Alabama Department of Environmental Management

FINAL

Siltation TMDL Development for 22 Segments in the Lower Tennessee River Basin

Water Quality Branch
Water Division
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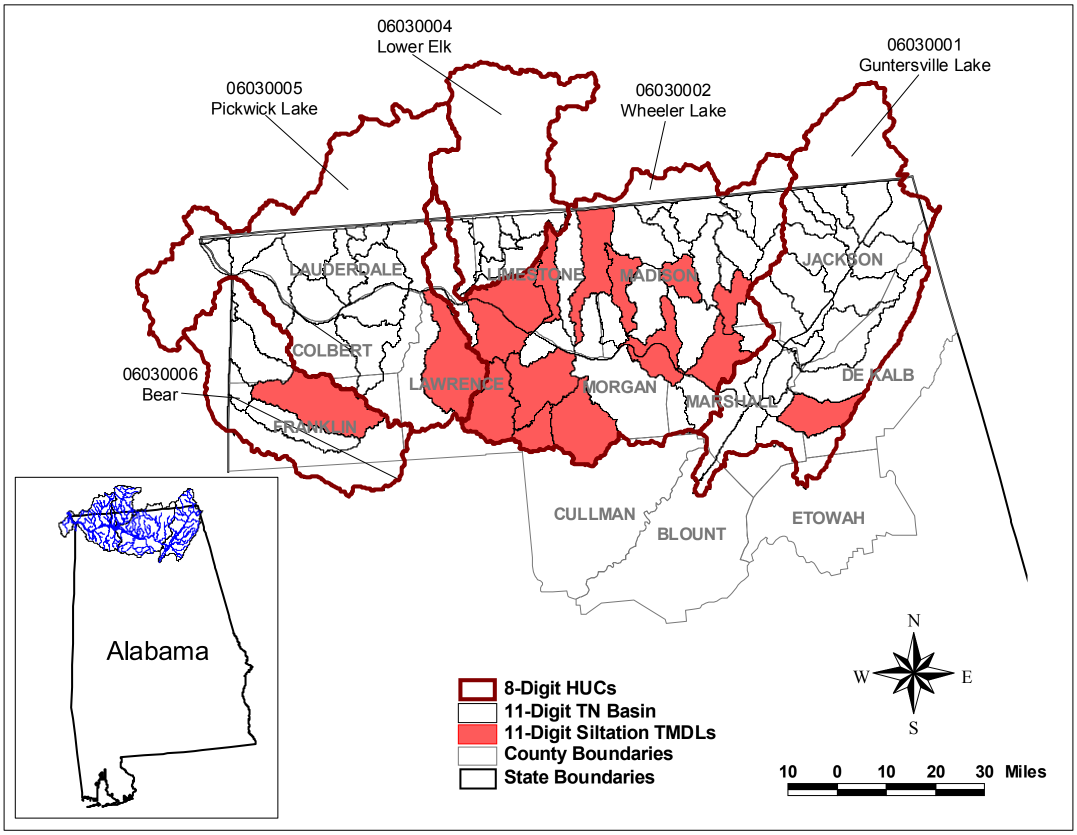

303(d) Listed Segments for Siltation within the Lower Tennessee River Basin

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1.0 Executive Summary

The Tennessee River flows from its headwaters in the State of Tennessee down to the Ohio River at the Illinois and Kentucky Border. The Tennessee River basin covers a total of 19,500 square miles and resides within the states of Tennessee, Alabama, Kentucky, Mississippi, and Georgia. Relative coverage for each of these states respectively are, 57 percent, 35 percent, 5 percent, 2 percent, and 1 percent. Within the Alabama portion of the Tennessee River Basin, a total of 22 segments have been on the State's §303(d) use impairment list since 1996 for siltation. The use classifications for all of these streams are Fish and Wildlife. Table 1-1 presents the 303(d) listed segments with their names and cataloging numbers.

Biological assessment data or information collected in 1994 and 1995 identified habitat alteration impairments for the 22 segments listed in Table 1-1. Biological assessment data from the TVA Macroinvertebrate/EPT and Fish/IBI Biological Data in 1994 and 1995 provided IBI scoring of the system health. The 22 listed segments scored IBI ratings below acceptable with fair to poor ratings.

The following report addresses the results of the TMDL analysis for siltation for the listed segments within the Tennessee River Basin. In accordance with the water quality criteria for the State of Alabama, a narrative criterion to maintain the biological integrity of the waters of the State exists and must be converted to an appropriate numerical target. The TMDL developed herein addresses this through determination of reference watersheds where biological integrity is presently maintained and a baseline sediment loading is determined that will maintain the biological integrity. An implicit margin of safety is applied through conservative assumptions used in the development and application of the sedimentation model as well as through a 10 percent reduction in the calculated target value for unimpaired segments.

The Watershed Characterization System (WCS) Sediment Tool is utilized to define baseline as well as impaired segment loads. This tool has been developed for Alabama and EPA Region IV to provide watershed based sediment load calculations and has been utilized in the development of numerous TMDLs throughout the southeast region.

A summary of the TMDL for each of the 22 listed segments is provided in the table presented on the next page. The pollutants shown in the table include the annual average point and nonpoint sediment loads to each listed segment. The non-point source components are normalized by the total subwatershed area analyzed to provide a per acre allowable annual contribution.

The primary sources of impairment identified through the TMDL process are row cropping practices as well as roadways. In the impaired segments, these uses represent greater than 90 percent of the sediment load. The model application utilizes coefficients and constants that represent typical row cropping practices in place at the time of biological assessments (1994 and 1995). These coefficients may not represent recent alterations in farming practice implemented within the state since the initial period of the data collection. These issues are addressed within the implementation section of this report.

Impaired Segment (ID)	1996 Priority Level	WLA Point Source Load (tons/year)	LA Non-point Source Load (tons/year)
USGS Catalogue Unit 06030001 - Guntersville Lake			
Scarham Creek (AL/06030001-270_01)	Low	0.0	7,326
USGS Catalogue Unit 06030002 - Wheeler Lake			
Cole Spring Branch (AL/06030002-070_01)	Low	0.0	1,667
Little Paint Rock Creek (AL/06030002-100_01)	Low	0.0	2,198
Chase Creek (AL/06030002-190_01)	Low	0.0	1,240
Cane Creek (AL/06030002-220_01)	Low	0.0	1,127
Aldridge Creek (AL/06030002-230_01)	Low	383.4	3,687
Indian Creek (AL/06030002-250_02)	Low	0.0	6,655
Limestone Creek (AL/06030002-300_01)	Low	5.1	17,800
Flint Creek (AL/06030002-330_01)	High	123.2	74,171
Mack Creek (AL/06030002-330_04)	Low	0.0	1,350
Robinson Creek (AL/06030002-330_05)	Low	0.0	758
Crowdabout Creek (AL/06030002-340_01)	High	0.0	8,517
Herrin Creek (AL/06030002-340_02)	Low	0.0	1,178
West Flint Creek (AL/06030002-350_02)	Medium	3.4	27,751
Village Branch (AL/06030002-350_03)	Low	0.0	1,872
McDaniel Creek (AL/06030002-360_02)	Low	0.0	2,213
Flat Creek (AL/06030002-360_03)	Low	0.0	1,640
Swan Creek (AL/06030002-390_01)	Low	410.8	9,735
Round Island Creek (AL/06030002-400_01)	Low	0.0	5,883
Mallard Creek (AL/06030002-410_01)	Low	0.0	16,626
USGS Catalogue Unit 06030005 - Pickwick Lake			
Big Nance Creek (AL/06030005-010_01)	High	56.9	34,597
USGS Catalogue Unit 06030006 - Bear Creek Reservoir			
Harris Creek (AL/06030006-040_02)	High	0.0	4,269

