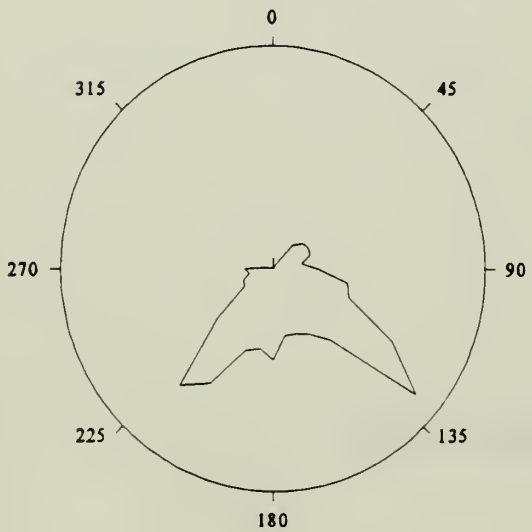
Total Length of Streams:

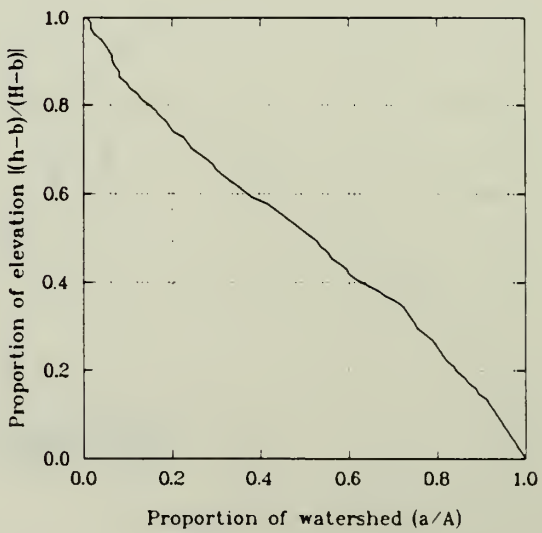
Feet	76702.41	Miles	14.54
Meters	23378.89	Km	23.38

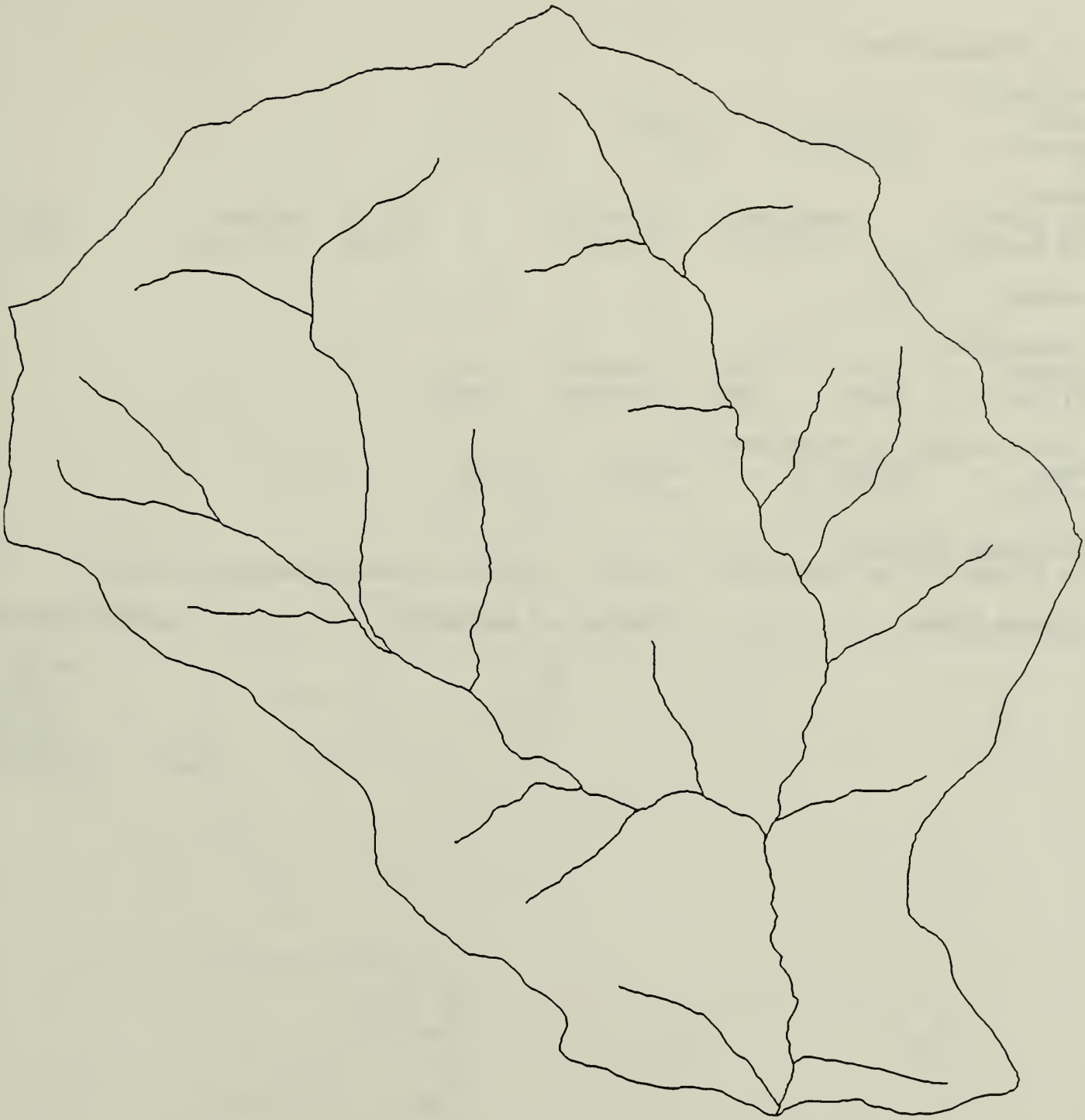
Drainage Density:

Km Stream/Sq Km Watershed 1.68 Miles Stream/Sq Miles Watershed 2.71

Stream Order	Number of Segments	Length (meters)
1	19	14695.72
2	10	5461.08
3	8	3222.09
	Total	23378.89







Watershed 31. Chambers Creek.

32. Forney Creek

Perimeter:

Feet	128452.25	Miles	24.33
Meters	39152.25	Km	39.15

Area:

Sq Feet	808301504.	Sq Miles	29.00	Acres	18562.30
Sq Meters	75118704.	Sq Km	75.12	Hectares	7511.94

Shape: 1.62

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	6643.	Meters	2025.

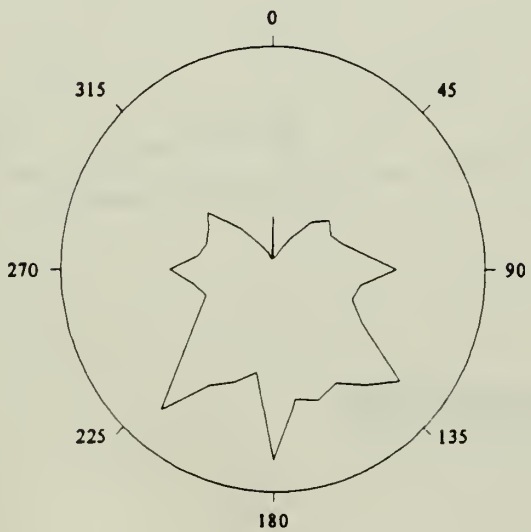
Total Length of Streams:

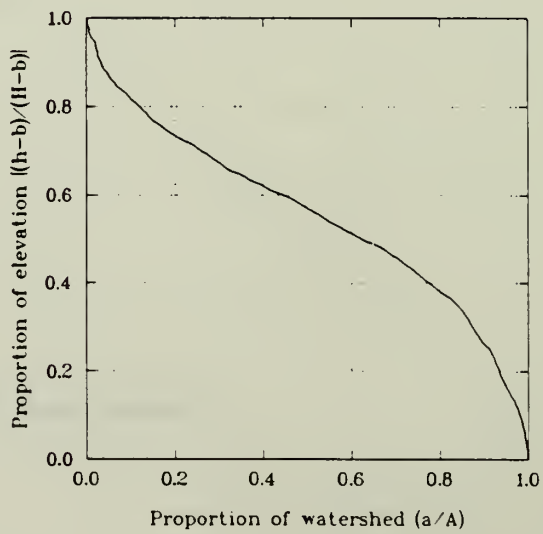
Feet	331518.43	Miles	62.80
Meters	101046.80	Km	101.05

Drainage Density:

Km Stream/Sq Km Watershed 1.34 Miles Stream/Sq Miles Watershed 2.16

Stream Order	Number of Segments	Length (meters)
1	51	56087.78
2	27	28550.48
3	8	6672.46
4	24	9736.08
	Total	101046.80





Watershed 32. Forney Creek.

33. Noland Creek

Perimeter:

Feet	122089.01	Miles	23.12
Meters	37212.73	Km	37.21

Area:

Sq Feet	612857152.	Sq Miles	21.99	Acres	14073.98
Sq Meters	56956196.	Sq Km	56.96	Hectares	5695.67

Shape: 1.93

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	6643.	Meters	2025.

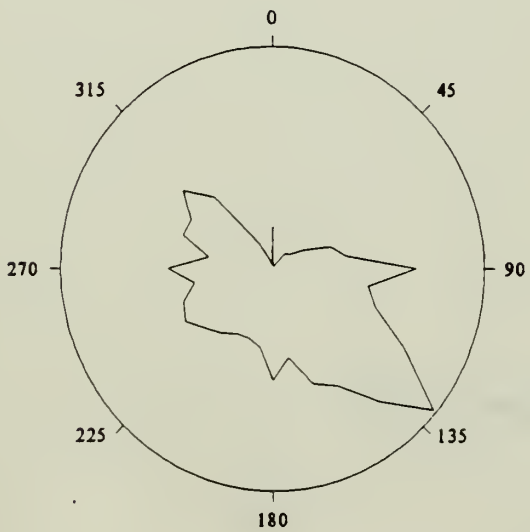
Total Length of Streams:

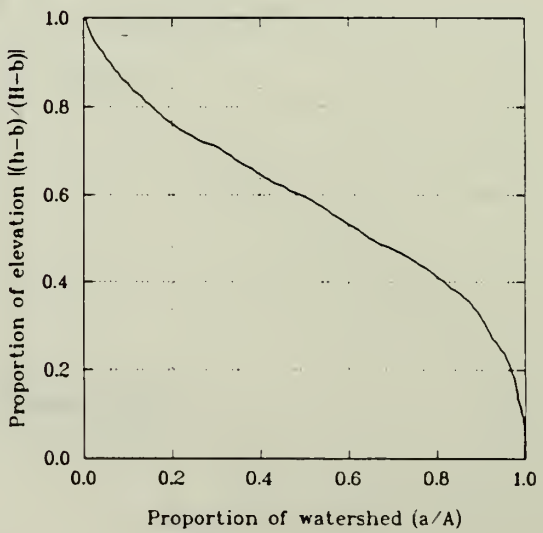
Feet	266365.96	Miles	50.46
Meters	81188.33	Km	81.19

Drainage Density:

Km Stream/Sq Km Watershed 1.42 Miles Stream/Sq Miles Watershed 2.29

Stream Order	Number of Segments	Length (meters)
1	52	50298.91
2	18	13714.41
3	16	9077.12
4	17	8097.88
	Total	81188.33





Watershed 33. Noland Creek.

34. Peachtree Creek

Perimeter:

Feet	33765.92	Miles	6.40
Meters	10291.85	Km	10.29

Area:

Sq Feet	60258136.	Sq Miles	2.16	Acres	1383.81
Sq Meters	5600193.	Sq Km	5.60	Hectares	560.02

Shape: 1.51

Elevation:

Lowest -	Feet	1708.	Meters	521.
Highest -	Feet	4280.	Meters	1304.