WLA = Wasteload Allocation, LA = Load Allocation

Table 1-1. Maximum Allowable Annual Sediment Loads by Source for the Impaired Segments within the Tennessee River Basin

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality criteria applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. Total maximum daily loads (TMDLs) for all pollutants causing violation of applicable water quality criteria are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality criteria with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

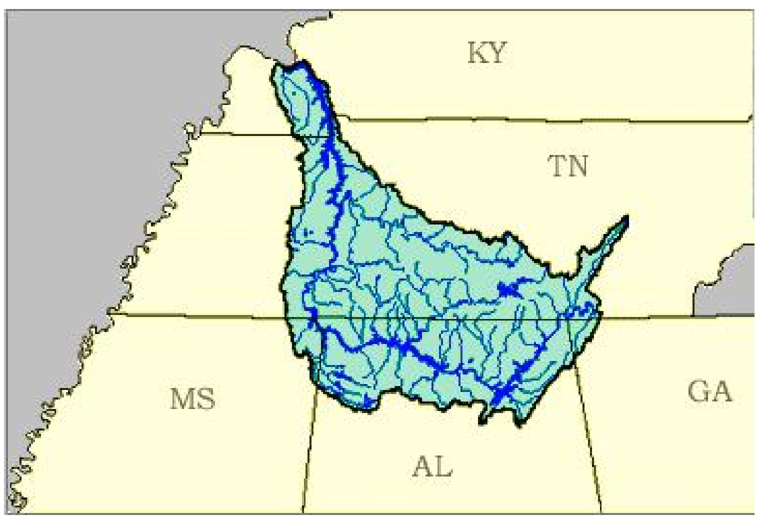

Figure 2-1. Tennessee River Basin

The Tennessee River flows from its headwaters in the state of Tennessee down to the Ohio River at the Illinois and Kentucky border. The Tennessee River Basin covers a total of 19,500 square miles and resides within the states of Tennessee, Alabama, Kentucky, Mississippi, and Georgia. Figure 2-1 presents the extent of the Tennessee River Basin relative to the state boundaries. Relative coverage for the States of Tennessee, Alabama, Kentucky, Mississippi and Georgia respectively are, 57 percent, 35 percent, 5 percent, 2 percent, and 1 percent. Within the State of Alabama, the Tennessee River Basin drains 6,826 square miles of land area and is comprised of 93 sub-watersheds, some of which are several hundred square miles.

The State of Alabama has identified 22 segments within the Tennessee River Basin as being impaired by siltation, as reported on the 1996 and 1998 §303(d) list(s) of impaired waters. Table 1-1 presents the individual listed segment names along with their priority level and the individual watershed in which they reside. Figure 2-2 presents the locations of the listed segments within the Alabama portions of the Tennessee River Basin.

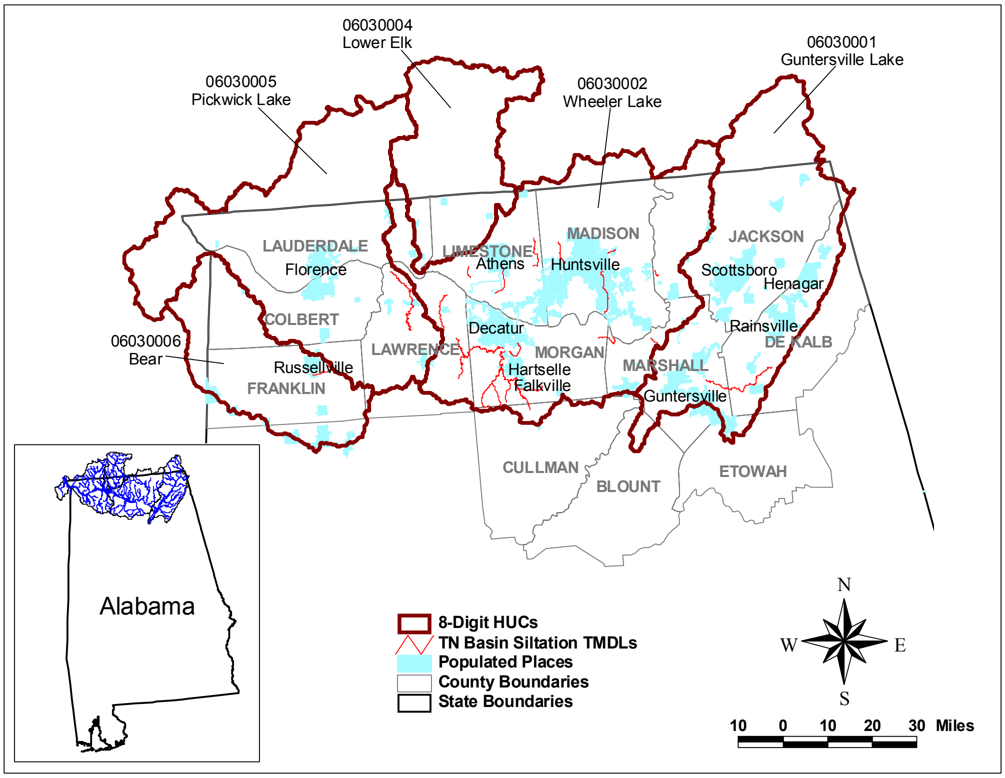

Figure 2-2. Listed Segments for Siltation within the Alabama Portion of the Tennessee River Basin

The TMDLs developed for these segments illustrate the steps that can be taken to address a waterbody impaired by siltation. The TMDL is consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls are implemented, and water quality is monitored for plan effectiveness. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed if monitoring indicates continuing water quality problems.

2.2 Problem Definition

The 22 water segments in the Tennessee River Basin for which these TMDLs are being established are listed on the State of Alabama's 1996 Section §303(d) list. All of the 22 segments are impaired based on biological community and habitat impairment (due to excessive sedimentation).

The purpose of this TMDL is to establish the acceptable loading of sediment from all sources, such that the long-term sediment loading levels in the 22 listed segments will not create conditions where biological communities and habitat are impaired as interpreted by EPA for protection of aquatic life.

Water Quality Criterion Violation: Biological Integrity (narrative)

Pollutant of Concern: Sediment

Water Use Classification: Fish & Wildlife

The impaired stream segments are classified as Fish and Wildlife. Usage of waters in this classification is described in ADEM Admin. Code R. 335-6-10-.09(5)(a), (b), (c), and (d).

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food processing purposes.

(b) Conditions related to best usage:

The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted criteria of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

Siltation Criteria:

The State of Alabama's Rules and Regulations for Water Quality Control do not include a numerical water quality criterion for aquatic life protection due to sediment. The narrative criterion is to maintain the biological integrity of the waters of the State of Alabama (ADEM 335-6-10-.06 (a) & (c)).

3.0 Technical Basis for TMDL Development

3.1 Applicable Water Quality Criterion

As stated in Section 2.0, Alabama's water quality criteria do not include a numerical water quality criterion for aquatic life protection due to sediment. The narrative criterion is to maintain the biological integrity of the waters of the State of Alabama. Therefore it is necessary to develop numerical targets based upon this narrative criterion.

Within this TMDL report, numerical targets are established through use of reference watersheds within the Tennessee River Basin that reflect conditions within the listed segments, and that have been determined through biological assessment to not be impaired. As the impairment of biological integrity is generally a long-term process of sediment build up, the use of the Sediment Tool (described in Section 4) to determine annual average loading conditions through the Universal Sediment Loss Equation (USLE) is appropriate for development of numerical targets in reference watersheds, as well as determination of existing loads and reductions in non-point source loads to the system. The reference watersheds then define the baseline annual average loading conditions as the numerical target. More detail on Target Development is presented in Section 3.3.

3.2 Source Assessment

A TMDL evaluation examines the known potential sources of the pollutant in the watershed, including point sources, nonpoint sources, and background levels. For the purpose of this TMDL, facilities permitted under the National Pollutant Discharge Elimination System (NPDES) Program are considered point sources.

ADEM maintains a database of current NPDES permits and GIS files that locate each permitted outfall. This database includes municipal, semi-public/private, industrial, mining, industrial storm water, and concentrated animal feeding operations (CAFOs) permits. Table 3-1, below, shows the permitted point sources within the Tennessee River Basin that discharge into the 22 impaired segments. Where data are available for each discharge, the table presents the average and maximum loads along with the receiving water name and NPDES permit number. Figure 3-1 shows the locations of each facility. The sub-watersheds where listed segments exist are also highlighted.

In general for sediment loads to the receiving streams, the point source discharge levels are negligible in relation to the non-point sources. In addition, the point sources are generally composed more of organic material and therefore would provide less direct impact to biological integrity (through settling and accumulation) than would direct soil loss to the streams.

NPDES Permit Number	Facility Name	Permit Limits for Suspended Solids (Tons/Year)		Receiving Water
		Average	Maximum	
Aldridge Creek (AL/06030002-230_01)				
AL0056855	Huntsville Aldridge Cr. WWTP	383.4	575.2	Aldridge Creek
Limestone Creek (AL/06030002-300_01)				
AL0068241	East Limestone School	5.1	7.7	UT Limestone Cr.
Swan Creek (AL/06030002-390_01)				
AL0020206	Athens WWTP	410.8	616.6	Town Creek
Big Nance Creek (AL/06030005-010_01)				
AL0020672	Moulton WWTP	56.9	85.6	Borden Creek
West Flint Creek (AL/06030002-350_02)				
AL0054879	East Lawrence School	3.4	5.1	UT West Flint Cr.
Flint Creek (AL/06030002-330_01)				
AL0054674	Hartselle WWTP	123.2	184.9	Shoal Creek

UT = unnamed Tributary

Table 3-1. Contributing NPDES Permitted Point Source Loads

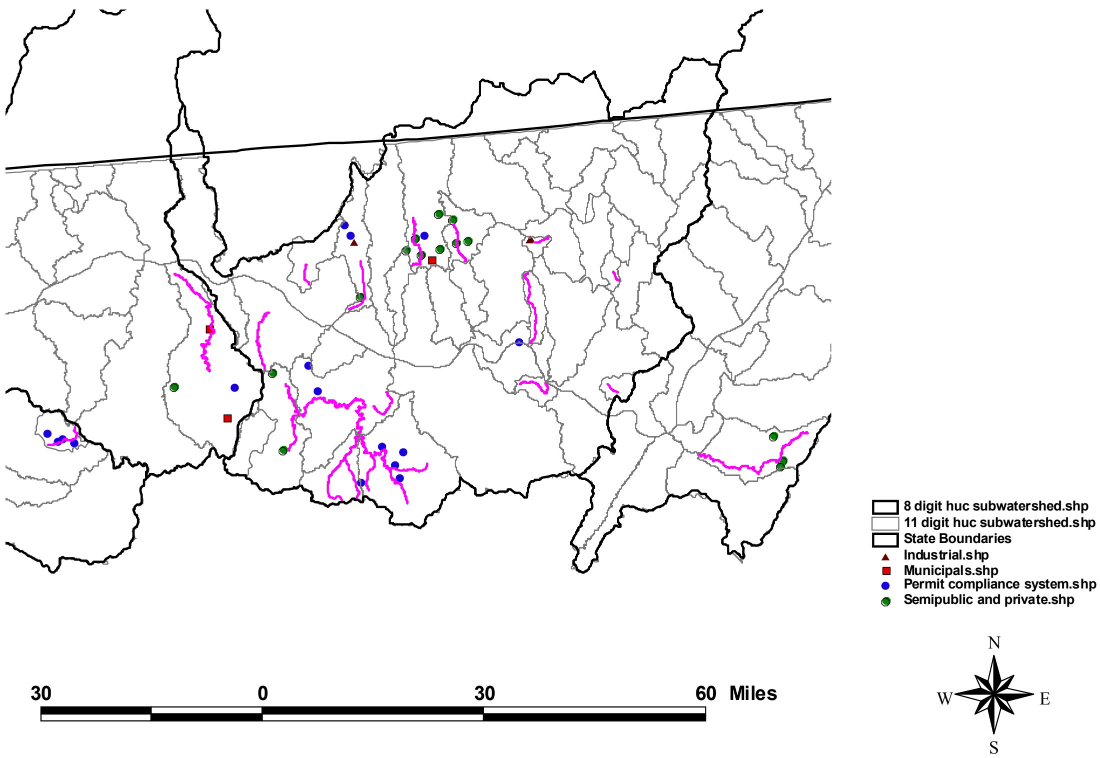

Figure 3-1. Location Map of Point Sources

3.2.2 Non-Point Sources in the Tennessee River Basin

For the listed waterbodies within the Tennessee River Basin, the primary sources of non-point source sediment loadings come from agriculture, roadways, and urban sources. Table 3-2 presents the biological assessment and identified non-point sources of impairment for each of the listed segments. The data was taken from the TVA Macroinvertebrate/EPT and Fish/IBI Biological Data for 1994 and 1995, included in Appendix B of Alabama's 1996 305(b) report.

Impaired Segment	Biological Health	Ecoregion	Identified Sources
USGS Catalogue Unit 06030001 - Guntersville Lake			
Scarham Creek	Poor/Fair	68d	Ag NPS
USGS Catalogue Unit 06030002 - Wheeler Lake			
Cole Spring Branch	Poor	71g	Ag NPS
Little Paint Rock Creek	Poor	71g	Ag NPS
Chase Creek	Poor/Fair	71g	Ag & Urban NPS
Cane Creek	Poor	68c	Ag NPS
Aldridge Creek	Poor	71g	Urban NPS
Indian Creek	Poor/Fair	71g	Ag NPS
Limestone Creek	Fair	71g	Ag NPS
Flint Creek	Poor/Fair	71g	Ag & Urban NPS
Mack Creek	Poor	71g	Ag NPS
Robinson Creek	Poor/Fair	68c	Ag NPS
Crowdabout Creek	Poor/Fair	71g	Ag NPS
Herrin Creek	Poor/Fair	71g	Ag NPS
West Flint Creek	Fair	71j	Ag NPS
Village Branch	Poor/Fair	71g	Ag NPS
McDaniel Creek	Poor/Fair	71g	Ag NPS
Flat Creek	Poor/Fair	71j	Ag NPS
Swan Creek	Very Poor/Poor	71g	Ag & Urban NPS
Round Island Creek	Poor	71g	Ag NPS
Mallard Creek	Poor/Fair	71g	Ag NPS
USGS Catalogue Unit 06030005 - Pickwick Lake			
Big Nance Creek	Poor/Fair	71g	Ag NPS
USGS Catalogue Unit 06030006 - Bear Creek Reservoir			
Harris Creek	Poor/Fair	71g	Ag NPS

Table 3-2. Biological Assessment and Non-point Sources for Listed Waters in the Tennessee Basin.