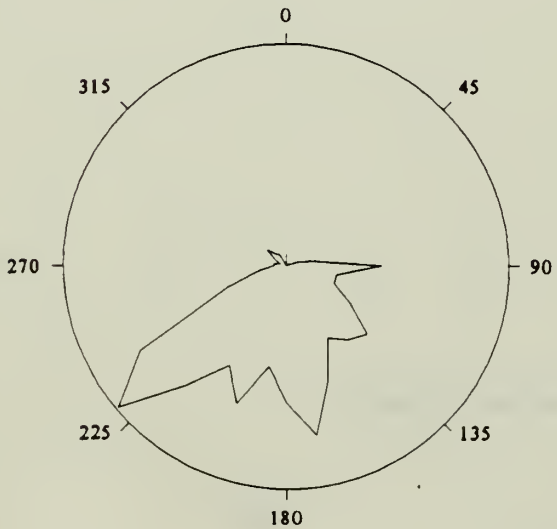
Total Length of Streams:

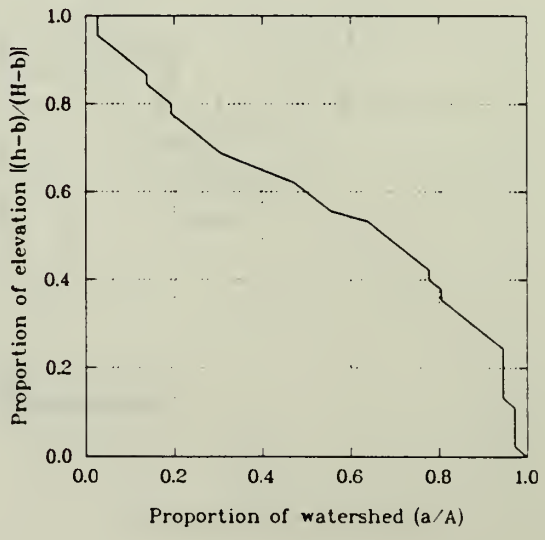
Feet	31198.27	Miles	5.91
Meters	9509.23	Km	9.51

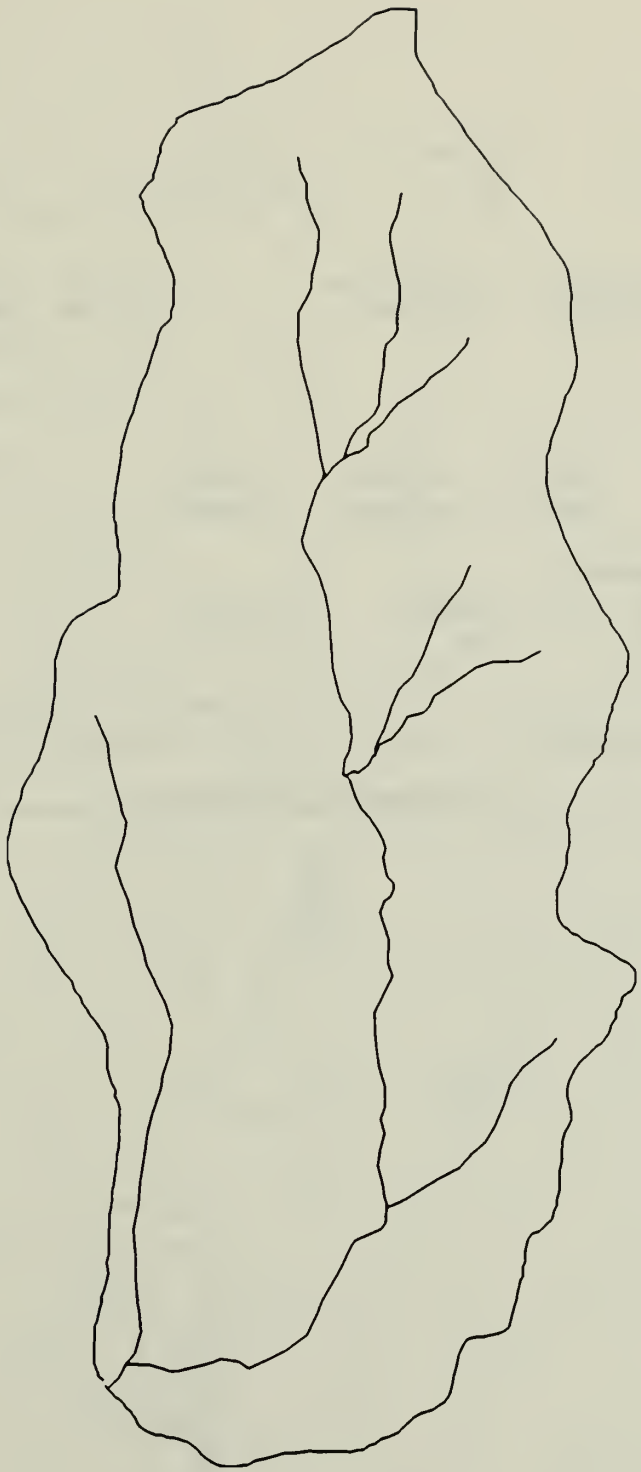
Drainage Density:

Km Stream/Sq Km Watershed 1.70 Miles Stream/Sq Miles Watershed 2.74

Stream Order	Number of Segments	Length (meters)
1	7	6050.92
2	3	1085.80
3	3	2372.51
	Total	9509.23







Watershed 34. Peachtree Creek.

35.Deep Creek

Perimeter:

Feet	161101.72	Miles	30.51
Meters	49103.80	Km	49.10

Area:

Sq Feet	1200880130.	Sq Miles	43.09	Acres	27578.22
Sq Meters	111597392.	Sq Km	111.60	Hectares	11160.44

Shape: 1.72

Elevation:

Lowest -	Feet	1800.	Meters	549.
Highest -	Feet	6200.	Meters	1890.

Total Length of Streams:

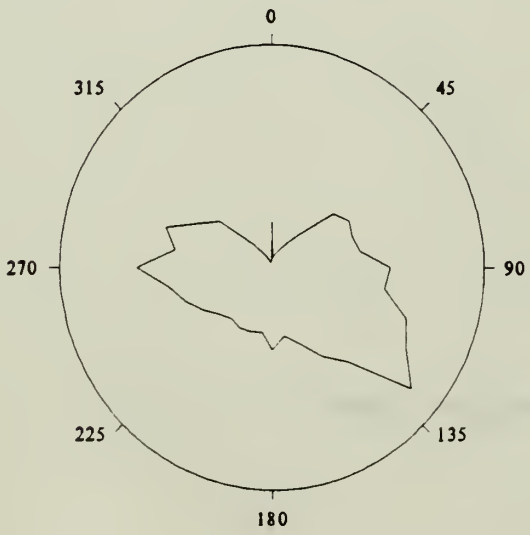
Feet	495746.68	Miles	93.91
Meters	151103.56	Km	151.10

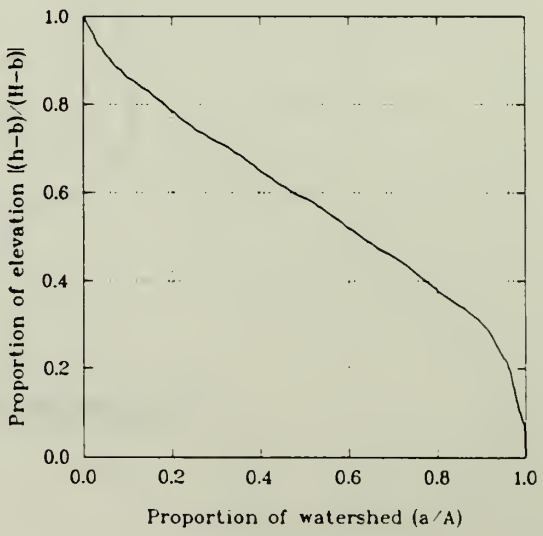
Drainage Density:

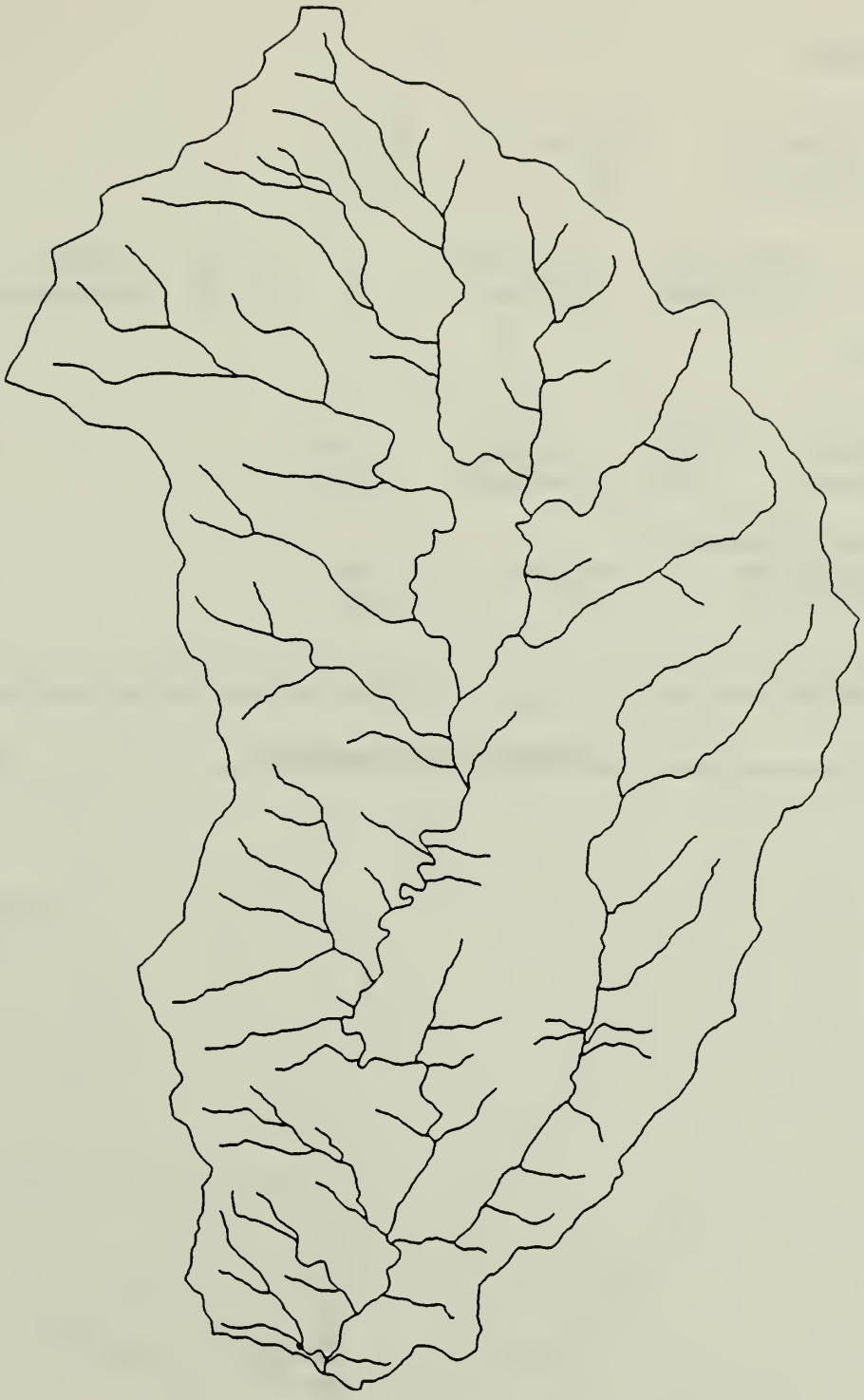
Km Stream/Sq Km Watershed 1.35 Miles Stream/Sq Miles Watershed 2.18

Stream Order	Number of Segments	Length (meters)
1	75	89444.27
2	44	41603.70
3	7	7447.59
4	22	12608.07
	Total	151103.56

Pond: 1 Hectares 0.18







Watershed 35. Deep Creek.