The primary agricultural practice that causes or contributes to sediment loads is row cropping. Within the watersheds of the Tennessee River Basin the primary crops grown that utilize the practice of row cropping are cotton, soybean, and corn. Within the Tennessee Basin the distribution of crop production varies by county. Within Jackson

County, the primary crops are soybeans. Within Madison, Limestone, Lawrence, Colbert, and Lauderdale counties the primary crop is cotton. As tillage and row cropping practices differ based upon the type of crop production, the potential for sediment erosion and delivery will vary county to county and within the watersheds of the 22 listed segments. The sediment analyses presented in Section 4.0 account for these varying agricultural practices through coefficients within the Universal Soil Loss Equation and reflect present best local knowledge.

At the time of the biological assessments for the 1996 §303(d) list (1994-1995), conventional practices for the row cropping of cotton were utilized throughout most of the Tennessee River Basin. Recent improvements have taken place within various counties such that more conservative methods should provide much less potential for soil erosion. As the listing is based upon conditions in place at the time of the biological assessment, the load determinations, and the TMDL reductions may not reflect more recent practices in-place.

Additional significant sources of sediment loading are roads and construction activities that expose base soils to erosion due to rainfall and wash off.

Land use distributions within the individual sub-watersheds are dominated by a mix of forest and agricultural uses with some showing additional urban areas. Appendix 9.2 presents figures of the individual sub-watershed land-use distributions.

For each sub-watershed the annual average sediment load was calculated using the Universal Soil Loss Equation (USLE)(see Section 4) and broken down by land use sediment sources and road erosion sediment sources. The simulated long-term area weighted watershed sediment loads calculated using the Sediment Tool (see Section 4.0) for the listed streams in the Tennessee River Basin are presented in Table 3-3. The table presents the watershed acreages associated with the listed segments; the road, source, and composite sediment erosion rates; the road, source, and composite sediment delivery rates, as well as the per unit area sediment delivery rates. Within this table erosion represents the material directly washed off of the land surface, sediment delivery represents the material that reaches the receiving stream. The composite sediment delivery rates, and the per acre sediment delivery rates will be targeted in the TMDL development presented in Section 5.0.

3.3 Numeric Sediment Target Determination

EPA regulations define loading, or assimilative capacity, as the greatest amount of loading that a waterbody can receive without violating water quality criteria (40 CFR Part 130.2(f)). For sedimentation, the State of Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10-.06-(a)&(c)) provides a narrative criteria that establishes that biological integrity within the stream segment must be maintained.

In order to develop a numeric criteria that provides for the protection of the designated uses of the stream segments within the Tennessee River Basin, a target annual average loading of sediment to the listed reaches was determined. The target represents loading conditions within reference watersheds where physical conditions are similar and biological assessments have identified that the waterbodies are fully supporting of designated uses. It has been determined that biological impairment of waterbodies due to excessive siltation is a long-term process and therefore the use of annual average loading conditions, as calculated through the Universal Soil Loss Equation, are appropriate as the TMDL target loading condition.

The determination of the reference watersheds for the 22 siltation TMDLs was based upon Ecoregional reference site monitoring data as well as other biological monitoring data. Ecoregion reference sites are established as fully supporting locations within specific Ecoregions. Table 3-2 presents the Ecoregion within which each of the listed segments reside. For the 22 TMDLs two level-three Ecoregions are present, these are:

- Southwestern Appalachians (68)
- Interior Plateau (71)

Within each of these level three ecoregions, the listed segments occupy 2 level four Ecoregions. Within the Southwestern Appalachians these are the Plateau Escarpment (68c) and the Southern Table Plateaus (68d). Within the Interior Plateau these are the Eastern Highland Rim (71g), and the Little Mountain (71j).

Ideally, Ecoregion reference sites (or fully supporting sample sites) would be available for each of the level four Ecoregions in order to establish reference annual average loads that coincide with fully supporting segments. Under the "Water Quality Report to Congress" submitted in June 1996, upon which the 1996 §303(d) list was developed, applicable reference sites were only available for the Southern Table Plateaus (68d). Additionally a fully supporting biological monitoring station was available for the Eastern Highland Rim (71g). The two locations were:

- Indian Camp Creek in 71g
- Bryant Creek in 68d

No direct reference site information, or fully supporting biological monitoring station was available for the Little Mountain Ecoregion, and the Plateau Escarpment Ecoregion. It is important that the biological evaluations utilized in the determination of the reference site conditions, coincide with the conditions upon which the site was listed in order to provide consistency with the methodology that established the 303(d) list being evaluated.

Based upon the limited data available under the 1996 listing conditions, the reference site loading conditions were generalized for each level three ecoregion (Southwestern Applalachians and Interior Plateau) based upon the two available reference sites. The applicable annual average sediment load was then calculated using the methodology described in Section 4.0. The reference annual average unit load for each Ecoregion was then set at:

- Southwestern Appalachians (68) – 0.1396 tons/acre/year
- Interior Plateau (71) – 0.3003 tons/acre/year

Under the requirements of the TMDL program a factor of safety of 10 percent was applied to these targets. The revised annual average target loads are:

- Southwestern Appalachians (68) – 0.1256 tons/acre/year
- Interior Plateau (71) – 0.2703 tons/acre/year

These become the target annual average loads for the ecoregions within which each listed segment resides.

Watershed	Area		Road Erosion	Source Erosion	Composite Erosion	Road Sediment	Source Sediment	Composite Sediment	Unit Sediment	
	sq. miles	acres	(tons/year)	(tons/year)	(tons/year)	(tons/year)	(tons/year)	(tons/year)	(tons/ac/year)	(lb/ac/year)
USGS Catalogue Unit 0603001 - Guntersville Lake										
Scarham Creek	91.1	58307.4	8519.5	32204.8	40724.3	2720.9	8943.0	11664.0	0.2000	400.1
USGS Catalogue Unit 0603002 - Wheeler Lake										
Cole Spring Branch	9.6	6167.8	1017.3	5468.9	6486.2	536.5	2357.9	2894.3	0.4693	938.5
Little Paint Rock Creek	12.7	8130.7	1900.9	5405.4	7306.3	918.5	1903.0	2821.6	0.3470	694.1
Chase Creek	7.2	4585.9	1343.4	4060.2	5403.5	648.2	1706.6	2354.7	0.5135	1027.0
Cane Creek	14.0	8968.0	1750.4	2531.0	4281.4	914.8	875.0	1789.8	0.1996	399.2
Aldridge Creek	21.3	13641.2	9605.6	7067.9	16673.5	5358.4	2921.0	8279.5	0.6069	1213.9
Indian Creek	38.5	24620.4	6343.7	51639.2	57982.9	2722.7	17436.4	20159.1	0.8188	1637.6
Limestone Creek	102.9	65853.8	10800.6	139807.0	150607.6	4825.3	44795.3	49620.6	0.7535	1507.0
Flint Creek	428.8	274407.2	37870.7	133950.0	171820.7	18081.0	43644.3	61725.3	0.4608	921.6
Mack Creek	7.8	4994.9	578.9	1808.6	2387.5	192.8	495.6	688.4	0.3806	761.3
Robinson Creek	9.4	6030.4	747.7	10835.6	11583.3	317.6	1236.9	1554.5	0.1435	286.9
Crowdabout Creek	49.2	31511.2	3031.8	11135.5	14167.3	1232.5	3078.7	4311.3	0.3872	774.3
Herrin Creek	6.8	4358.5	417.7	1494.1	1911.8	174.0	403.5	577.5	0.3865	773.0
West Flint Creek	160.4	102667.1	13021.7	49320.9	62342.6	6352.6	17839.8	24192.4	0.4905	981.0
Village Branch	10.8	6925.4	1667.3	2587.7	4255.0	722.0	801.4	1523.4	0.5887	1177.5
McDaniel Creek	12.8	8185.6	547.9	3456.6	4004.6	251.7	1017.4	1269.1	0.3671	734.3
Flat Creek	9.5	6067.2	1035.9	5656.0	6691.9	602.6	2480.2	3082.8	0.5451	1090.1
Swan Creek	56.3	36016.2	6413.8	31848.6	38262.4	3147.8	9480.7	12628.5	0.3506	701.3
Round Island Creek	34.0	21766.2	1411.7	19961.0	21372.7	579.4	5398.9	5978.3	0.2747	549.3
Mallard Creek	96.1	61509.0	3951.2	58301.3	62252.5	1671.2	13513.1	15184.3	0.2469	493.7
USGS Catalogue Unit 0603005 - Pickwick Lake										
Big Nance Creek	200.0	127996.3	10960.1	144394.0	155354.1	5135.0	42990.2	48125.2	0.3760	752.0
USGS Catalogue Unit 0603006 - Bear Creek Reservoir										
Harris Creek	24.7	15793.5	6804.3	6258.4	13062.7	3915.2	2425.8	6341.1	0.4015	803.0

Table 3-3 Detailed Sediment Loading Analysis

4.0 Watershed Sediment Loading Model

For analysis of the sediment loading to the listed segments and for determination of the reference watershed loading values, the WCS Sediment Tool was utilized. The following describes in detail the theory behind the Sediment Tool and its application for TMDL determinations.

4.1 Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE), developed by Agriculture Research Station (ARS) scientists W. Wischmeier and D. Smith, has been the most widely accepted and utilized soil loss equation for over 30 years. Designed as a method to predict average annual soil loss caused by sheet and rill erosion, the USLE is often criticized for its lack of applications. While it can estimate long-term annual soil loss and guide conservationists on proper cropping, management, and conservation practices, it cannot be applied to a specific year or a specific storm. The USLE is mature technology and enhancements to it are limited by the simple equation structure. However, based on its long history of use and wide acceptance by the forestry and agriculture communities, it was selected as an adequate tool for estimating long-term annual soil erosion, for evaluating the impacts of land use changes and the benefits of various Best Management Practices (BMPs).

The Sediment Tool, which incorporates the USLE equation, is an extension of the Watershed Characterization System (WCS). For more detailed information on WCS, refer to the WCS User's Manual. The Sediment Tool can be used to perform the following tasks:

- Estimate extent and distribution of potential soil erosion in the watershed.
- Estimate potential sediment delivery to receiving waterbodies.
- Evaluate effects of land use, BMPs, and road network on erosion and sediment delivery.

Soil loss from sheet and rill erosion is mainly due to detachment of soil particles during rainfall. It causes the majority of soil loss in crop production, grazing areas, construction sites, mine sites, logging areas, and unpaved roads. The magnitude of soil erosion is normally estimated through the use of the Universal Soil Loss Equation (USLE). The USLE equation is a multiplicative function of crop and site specific factors that represent rainfall erosivity *(*R), soil erodibility *(*K), soil slope *(*S), slope length *(*L), cropping or conservation management practices *(*C), and erosion control practices *(*P). The R factor describes the kinetic energy generated by the frequency and intensity of rainfall. The *K* factor represents the susceptibility of soil to erosion (i.e. soil detachment). The *L* and *S* factors represent the effect of slope length and slope steepness on erosion, respectively. The *C* factor represents the effect of plants, soil cover, soil biomass and soil disturbing activities on erosion including crop rotations, tillage and residue practices. Finally, the *P* factor represents the effects of conservation practices such as contour farming, strip cropping and terraces. The USLE equation for estimating average annual soil erosion is:

$$A = R \times K \times LS \times C \times P$$

A = average annual soil loss in t/a (tons per acre)
R = rainfall erosivity index
K = soil erodibility factor
LS = topographic factor - L is for slope length and S is for slope
C = cropping factor
P = conservation practice factor

Evaluating the factors in USLE:

R - the rainfall erosivity index

Most appropriately called the erosivity index, it is a statistic calculated from the annual summation of rainfall energy in every storm (correlates with raindrop size) times its maximum 30 - minute intensity. As expected, it varies geographically.

K - the soil erodibility factor

This factor quantifies the cohesive or bonding character of a soil type and its resistance to dislodging and transport due to raindrop impact and overland flow.

LS - the topographic factor

Steeper slopes produce higher overland flow velocities. Longer slopes accumulate runoff from larger areas and also result in higher flow velocities. Thus, both result in increased erosion potential, but in a non - linear manner. For convenience L and S are frequently lumped into a single term.

C - the crop management factor

This factor is the ratio of soil loss from land cropped under specified conditions to corresponding loss under tilled, continuous fallow conditions. The most computationally complicated of USLE factors, it incorporates effects of: tillage management (dates and types), crops, seasonal erosivity index distribution, cropping history (rotation), and crop yield level (organic matter production potential).

P - the conservation practice factor

Practices included in this term are contouring, strip cropping (alternate crops on a given slope established on the contour), and terracing.

Appropriate values for the USLE parameters should be provided for each of the management activities. Literature values are available, but site-specific values should be used when available. Estimates of the USLE parameters and thus the soil erosion as computed from the USLE equation are provided by the Natural Resources Conservation Service's National Resources Inventory (NRI) 1994. The NRI database contains information of the status, condition and trend of soil, water and related resources collected from approximately 800,000 sampling points across the country.

Soil loss from gully erosion occurs in sloping areas mainly as a result of natural processes. Farming practices such as livestock grazing exacerbates it. The deepening of rill erosion causes gullies. The amount of sediment yield from gully erosion is generally less than that caused by sheet and rill erosion. Sheet and rill erosion relates to the flow of water over sediments and the resultant small rills formed as sheet flow erodes the material. There are no exact methods or equations to quantify gully erosion, but Dunne and Leopold (1978) provide percent sediment yield estimates for various regions of the country. In a small grazed catchment near Santa Fe, New Mexico, gully erosion was found to contribute only 1.4 percent of the total sediment load as compared to sheet erosion and rain splash, which contributed 97.8 percent of the sediment load. Dunne and Leopold report that in most cases (nationally and internationally) gully erosion contributes less than 30 percent of the total sediment load, although the percentages have ranged from 0 percent to 89 percent contribution (Dunne and Leopold, 1978).