36. Cooper Creek

Perimeter:

Feet	50204.74	Miles	9.51
Meters	15302.41	Km	15.30

Area:

Sq Feet	118532528.	Sq Miles	4.25	Acres	2722.07
Sq Meters	11016066.	Sq Km	11.02	Hectares	1101.60

Shape: 1.69

Elevation:

Lowest -	Feet	2560.	Meters	780.
Highest -	Feet	5160.	Meters	1573.

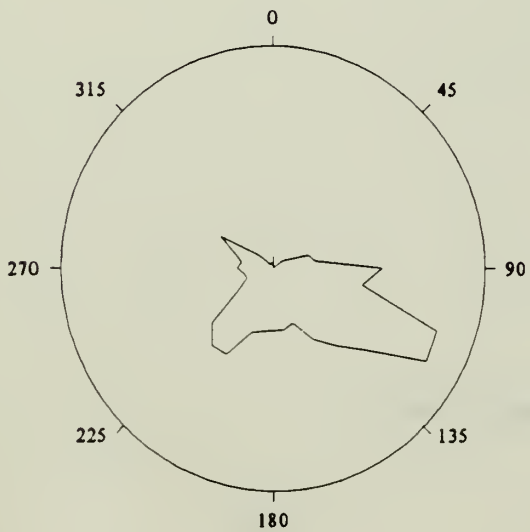
Total Length of Streams:

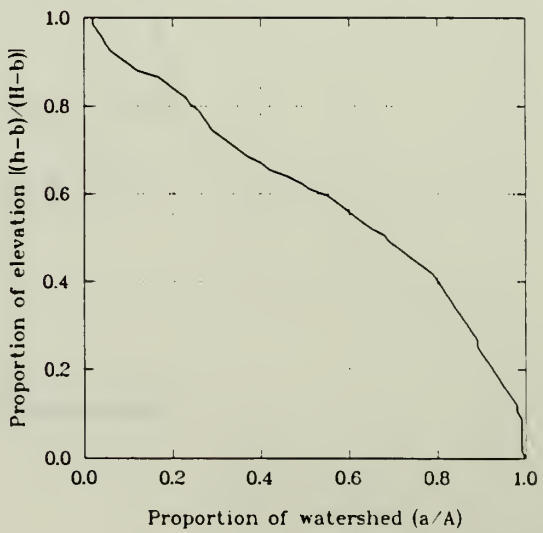
Feet	50968.48	Miles	9.66
Meters	15535.19	Km	15.54

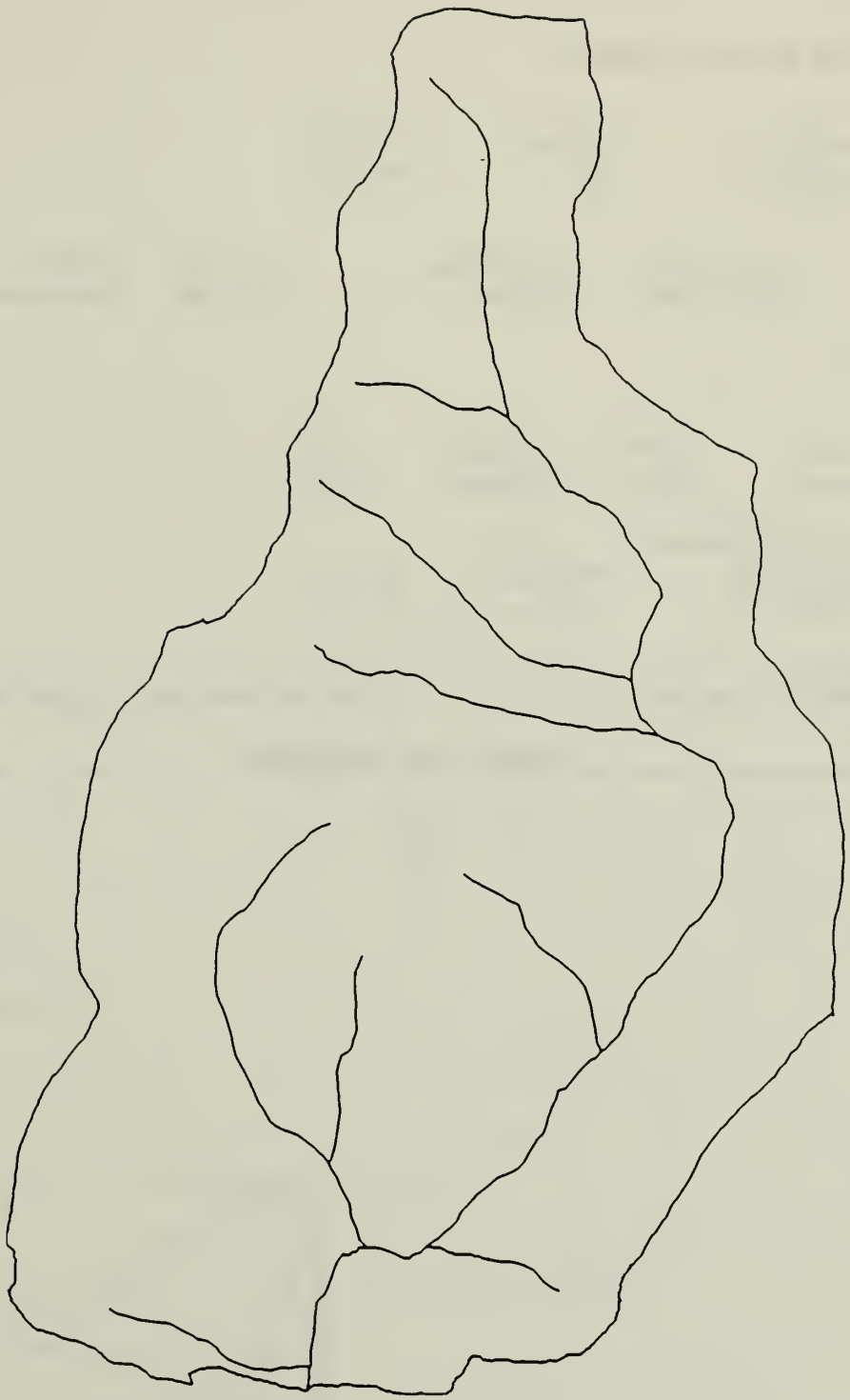
Drainage Density:

Km Stream/Sq Km Watershed 1.41 Miles Stream/Sq Miles Watershed 2.27

Stream Order	Number of Segments	Length (meters)
1	9	9957.46
2	6	4819.37
3	2	758.36
	Total	15535.19







Watershed 36. Cooper Creek.

37. Oconaluftee River (Lower)

Perimeter:

Feet	94310.87	Miles	17.86
Meters	28745.96	Km	28.75

Area:

Sq Feet	342634880.	Sq Miles	12.29	Acres	7868.55
Sq Meters	31843186.	Sq Km	31.84	Hectares	3184.33

Shape: 2.06

Elevation:

Lowest -	Feet	2020.	Meters	616.
Highest -	Feet	5053.	Meters	1540.

Total Length of Streams:

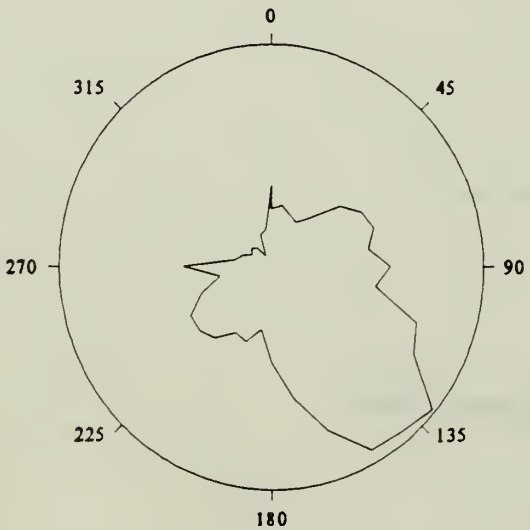
Feet	182369.92	Miles	34.54
Meters	55583.64	Km	55.58

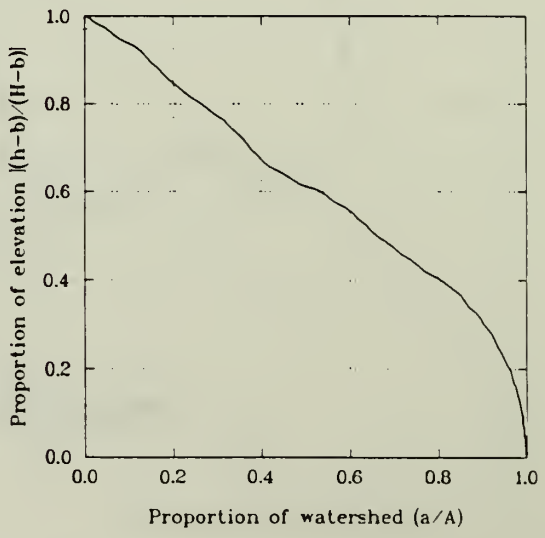
Drainage Density:

Km Stream/Sq Km Watershed 1.74 Miles Stream/Sq Miles Watershed 2.81

Stream Order	Number of Segments	Length (meters)
1	36	38046.59
2	16	8919.44
3	7	2069.27
5	16	6548.35
	Total	55583.64

Pond: 1 Hectares 0.13





Watershed 37. Oconaluftee River (Lower).

38. Oconaluftee River (West)

Perimeter:

Feet	122992.98	Miles	23.29
Meters	37488.26	Km	37.49

Area:

Sq Feet	607227520.	Sq Miles	21.79	Acres	13944.69
Sq Meters	56433100.	Sq Km	56.43	Hectares	5643.36

Shape: 1.98

Elevation:

Lowest -	Feet	2200.	Meters	671.
Highest -	Feet	6217.	Meters	1895.

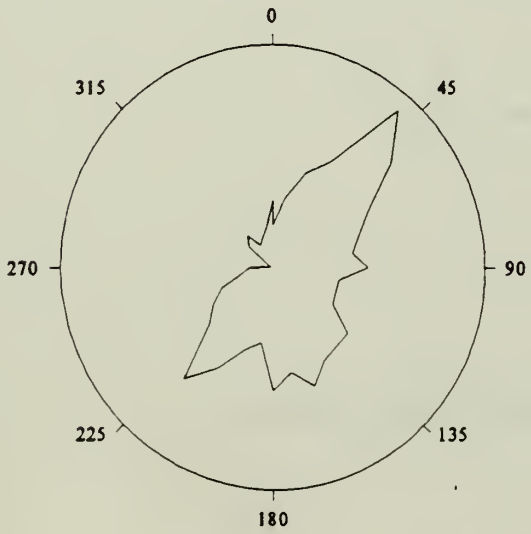
Total Length of Streams:

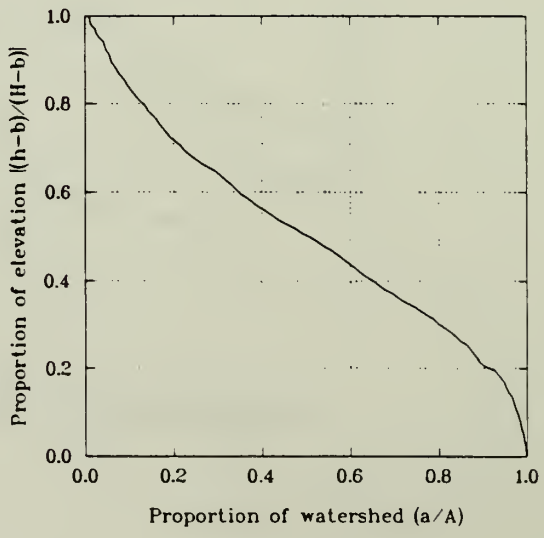
Feet	303794.28	Miles	57.55
Meters	92596.48	Km	92.60

Drainage Density:

Km Stream/Sq Km Watershed 1.64 Miles Stream/Sq Miles Watershed 2.64

Stream Order	Number of Segments	Length (meters)
1	60	60659.28
2	29	16538.26
3	16	8635.47
4	17	6763.47
	Total	92596.48





Watershed 38. Oconaluftee River (West).

39.Bradley Fork

Perimeter:

Feet	111851.56	Miles	21.18
Meters	34092.36	Km	34.09

Area:

Sq Feet	608164352.	Sq Miles	21.82	Acres	13966.21
Sq Meters	56520172.	Sq Km	56.52	Hectares	5652.03

Shape: 1.64

Elevation:

Lowest -	Feet	2200.	Meters	671.
Highest -	Feet	5907.	Meters	1800.

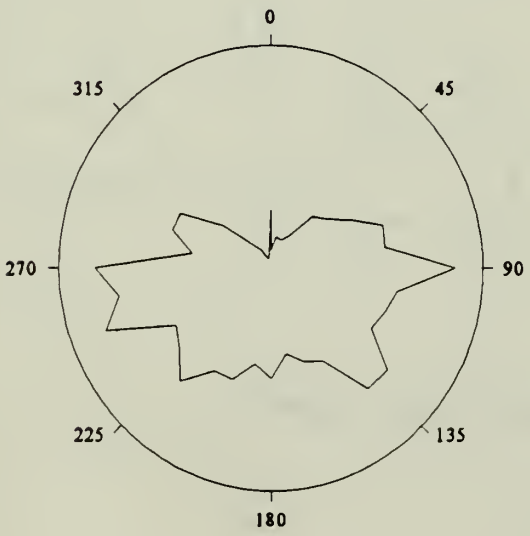
Total Length of Streams:

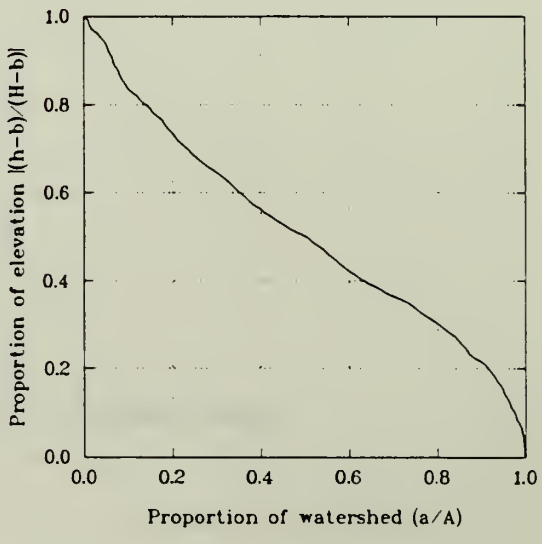
Feet	263313.04	Miles	49.88
Meters	80257.80	Km	80.26

Drainage Density:

Km Stream/Sq Km Watershed 1.42 Miles Stream/Sq Miles Watershed 2.28

Stream Order	Number of Segments	Length (meters)
1	51	50277.72
2	23	15353.64
3	28	11792.24
4	7	2834.21
	Total	80257.80





Watershed 39. Bradley Fork.

Oconaluftee River (Combined Watershed)

Perimeter:

Feet	187924.48	Miles	35.59
Meters	57279.38	Km	57.28

Area:

Sq Feet	1558026752.	Sq Miles	55.90	Acres	35779.45
Sq Meters	144796458.	Sq Km	144.79	Hectares	14479.72

Shape: 1.80

Elevation:

Lowest -	Feet	2020.	Meters	616.
Highest -	Feet	6217.	Meters	1895.

Total Length of Streams:

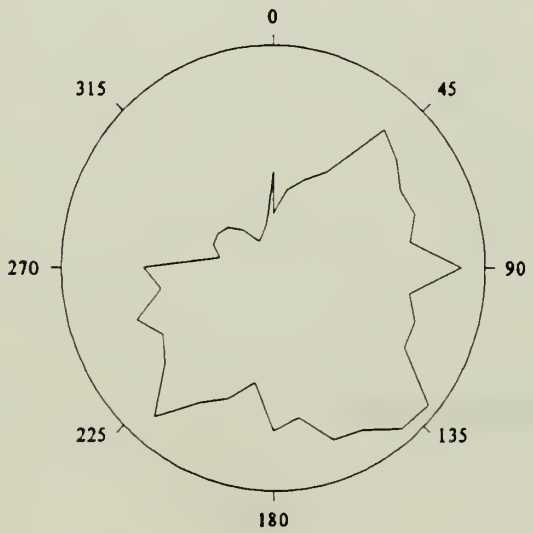
Feet	749505.37	Miles	141.96
Meters	228438.09	Km	228.44

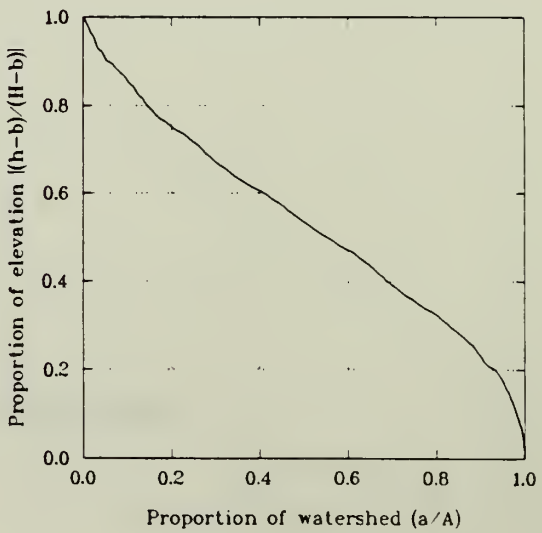
Drainage Density:

Km Stream/Sq Km Watershed 1.58 Miles Stream/Sq Miles Watershed 2.54

Stream Order	Number of Segments	Length (meters)
1	147	148983.62
2	68	40811.34
3	51	22496.98
4	24	9597.68
5	16	6548.35
	Total	228438.09

Pond: 1 Hectares 0.13





Oconaluftee River (Combined Watershed).

40. Raven Fork

Perimeter:

Feet	109547.42	Miles	20.75
Meters	33390.06	Km	33.39

Area:

Sq Feet	586422016.	Sq Miles	21.04	Acres	13466.90
Sq Meters	54499276.	Sq Km	54.50	Hectares	5449.96

Shape: 1.63

Elevation:

Lowest -	Feet	2720.	Meters	829.
Highest -	Feet	6417.	Meters	1956.

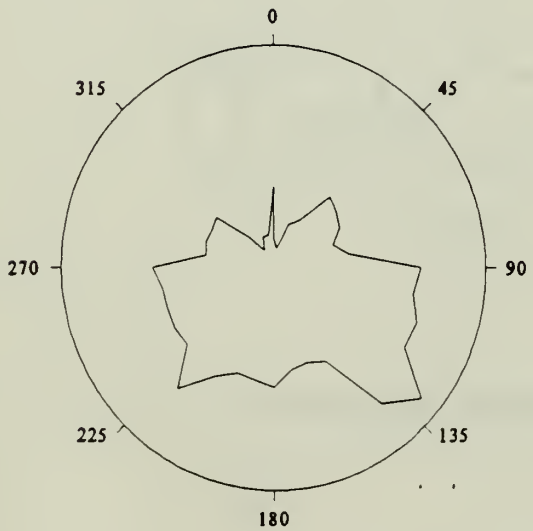
Total Length of Streams:

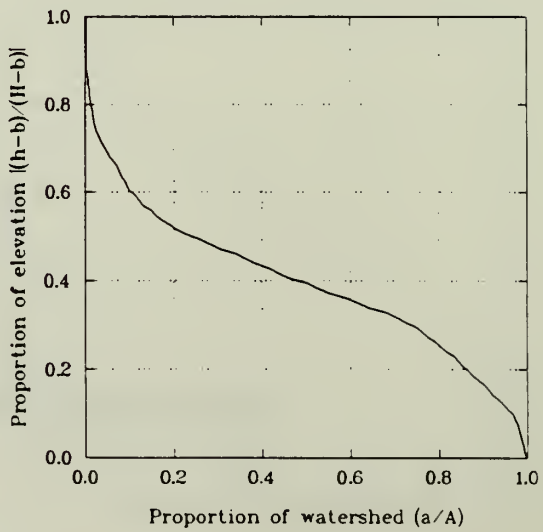
Feet	275595.95	Miles	52.21
Meters	84001.63	Km	84.00

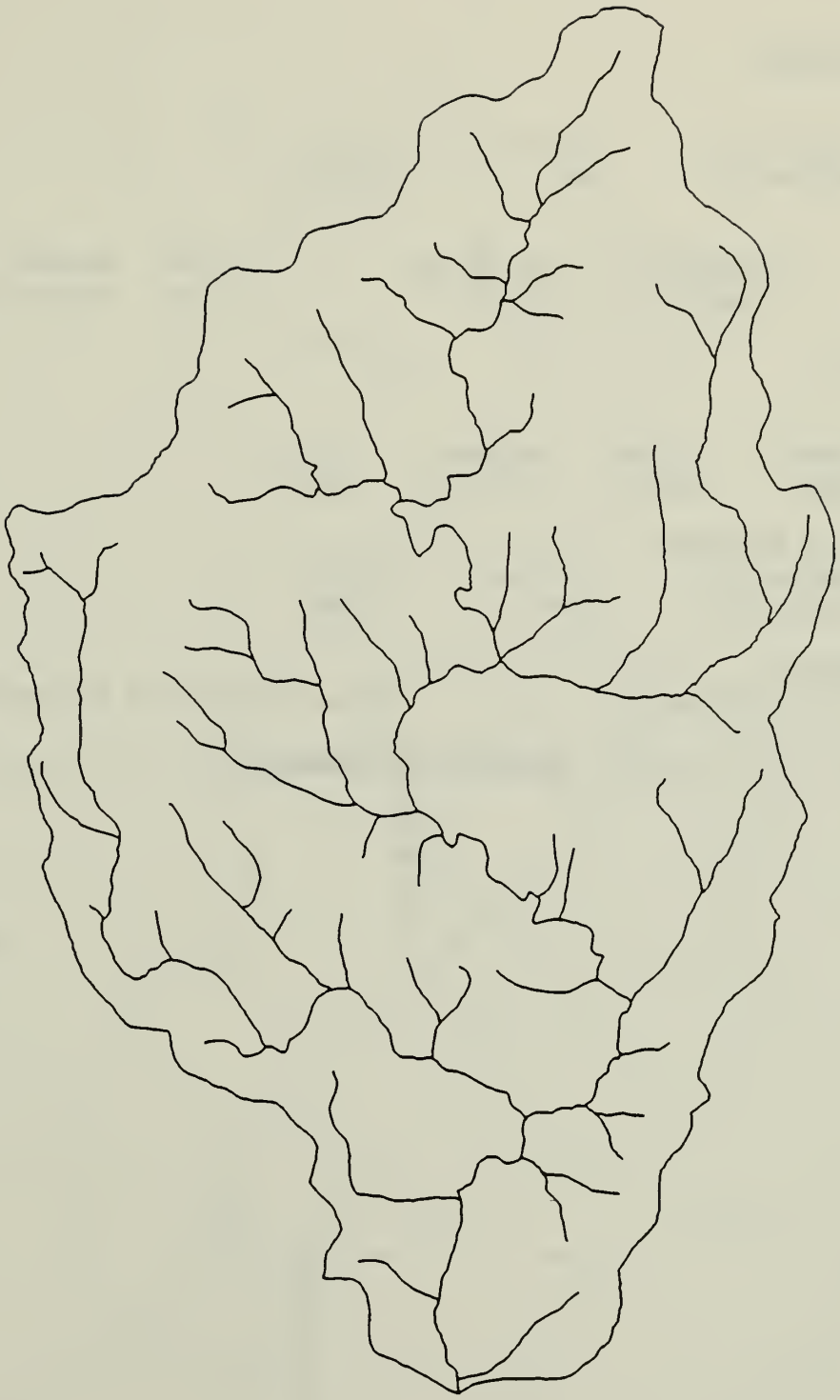
Drainage Density:

Km Stream/Sq Km Watershed 1.54 Miles Stream/Sq Miles Watershed 2.48

Stream Order	Number of Segments	Length (meters)
1	55	44598.35
2	27	21344.77
3	14	10185.39
4	13	7873.12
	Total	84001.63







Watershed 40. Raven Fork.