The soil losses from the erosion processes described above are localized losses and not the total amount of sediment that reaches the stream. The fraction of the soil lost in the field that is eventually delivered to the stream depends on several factors. These include, the distance of the source area from the stream, the size of the drainage area, and the intensity and frequency of rainfall. Soil losses along the riparian areas will be delivered into the stream with runoff-producing rainfall.

4.2 Sediment Analysis

The watershed sediment loads for selected watersheds are determined using the USLE and available GIS coverage. The Sediment Tool produces the following outputs:

- Source Erosion and Sediment Delivery
- Road Erosion and Sediment Delivery

The Sediment Tool is also able to evaluate default scenarios by, for example, changing land uses and BMPs. The following are some of the parameters that may be altered:

- C and P Lookup values
- Land Use Change Layer
- BMP Layers
- Add/Delete Roads
- Create Road Control Structure Layer

The sediment analysis can be run for a single watershed or multiple watersheds. For TMDL development purposes, the Sediment Tool was used for developing relative impacts between impaired segments and relatively unimpaired reference watersheds.

4.3 Sediment Modeling Methodology

The watersheds of interest are first delineated. The stream grid for each delineated watershed, based on the Digital Elevation Maps (DEM) data, is created so that the stream matches the elevation (i.e., the stream corresponds to the lower elevations in the watershed). The system uses this threshold to determine whether a particular cell within the watershed area delivers load to a corresponding stream segment. Grid cells having flow accumulation values higher than the threshold will be considered as part of the stream network. The RF3 stream network is used as a reference or basis of comparison to obtain the desired stream density. Figure 4-1 presents the present RF3 stream network used throughout the Tennessee River Basin. A stream grid corresponding to the stream network that has fifty, 30 by 30 meter headwater cells is the default.

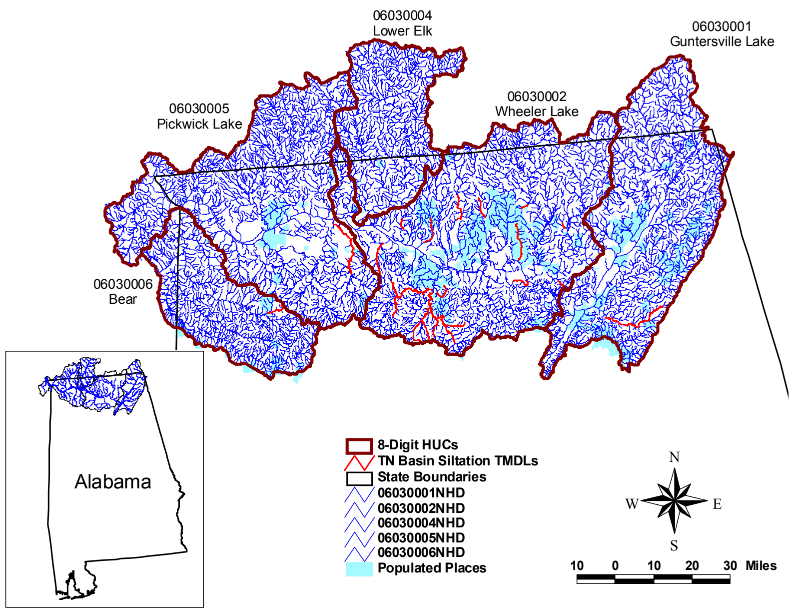

Figure 4-1. Stream Network within the Tennessee River Basin.

For each 30 by 30 meter grid cell, the potential erosion based on USLE and potential sediment delivery to the stream network is estimated. The potential erosion from each cell is calculated using the USLE and the sediment delivery to the stream network is calculated using one of four available sediment delivery equations.

(1) Distance-based equation 1 (Sun and McNulty 1988)

$$Md = M * (1 - 0.97 * D / L),$$

$$L = 5.1 + 1.79 * M,$$

Where Md is the mass moved from each cell to the closest stream network (US tons/acre/yr); D (feet) is the least cost distance from a cell to the nearest stream network; and L (feet) is the maximum distance that sediment with mass M (US ton) may travel.

(2) Distance-based equation 2 (Yagow et al. 1998)

$$DR = \exp(-0.4233 * L * Sf),$$

$$Sf = \exp(-16.1 * (r / L + 0.057)) - 0.6,$$

Where, DR is the sediment delivery ratio, L is the distance to the stream in meters (based on the least cost distance), and r is the relief to the stream in meters.

(3) Area-based equation (converted from a curve from National Engineering Handbook by Soil Conservation Service 1983)

$$DR = 0.417762 * A \wedge (-0.134958) - 0.127097,$$

$$DR <= 1.0,$$

Where DR is the sediment delivery ratio and A is area in square miles;

(4) WEPP-based regression equation (L.W.Swift, Jr., 2000)

$$Z=0.9004-0.1341*X-0.0465*X\wedge 2+0.00749*X\wedge 3-0.0399*Y+0.0144*Y\wedge 2+0.00308*Y\wedge 3,$$

$$X>0, Y>0,$$

Where Z is percent of source sediment passing to next grid cell, X is cumulative distance downslope, Y is the percent slope in a grid cell.

The sediment analysis provides the calculations for six new parameters.

- Source Erosion – estimated erosion from each grid cell due to the land cover
- Road Erosion – estimated erosion from each grid cell representing a road
- Composite Erosion – composite of the source and road erosion layers
- Source Sediment – estimated fraction of the soil erosion from each grid cell that reaches the stream (sediment delivery)
- Road Sediment – estimated fraction of the road erosion from each grid cell that reaches the stream
- Composite Sediment – composite of the source and erosion sediment layers

The sediment delivery can be calculated based on the composite sediment, road sediment, or source sediment layer. The sources of sediment by each land use type is determined showing the types of land use, the acres of each type of land use, and the tons of sediment estimated to be generated from each land use.

4.4 Sediment Analysis Inputs

Before conducting a sediment analysis, a number of data layers must be available. These include the following:

- DEM (grid) – The DEM layers that come with the WCS distribution system are shape files and are of coarse resolution (300 m x 300 m). The user needs to import a DEM grid layer. A higher resolution DEM grid layer (30m x 30 m) was downloaded from USGS web site or from a state's GIS data clearinghouse.
- Road – The road layer is needed as a shape file and requires additional attributes such as C (road type), P (road practice) and ditch (value of either 3 or 4, indicating presence or absence of side ditch, respectively). If these attributes are not provided, the Sediment Tool automatically assigns default values of road type 2 (secondary paved roads) ditch 3 (with ditch) and road practice 1 (no practices).
- Soil – The SSURGO (1:24k) soil data may be imported into the WCS project if higher-resolution soil data is required for the estimation of potential erosion. If the SSURGO soil database not available, the system uses the STATSGO Soil data (1:250k) by default.
- The Multi-Resolution Land use Classification (MRLC) data are also used.
- Rainfall erosivity index is either provides based on a rainfall index of the USA or can be calculated based on precipitation data.

Detailed maps of the model inputs to the Sediment Tool by subwatershed are presented in the Appendices as well as tables of the Sediment Tool coefficients used for each subwatershed.