41. Straight Fork

Perimeter:

Feet	131944.07	Miles	24.99
Meters	40216.55	Km	40.22

Area:

Sq Feet	625267840.	Sq Miles	22.44	Acres	14359.01
Sq Meters	58109900.	Sq Km	58.11	Hectares	5811.00

Shape: 2.21

Elevation:

Lowest -	Feet	2560.	Meters	780.
Highest -	Feet	6234.	Meters	1900.

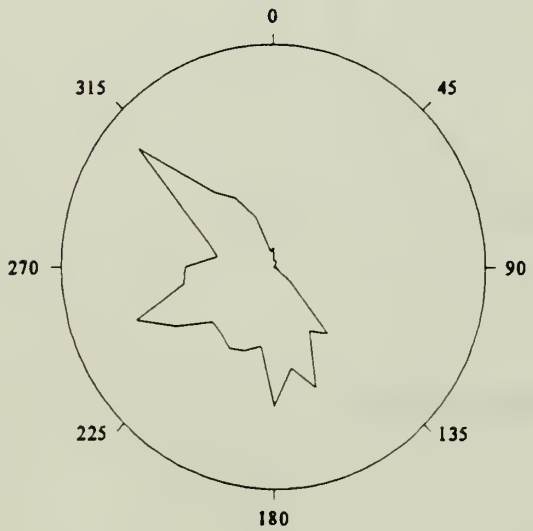
Total Length of Streams:

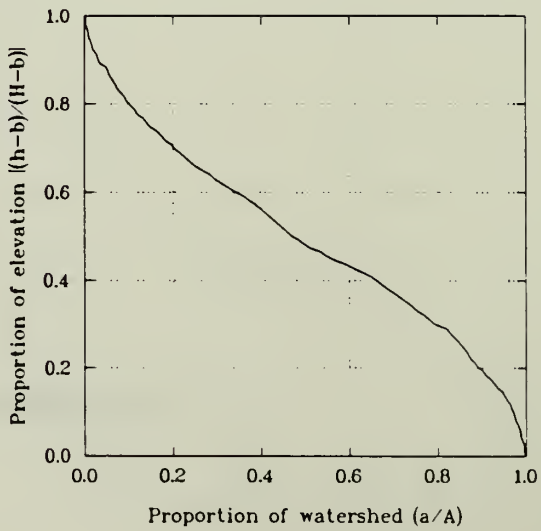
Feet	239449.91	Miles	43.36
Meters	72984.32	Km	72.98

Drainage Density:

Km Stream/Sq Km Watershed 1.26 Miles Stream/Sq Miles Watershed 1.93

Stream Order	Number of Segments	Length (meters)
1	48	44341.61
2	19	9795.19
3	13	8870.28
4	14	9977.22
	Total	72984.32





Watershed 41. Straight Fork.

42. Stillwell Creek

Perimeter:

Feet	46587.23	Miles	8.82
Meters	14199.79	Km	14.20

Area:

Sq Feet	89913032.	Sq Miles	3.23	Acres	2064.83
Sq Meters	8356213.	Sq Km	8.36	Hectares	835.62

Shape: 1.92

Elevation:

Lowest -	Feet	2800.	Meters	853.
Highest -	Feet	5890.	Meters	1795.

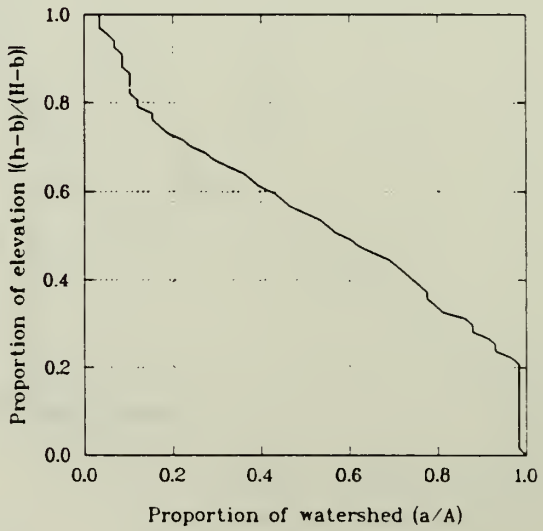
Total Length of Streams:

Feet	26667.16	Miles	5.05
Meters	8128.15	Km	8.13

Drainage Density:

Km Stream/Sq Km Watershed 0.97 Miles Stream/Sq Miles Watershed 1.56

Stream Order	Number of Segments	Length (meters)
1	4	3643.05
2	3	4485.10
	Total	8128.15



Watershed 42. Stillwell Creek.

43. Bunches Creek

Perimeter:

Feet	64822.35	Miles	12.28
Meters	19757.85	Km	19.76

Area:

Sq Feet	160277392.	Sq Miles	5.75	Acres	3680.71
Sq Meters	14895666.	Sq Km	14.90	Hectares	1489.57

Shape: 2.09

Elevation:

Lowest -	Feet	3160.	Meters	963.
Highest -	Feet	5970.	Meters	1820.

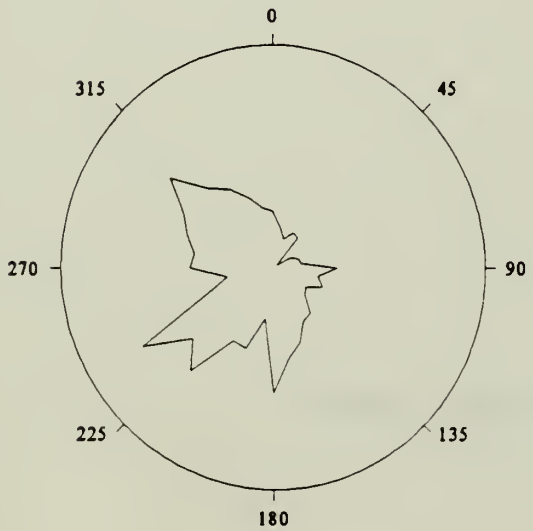
Total Length of Streams:

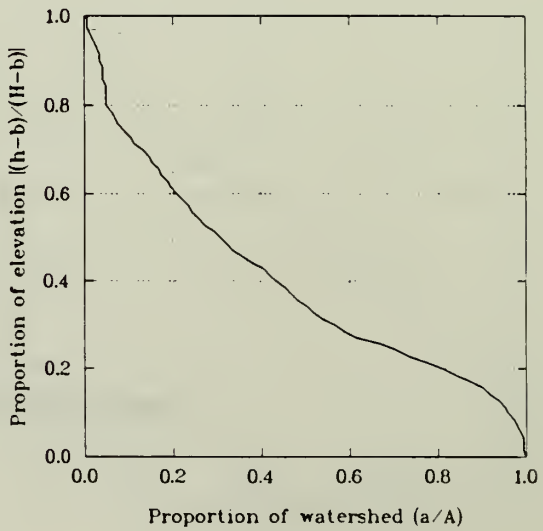
Feet	56431.11	Miles	10.69
Meters	17200.20	Km	17.20

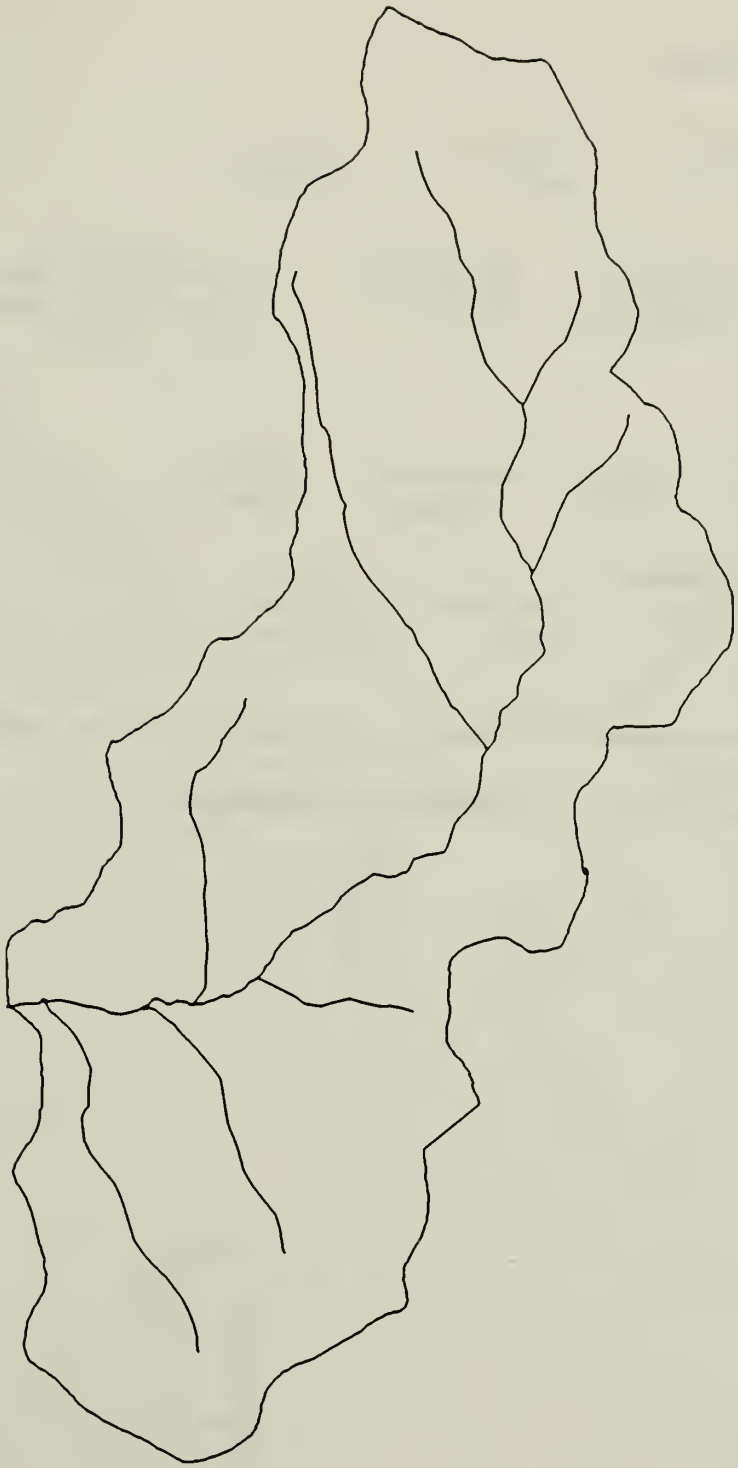
Drainage Density:

Km Stream/Sq Km Watershed 1.15 Miles Stream/Sq Miles Watershed 1.86

Stream Order	Number of Segments	Length (meters)
1	8	12027.33
2	7	5172.88
	Total	17200.20







Watershed 43. Bunches Creek.

44. Cataloochee Creek

Perimeter:

Feet	182720.79	Miles	34.61
Meters	55693.30	Km	55.69

Area:

Sq Feet	1735204350.	Sq Miles	62.26	Acres	39848.92
Sq Meters	161255024.	Sq Km	161.26	Hectares	16126.42

Shape: 1.53

Elevation:

Lowest -	Feet	2320.	Meters	707.
Highest -	Feet	6155.	Meters	1876.

Total Length of Streams:

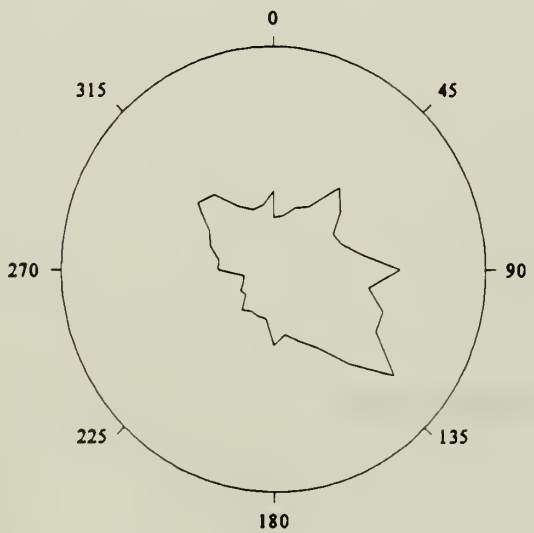
Feet	786047.81	Miles	148.90
Meters	239587.33	Km	239.59

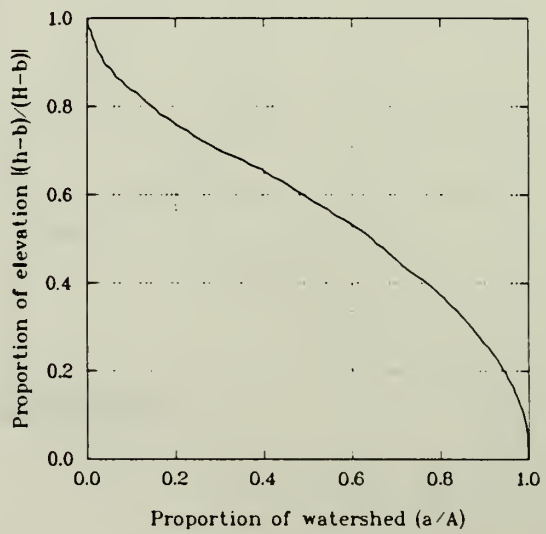
Drainage Density:

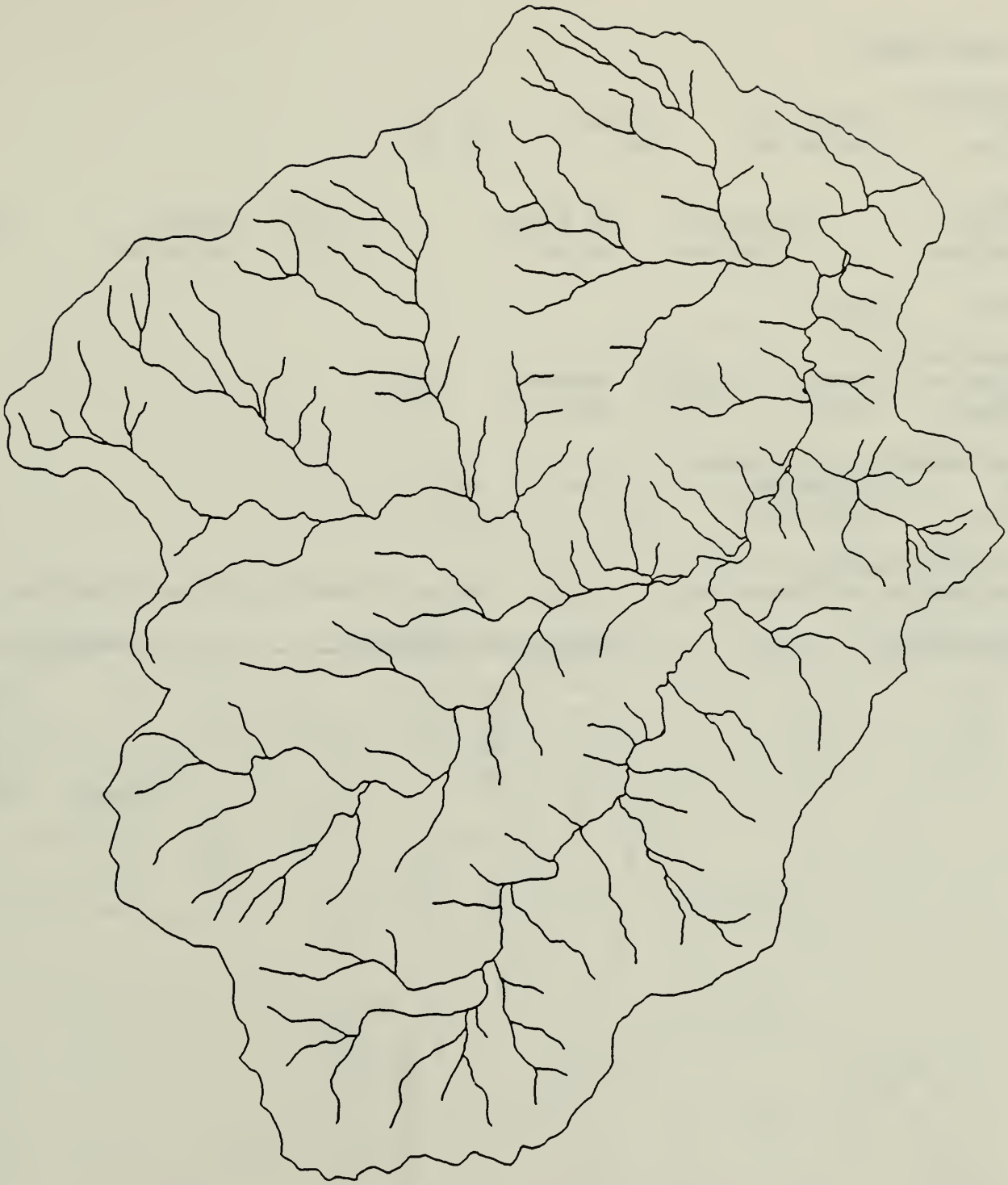
Km Stream/Sq Km Watershed 1.48 Miles Stream/Sq Miles Watershed 2.39

Stream Order	Number of Segments	Length (meters)
1	135	151658.27
2	61	43122.62
3	49	29189.77
4	28	12537.21
5	5	3079.53
	Total	239587.33

Pond: 1 Hectares 0.14







Watershed 44. Cataloochee Creek.

45. Big Creek

Perimeter:

Feet	145584.21	Miles	27.57
Meters	44374.07	Km	44.37

Area:

Sq Feet	971556096.	Sq Miles	34.86	Acres	22311.81
Sq Meters	90290464.	Sq Km	90.29	Hectares	9029.20

Shape: 1.74

Elevation:

Lowest -	Feet	1557.	Meters	474.
Highest -	Feet	6621.	Meters	2018.

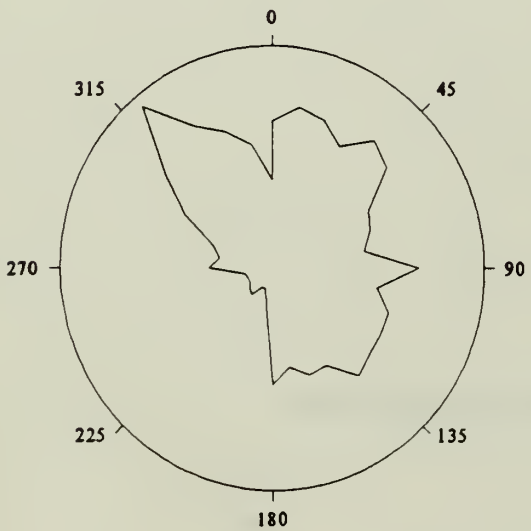
Total Length of Streams:

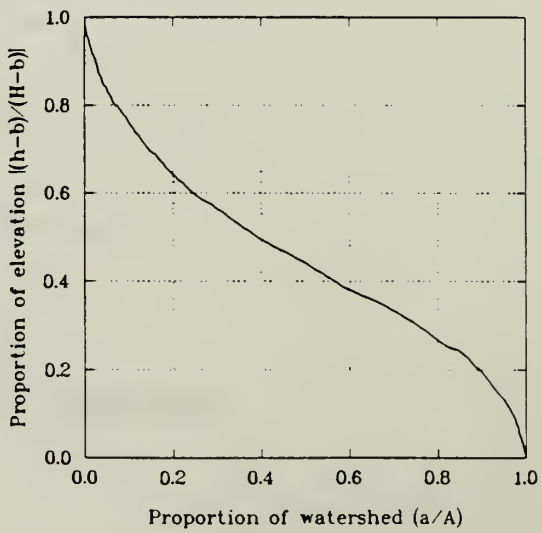
Feet	491182.90	Miles	93.04
Meters	149712.52	Km	149.71

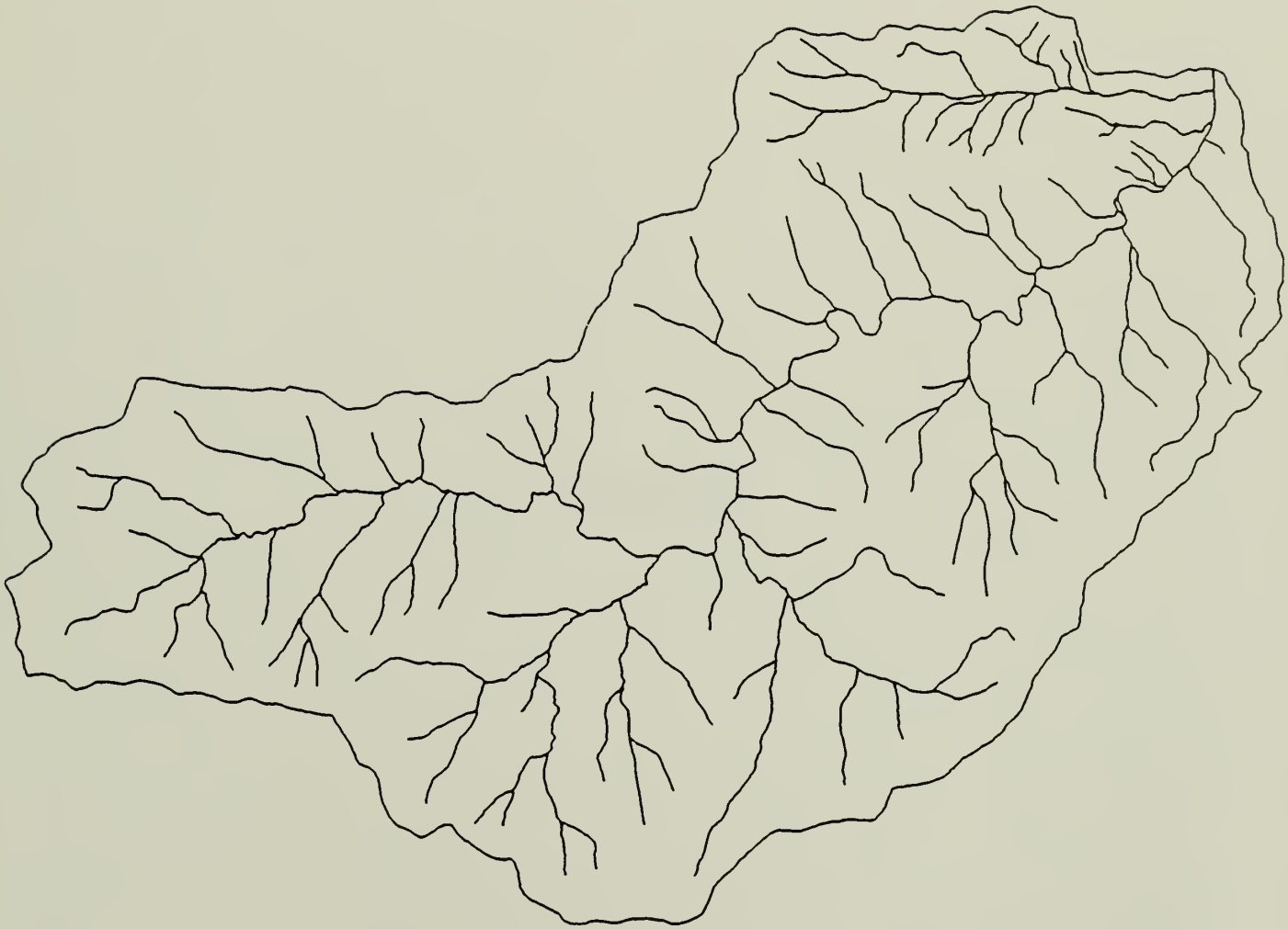
Drainage Density:

Km Stream/Sq Km Watershed 1.66 Miles Stream/Sq Miles Watershed 2.67

Stream Order	Number of Segments	Length (meters)
1	98	94587.46
2	41	26085.90
3	31	16799.30
4	28	12239.94
	Total	149712.52







Watershed 45. Big Creek.