4.5 Sediment Load Development Methodology

For each watershed of interest, the "existing" long–term sediment loading is estimated via the USLE sediment analysis. The USLE is designed as a method to predict average annual soil loss caused by sheet and rill erosion. While it can estimate long - term annual soil loss and guide on proper cropping, management, and conservation practices, it cannot be applied to a specific year or a specific storm.

The resultant sediment load calculation for each watershed is therefore expressed as a long-term annual soil loss expressed in tons per year calculated for the R - the rainfall erosivity index, a statistic calculated from the annual summation of rainfall energy in every storm (correlates with raindrop size) times its maximum 30 - minute intensity.

The watershed sediment load target is based on the long-term annual soil loss expressed in tons per year calculated for relatively unimpacted watershed with demonstrated healthy biology and habitat. For the initial sediment load development, consistent default parameters and inputs are used for each watershed. These include the MRLC land use data, the USGS DEM data, STASTGO soil information and watershed average C and P values for each land use type. The USLE coefficients utilized within each of the listed segment watersheds are presented in Table 4-1.

To refine the sediment tool and the calculated sediment loads, the C and P values utilized within the modeling effort represent site-specific values as defined by the various counties. The United States Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS) was contacted to incorporate county C-factors in the sediment tool. The C-factors were dependent upon the dominant crop and crop management practices in each county. For example, Lawrence County has predominantly cotton for row crops. Based on the county C-factor along with the soil properties (residue) and tillage practices, a C-factor was determined for use in the sediment model. Typically, high residue crops such as corn have less runoff than low residue crops such as cotton. The site-specific (county) information was important in the determination of the source erosion in the watershed. Although the use of county specific C and P values does represent use of actual data, these parameters have been developed through evaluation of local crop management practices.

Watershed	LS_Factor			K Factor			P Factor			C Factor			R Factor		
	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean
indian creek	0.076	14.388	0.666	0.23	0.4	0.336	1	1	1	0	0.12	0.056	275	275	275
limestone creek	0.076	11.112	0.390	0.34	0.4	0.388	1	1	1	0	0.12	0.055	275	275	275
aldridge creek	0.076	25.525	2.702	0.23	0.35	0.28	1	1	1	0	0.12	0.013	275	275	275
village branch	0.076	12.166	0.897	0.23	0.35	0.288	1	1	1	0	0.12	0.013	300	300	300
flat creek	0.076	4.827	0.439	0.28	0.34	0.281	1	1	1	0	0.12	0.03	300	300	300
chase creek	0.076	16.312	1.914	0.23	0.37	0.338	1	1	1	0	0.12	0.027	275	275	275
west flint creek	0.076	16.727	0.808	0.23	0.34	0.299	1	1	1	0	0.12	0.019	300	300	300
cole spring branch	0.076	22.123	2.852	0.23	0.35	0.287	1	1	1	0	0.12	0.022	275	275	275
flint creek	0.076	30.393	0.862	0.23	0.35	0.862	1	1	1	0	0.75	0.019	300	325	302.143
harris creek	0.076	8.509	0.447	0.25	0.35	0.315	1	1	1	0	0.12	0.016	312.5	312.5	312.5
crowdabout creek	0.076	19.438	0.992	0.23	0.34	0.302	1	1	1	0	0.12	0.017	300	325	302
herrin creek	0.076	16.882	1.129	0.23	0.34	0.283	1	1	1	0	0.12	0.015	300	325	301.9
mack creek	0.076	13.350	0.823	0.23	0.34	0.299	1	1	1	0	0.12	0.023	300	300	300
mcdaniel creek	0.076	12.089	0.505	0.25	0.34	0.311	1	1	1	0	0.12	0.023	300	300	300
swan creek	0.076	3.901	0.242	0.34	0.4	0.377	1	1	1	0	0.12	0.035	275	275	275
little paint rock cr	0.076	27.972	2.619	0.23	0.35	0.269	1	1	1	0	0.12	0.012	275	300	288.805
round island creek	0.076	1.931	0.197	0.34	0.4	0.388	1	1	1	0	0.12	0.043	275	275	275
mallard creek	0.076	9.815	0.309	0.28	0.38	0.343	1	1	1	0	0.75	0.042	300	300	300
big nance creek	0.076	17.118	0.509	0.25	0.35	0.316	1	1	1	0	0.24	0.053	300	300	300
scarham creek	0.076	17.082	0.491	0.23	0.31	0.242	1	1	1	0	0.08	0.018	300	300	300
cane creek	0.076	51.329	3.391	0.23	0.24	0.233	1	1	1	0	0.12	0.009	275	300	299.831
robinson creek	0.076	8.938	0.898	0.23	0.34	0.29	1	1	1	0	0.75	0.04	300	300	300

Table 4-1. USLE Coefficients Utilized in each Subwatershed

5.0 Total Maximum Daily Load

The TMDL is the total amount of a pollutant that can be assimilated by the receiving waterbody without exceeding the applicable water quality criterion, in this case, a numeric interpretation of the State of Alabama's narrative water quality criterion for aquatic life. This TMDL determines the annual average load of sediments that can enter the listed segments and maintain the biological integrity of the system.

5.1 Critical Condition Determination

The annual average load is reported for these TMDLs since this loading is more appropriate than a daily load for representing the long-term processes of accumulation of sediments in the stream habitat areas. These are associated with the potential for habitat alteration and aquatic life effects. As such the critical condition determination need only reflect the worst-case annual average rainfall and erosivity potential.

5.2 Seasonal Variation

The use of flow to determine the allowable loads under this TMDL accounts for seasonal variations relevant to this TMDL. Sediment is expected to fluctuate based on the amount and distribution of rainfall. Since flow is greatest in the spring and winter seasons, loadings of sediment are highest during these seasons. However, these seasonal impacts or other short-term variability in loadings are evened out by the response of habitat alteration, which as discussed above, is a long-term process.

5.3 Margin of Safety

A Margin of Safety (MOS) is a required component of a TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody. The MOS is typically incorporated into the conservative assumptions used to develop the TMDL. A MOS is incorporated into this TMDL in a variety of ways. These include a MOS implicitly assigned by selection of average USLE factors and by an explicit 10 percent reduction in the sediment loading numeric target.

5.4 TMDL Determination

Utilizing the annual average loads determined from the Sediment Tool for each of the listed watersheds, along with the target load based upon the reference watersheds, the percent reductions required in the total annual average loads were calculated. Table 5-1 presents the existing load rates and totals, the targets, and percent reductions for each sub-watershed. For the 19 TMDLs within the Wheeler Lake HUC only one segment has a calculated total annual average load less than the defined reference watershed. In this case it is recommended that no reduction of loads is needed, and additional data should be gathered to determine if the system is truly impaired and that all assumptions made through the USLE calculations are appropriate.