APPENDICES

Appendix A
Data Files

All of the data files created for this project are in ERDAS DIG format. These are fixed format ACSII files that can be accessed in sequential or random mode. The structure of these file is explained in detail in the ERDAS User's Guide, Appendix B. For each watershed there are two files, one containing the stream coordinates and one containing the watershed boundary coordinates. In addition there is one file for the streams not contained in a named watershed, and one file of the boundary of GRSM. These files are listed in Table A1. Because both stream files and watershed boundary files have the same name, it is necessary to keep the files in different subdirectories or on separate floppy disks. On the GIS computers at Uplands and at Headquarters they are kept in separate sub-directories named \STREAMS and \WTRSHDBN, respectively. Backup copies are on separate, labeled diskettes. Backup copies are kept at Uplands and Headquarters.

Streams are recorded in the files by stream segment. Stream order is stored as the GIS value of the segment minus 1. For example, a stream having a GIS value of 2 has an order of 1, and a stream segment of GIS value 3 has an order of 2. In the boundary files, only a single item is stored, with the exception of East Prong Little River which has two items. This is because of an undocumented limitation in ERDAS that prevents individual items from exceeding 5000 points, and the boundary of the East Prong Little River exceeded that number. The GIS value of boundary items is the same as the watershed numbers used in the report. Little River (Combined) has a GIS value of 46, and Oconaluftee River (Combined) has a GIS value of 47.

Table A1. Stream and boundary data files. Files are in ERDAS DIG format.

WATERSHED	FILE NAME	STREAM FILE SIZE (BYTES)	BOUNDARY FILE SIZE (BYTES)
Cosby Creek	COSBY DIG	66,474	20,980
Greenbriar Creek	GRNBRIAR DIG	25,813	18,469
Indian Camp Creek	INDNCAMP DIG	43,984	20,629
Dunn Creek	DUNN DIG	33,265	19,522
Ramsey Creek	RAMSEY DIG	17,227	16,876
Soak Ash Creek	SOAKASH DIG	25,003	11,962
Copeland Creek	COPELAND DIG	16,984	17,065
Middle Prong Little Pigeon River	MPLPRVR DIG	106,650	77,923
Dudley Creek	DUDLEY DIG	34,939	22,087
Roaring Creek	ROARING DIG	54,972	32,023
Baskins Creek	BASKINS DIG	16,984	18,982
LeConte Creek	LECONTE DIG	30,457	26,650
West Prong Little Pigeon River	WPLPRVR DIG	124,578	79,921
East Prong Little River	EPLTLRVR DIG	256,095	125,605
Middle Prong Little River	MPLTLRVR DIG	109,485	94,852
West Prong Little River	WPLTLRVR DIG	83,917	63,100
Little River (Lower)	LWLTLRVR DIG	16,605	22,006
Little River (Combined)	LTLALL DIG	460,242	154,738
White Oak Sinks	OAKSINKS DIG	5,859	16,282
Hesse Creek	HESSE DIG	101,547	50,140
Cane Creek	CANE DIG	25,056	25,975
Abrams Creek	ABRAMS DIG	374,679	124,336
Panther Creek	PANTHER DIG	53,002	54,757
Shop Creek	SHOP DIG	11,638	17,578
Tabcat Creek	TABCAT DIG	19,980	34,642
Parson Creek	PARSON DIG	54,999	36,910
Twentymile Creek	TWENTY DIG	142,237	47,575
Lost Cove Creek	LOSTCOVE DIG	29,647	20,710
Eagle Creek	EAGLE DIG	58,293	62,317
Hazel Creek	HAZEL DIG	122,202	99,415
Pilkey Creek	PILKEY DIG	23,113	17,092
Chambers Creek	CHAMBERS DIG	40,447	24,679
Forney Creek	FORNEY DIG	71,982	68,311
Noland Creek	NOLAND DIG	74,682	59,536
Peachtree Creek	PEACHTRE DIG	7,075	13,204
Deep Creek	DEEP DIG	150,309	70,039
Cooper Creek	COOPER DIG	13,285	24,976
Oconaluftee River (Lower)	LUFTLOWR DIG	52,623	32,590
Oconaluftee River (West)	LUFTWEST DIG	84,429	48,466
Bradley Fork	BRADLEY DIG	65,691	45,874
Oconaluftee River (Combined)	LUFTALL DIG	197,694	71,686
Raven Fork	RAVEN DIG	68,256	44,119
Straight Fork	STRAIGHT DIG	67,068	45,280
Stillwell Creek	STILLWEL DIG	5,265	19,441
Bunches Creek	BUNCHES DIG	11,529	28,594
Cataloochee Creek	CAT DIG	244,458	61,615
Big Creek	BIG DIG	137,679	48,817
Non-Watershed Creeks	FRINGE DIG	293,598	NA
GRSM Outline	GRSMOUTL DIG	NA	28,324

Appendix B
Topographic Data

The topographic data used in this report were derived from the USGS Knoxville W 1/2 1:250,000-scale Digital Elevation Model (DEM), the only complete elevation data set for the entire park. The data were obtained by Dr. James Carter of the University of Tennessee. DEM data are arrayed on a grid in which each data point represents an elevation in meters for the geographic location represented by the point. Slope and aspect data were calculated from the elevation data for each point by a spatial derivative algorithm written by Dr. Carter (Carter, J. 1990. Some effects of spatial resolution in the calculation of slope using the spatial derivative. Technical Papers, 1990 ACSM-ASPRS Annual Convention, Volume 1:43-52.).

In the 1:250,000 DEM the points are 3 seconds apart east to west and north to south. This represents a spacing of approximately 90 m by 75 m. However, since the data are arrayed in latitude and longitude, there is greater separation between the points in the south than between those in the north. These considerations make the translation of data from the DEM to the constant square 90 m by 90 m pixels of the GIS complicated. A program was written that used a nearest-neighbor approach to select the most appropriate value for each pixel. After selecting the appropriate data point, the corresponding elevation, slope, and aspect data were written into separate ERDAS GIS files. Then separate analyses by watershed were conducted to obtain the watershed statistics used in the aspect rosettes and elevation hypsographs.

During construction of the aspect rosettes, large spikes were noted along the cardinal axes (Fig. B1). Carter determined that the spikes were the result of the use of integer elevation values, and the effects were greatest at gentle slopes (<10°), but even at 45° slope only 26

distinct categories of aspect can be computed (Carter, J. submitted. The effect of data precision on the calculation of aspect using gridded DEMs. Photogrammetric Engineering and Remote Sensing.). These same considerations apply to the calculation of slopes from integer elevation data in DEMs, but slope calculations are not affected to the same degree as aspect calculations. Since DEMs are available only in integer format there is no way to obtain more precise aspect data. Therefore, we have combined the aspects calculated at 1° increments

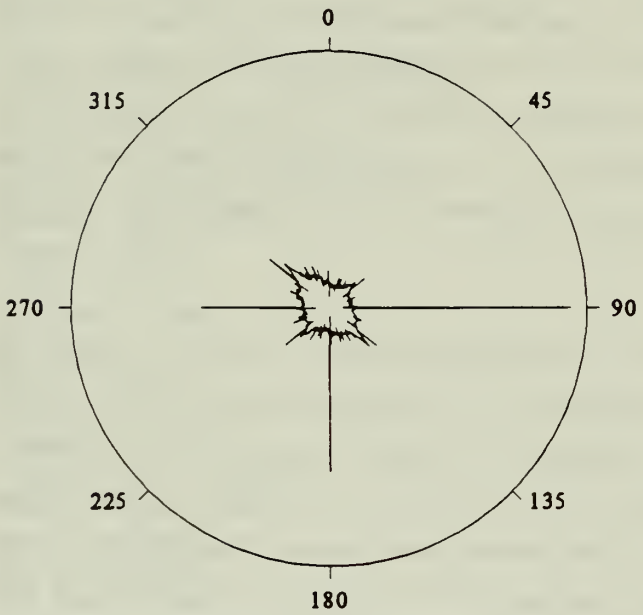


Figure B1. Aspect rosette of park in 1° increments of aspect.

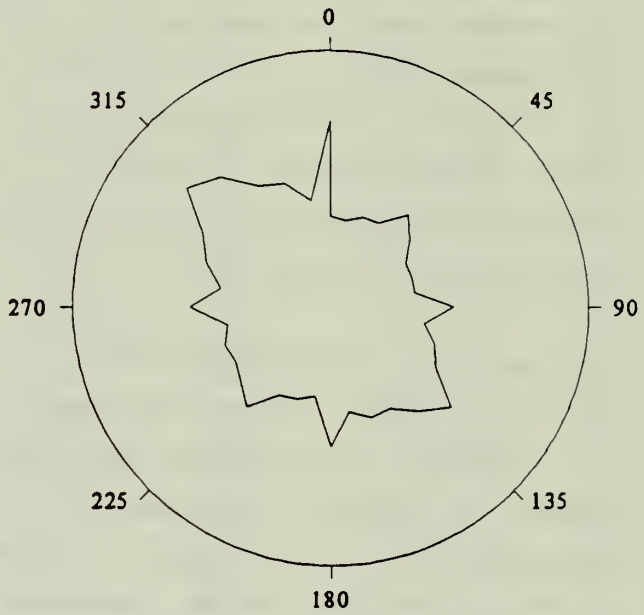


Figure B2. Aspect rosette of park in 10° increments of aspect.

into 10° increments. This smoothes the data and has the effect of reducing the spikes shown in Fig. B1 into the more interpretable form shown in Fig. B2. Spikes still are evident at the cardinal compass points, but are much reduced.

Additional problems with the DEM data were discovered while performing other operations on the data. Fig. B3 is a plot of the differences between elevations in the DEM and 776 digitized elevations from the 7.5 min quadrangles. The elevations were digitized from benchmarks and

other clearly labeled elevation points on the maps. These data were gridded into an ERDAS GIS file and overlain with the DEM data in the elevation GIS file for comparison. It is clear from the figure that there is a large systematic underestimate of elevations in the DEM. While there is no reason to expect exact correspondence between the two data sets, the degree of disparity is great. Differences between the two ranged from -117 m (DEM greater than digitized elevation) to +171 m (digitized elevation greater than DEM), and averaged 30.9 m (P<.0001,

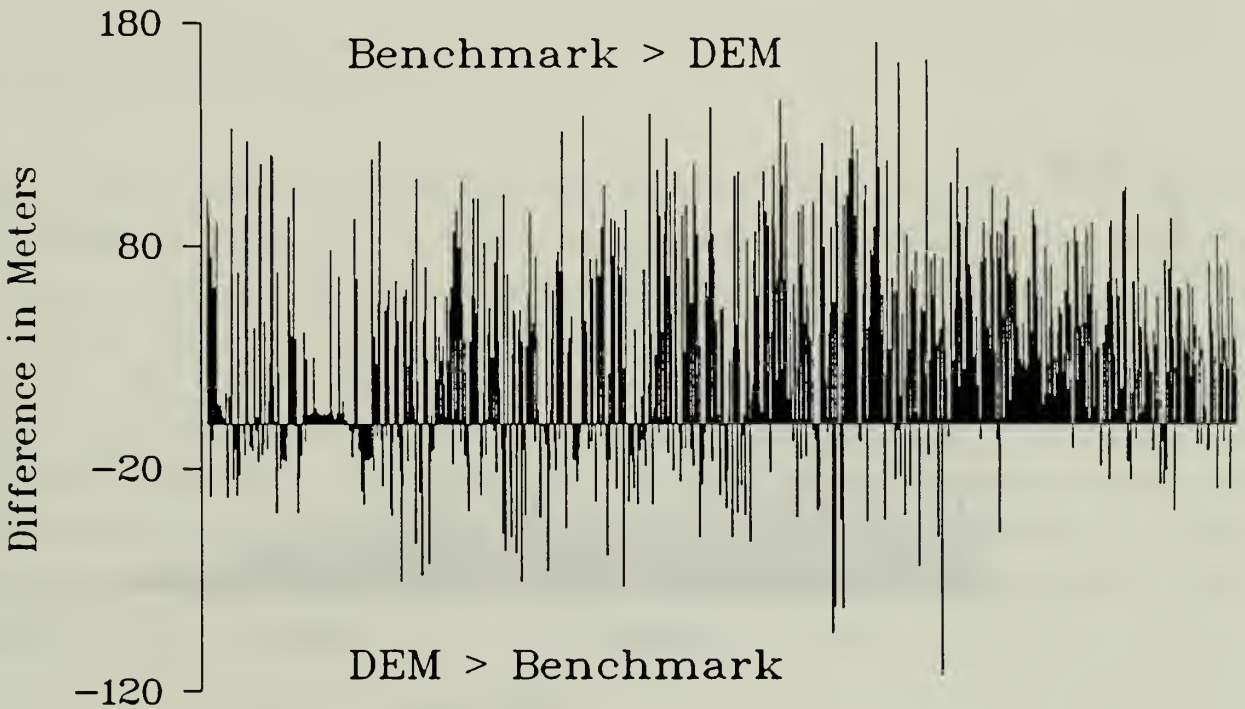


Figure B3. Differences between elevations digitized from 7.5 min topographic quadrangles and those from the Knoxville W 1/2 1:250000-scale DEM for Great Smoky Mountains National Park. Elevations are sorted in increasing order from left to right.

paired sample t-test). The average absolute difference between elevations was 43.0 m. Since the digitized elevations frequently represent mountain peaks and other prominent features of the landscape, it may not be surprising that the DEM elevations are lower than the digitized elevations. However, the degree to which the DEM

underestimates the elevation seems too great to be simply a matter of high elevation bias in the digitized data set.

Fig. B4 illustrates a second type of error found in the DEM. This is a plot of the frequency at which each elevation occurs in the DEM, or in the portion of it available to the authors. The large, uniformly

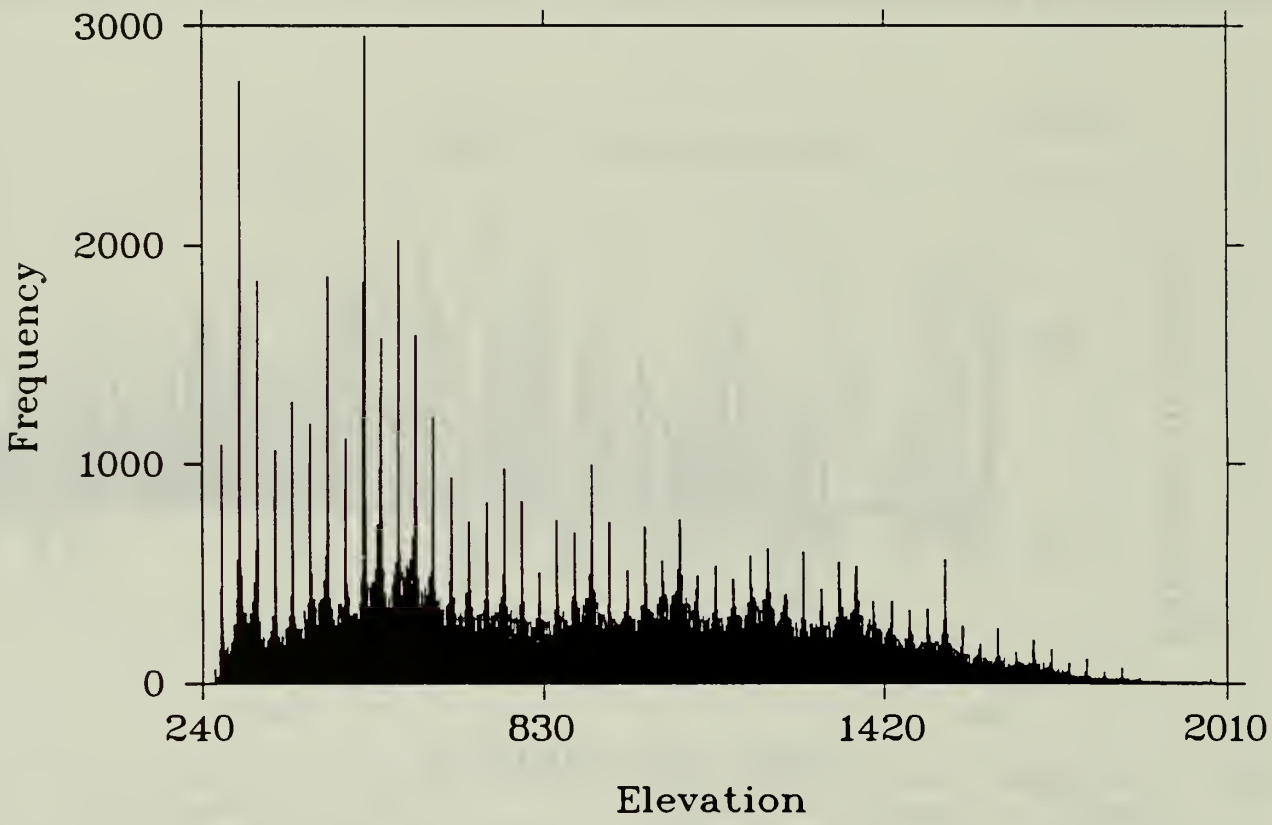


Figure B4. Frequency of elevations in the USGS Knoxville W 1/2 1:25000-scale DEM for 420645 points in and around Great Smoky Mountains National Park.

spaced spikes throughout the plot represent unusually high frequencies of elevations that are at intervals of approximately 31 m. A listing of a portion of the data is presented in Table B1. Dr. Carter believes this spacing represents the original 100 ft interval of contour lines on the 1:250000-scale maps from which the DEM was created. He suggests that this type of anomaly could result if an algorithm was used while

digitizing that interpolated the elevation of a point between two contour lines as being the same as one of the contour lines if the point was within a certain distance of the line. This would lead to a considerable overestimate of elevations equal to those of the contour intervals, accounting for the uniform spacing seen in Fig. B4. The actual algorithm used in digitizing apparently has not been published (A.A. Elassal and V.M. Caruso. 1983. USGS digital cartographic data standards. Digital elevation models. U.S. Geological Survey Circular 895-B. 40pp). Note that the highest spike in Fig. B4 corresponds to an elevation of 521 m in Table B1. This spike represents the normal pool elevation of Lake Fontana and is in fact a normal feature of the landscape, not an aberration.

Finally, when the elevation file derived from the DEM data is displayed on a graphics terminal in black and white, uniformly spaced diagonal lines are visible. These lines are oriented from the southwest to the northeast, and are approximately 4837 m apart (distance along the ground). The lines appear in files derived from the elevation data, and are quite intrusive once they have been noticed. As of yet no explanation has been advanced to explain the origin of these lines, but they clearly do not represent natural features of the landscape. Other types of non-random lines have been found by researchers using different DEM data sets (J.R. Carter, pers. comm.).

Table B1. Partial listing of elevation frequencies from USGS Knoxville W 1/2 1:250000-scale DEM. Elevations corresponding to approximate 100 foot contour intervals are highlighted.

m	freq	m	freq	m	freq	m	freq	m	freq	m	freq
262	65	306	531	351	195	**396**	**1285**	441	232	486	613
263	6	307	415	352	149	397	608	442	288	487	884
264	9	308	494	353	163	398	299	443	383	**488**	**1117**
265	28	309	305	354	207	399	307	444	294	489	455
266	14	310	358	355	184	400	221	445	294	490	426
267	18	311	302	356	179	401	272	446	293	491	298
268	39	312	322	357	159	402	191	447	390	492	312
269	156	313	261	358	241	403	213	448	329	493	397
270	105	314	237	359	190	404	252	449	330	494	250
271	163	315	331	360	207	405	209	450	470	495	255
272	430	316	235	361	307	406	202	451	382	496	237
273	278	317	252	362	266	407	198	452	392	497	312
274	**1088**	319	280	363	265	408	249	453	411	498	244
275	244	320	237	364	289	409	192	454	581	499	251
276	192	321	225	365	852	410	185	455	534	500	325
277	123	322	322	366	1064	411	256	456	653	501	250
278	121	323	263	367	309	412	182	**457**	**1859**	502	219
279	120	324	272	368	240	413	204	458	735	503	218
280	155	325	254	369	276	414	191	459	347	504	323
281	142	326	377	370	192	415	335	460	323	505	242
282	133	327	273	371	182	416	241	461	394	506	230
283	171	328	336	372	215	417	227	462	296	507	324
284	120	329	462	374	149	418	277	463	257	508	252
285	126	330	352	375	183	419	231	464	257	509	294
286	133	331	388	376	220	420	295	465	346	510	266
287	152	332	376	377	173	421	279	466	248	511	368
288	132	333	607	378	166	422	368	467	230	512	318
289	120	334	540	379	215	423	283	468	294	513	276
290	187	**335**	**1837**	380	170	424	327	469	250	514	307
291	119	336	662	381	164	425	383	470	266	515	470
292	142	337	272	382	174	426	1004	471	214	516	386
293	202	338	241	383	249	**427**	**1183**	472	304	517	496
294	269	339	228	384	187	429	503	473	244	**518**	**1833**
295	181	340	285	385	185	430	320	474	234	519	484
296	222	341	200	386	258	431	291	475	363	520	378
297	272	342	167	387	216	432	265	476	257	521	2955
298	248	343	163	388	200	433	388	477	259	522	842
299	385	344	220	389	249	434	260	478	275	523	375
300	396	345	159	390	310	435	274	479	366	524	361
301	563	346	160	391	270	436	348	480	255	525	460
302	424	347	209	392	294	437	268	481	283	526	351
303	535	348	142	393	403	438	243	482	346	527	332
304	1849	349	164	394	329	439	250	484	336	528	341
305	**2749**	350	142	395	398	440	371	485	357	529	440

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