Impaired Segment	Acreage	Ecoregion	Existing Annual Average Unit Load (tons/acre/year)	Existing Annual Average Load (tons/year)	Target Unit Load (tons/acre/year)	Target Load (tons/year)	Percent Reduction
USGS Catalogue Unit 06030001 - Guntersville Lake							
Scarham Creek	58307	68d	0.2000	11664	0.1256	7326	37%
USGS Catalogue Unit 06030002 - Wheeler Lake							
Cole Spring Branch	6168	71g	0.4693	2894	0.2703	1667	42%
Little Paint Rock Creek	8131	71g	0.3470	2822	0.2703	2198	22%
Chase Creek	4586	71g	0.5135	2355	0.2703	1240	47%
Cane Creek	8968	68c	0.1996	1790	0.1256	1127	37%
Aldridge Creek	13641	71g	0.6069	8279	0.2703	3687	55%
Indian Creek	24620	71g	0.8188	20159	0.2703	6655	67%
Limestone Creek	65854	71g	0.7535	49621	0.2703	17800	64%
Flint Creek	274407	71g	0.4608	126449	0.2703	74171	41%
Mack Creek	4995	71g	0.3806	1901	0.2703	1350	29%
Robinson Creek	6030	68c	0.1435	865	0.1256	758	12%
Crowdabout Creek	31511	71g	0.3872	12200	0.2703	8517	30%
Herrin Creek	4359	71g	0.3865	1685	0.2703	1178	30%
West Flint Creek	102667	71j	0.4905	50359	0.2703	27751	45%
Village Branch	6925	71g	0.5887	4077	0.2703	1872	54%
McDaniel Creek	8186	71g	0.3671	3005	0.2703	2213	26%
Flat Creek	6067	71j	0.5451	3307	0.2703	1640	50%
Swan Creek	36016	71g	0.3506	12628	0.2703	9735	23%
Round Island Creek	21766	71g	0.2747	5978	0.2703	5883	2%
Mallard Creek	61509	71g	0.2469	15184	0.2703	16626	0%
USGS Catalogue Unit 06030005 - Pickwick Lake							
Big Nance Creek	127996	71g	0.3760	48125	0.2703	34597	28%
USGS Catalogue Unit 06030006 - Bear Creek Reservoir							
Harris Creek	15794	71g	0.4015	6341	0.2703	4269	33%

Table 5-1. Watershed Loading Breakdown and TMDL Percent Reductions.

6.0 TMDL Implementation

6.1 Non-Point Source Approach

The listed segments within the Tennessee River Basin are impaired primarily by nonpoint sources. For 303(d) listed waters impaired solely or primarily by nonpoint source (NPS) pollutants, necessary reductions will be sought during TMDL implementation using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired water. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

The primary TMDL implementation mechanism used will employ concurrent education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The ADEM Office of Education and Outreach (OEO) will assist in the implementation of TMDLs in cooperation with public and private stakeholders. Planning and oversight will be provided by or coordinated with the Alabama Department of Environmental Management's (ADEM) Section 319 nonpoint source grant program in conjunction with other local, state, and federal resource management and protection programs and authorities. The CWA Section 319 grant program may provide limited funding to specifically ascertain NPS pollution sources and causes, identify and coordinate management programs and resources, present education and outreach opportunities, promote pollution prevention, and implement needed management measures to restore impaired waters.

Depending on the pollutant of concern, resources for corrective actions may be provided, as applicable, by the Alabama Cooperative Extension System (education and outreach); the USDA-Natural Resources Conservation Service (NRCS) (technical assistance) and Farm Services Agency (FSA) (federal cost-share funding); and the Alabama Soil and Water Conservation Committee (state agricultural cost share funding and management measure implementation assistance) through local Soil and Water Conservation Districts, or Resource Conservation and Development Councils (funding, project implementation, and coordination). Additional assistance from such agencies as the Alabama Department of Public Health (septic systems), Alabama Department of Agriculture and Industries (pesticides), and the Alabama Department of Industrial Relations and Dept of Interior - Office of Surface Mining (abandoned minelands), Natural Heritage Program and US Fish and Wildlife Service (threatened and endangered species), may also provide practical TMDL implementation delivery systems, programs, and information. Land use and urban sprawl issues will be addressed through the Nonpoint Source for Municipal Officials (NEMO) education and outreach program. Memorandums of Agreements (MOAs) may be used as a tool to formally define roles and responsibilities.

Additional public/private assistance is available through the Alabama Clean Water Partnership (CWP) Program. The CWP program uses a local citizen-based environmental protection approach to coordinate efforts to restore and protect the state's resources in accordance with the goals of the Clean Water Act. Interaction with the state or river basin specific CWP will facilitate TMDL implementation by providing improved and timely communication and information exchange between community-based groups, units of government, industry, special interest groups, and individuals. The CWP can assist local entities to plan, develop, and coordinate restoration strategies that holistically meet multiple needs, eliminate duplication of efforts, and allow for effective and efficient use of available resources to restore the impaired waterbody or watershed.

Other mechanisms that are available and may be used during implementation of this TMDL include local regulations or ordinances related to zoning, land use, or storm water runoff controls. Local governments can provide funding assistance through general revenues, bond issuance, special taxes, utility fees, and impact fees. If applicable, reductions from point sources will be addressed by the NPDES permit program. The Alabama Water Pollution Control Act empowers ADEM to monitor water quality, issue permits, conduct inspections, and pursue enforcement of discharge activities and conditions that threaten water quality. In addition to traditional "end-of-pipe" discharges, the ADEM NPDES permit program addresses animal feeding operations and land application of animal wastes. For certain water quality improvement projects, the State Clean Water Revolving Fund (SRF) can provide low interest loans to local governments.

Long-term physical, chemical, and biological improvements in water quality will be used to measure TMDL implementation success. As may be indicated by further evaluation of stream water quality, the effectiveness of implemented management measures may necessitate revisions of this TMDL. The ADEM will continue to monitor water quality according to the rotational river basin monitoring schedule as allowed by resources. In addition, assessments may include local citizen-volunteer monitoring through the Alabama Water Watch Program and/or data collected by agencies, universities, or other entities using standardized monitoring and assessment methodologies. Core management measures will include, but not be limited to water quality improvements and designated use support, preserving and enhancing public health, enhancing ecosystems, pollution prevention and load reductions, implementation of NPS controls, and public awareness and attitude/behavior changes.

The analyses presented herein reflect agricultural practices that existed at the time of the listing of the 22 stream segments (1994-1996). Since that time various areas counties have implemented more conservative tillage practices that will serve to reduce the loads calculated and presented in Sections 3 and 5. Therefore some of the reductions listed in Section 5 may have already occurred through these improved conditions. For example the tillage practices within the Big Nance Creek watershed have been updated and the C factor for the USLE equations has been updated from a value of 0.24 (utilized in the 1994 analyses) to a value of 0.12 under present conditions. Applying this value to the analyses presented in Section 5 reduces the unit loading for the Big Nance watershed from 0.376 tons/acre/year down to 0.2135 tons/acre/year. This revised value falls below that identified as the reference load for this ecoregion and therefore under present practices no additional load reductions would be necessary. These are implemented practices that provide credit within the TMDL development process.

6.2 Point Source Approach

If applicable, reductions from point sources will be addressed by the NPDES permit program. Present calculations do not show a need for reduction of point sources under this TMDL.

7.0 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, the ADEM water quality resources are concentrated in one of the basin groups. One goal is to continue to monitor §303(d) listed waters. This monitoring will occur in each basin according to the following schedule:

River Basin Group	Schedule
Cahaba / Black Warrior	2002
Tennessee	2003
Choctawhatchee/Chipola / Perdido-Escambia / Chattahoochee	2004
Tallapoosa/Alabama/Coosa	2005
Escatawpa/Upper Tombigbee/Lower Tombigbee / Mobile	2006

Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

8.0 Public Participation

A sixty-day public notice was provided for this TMDL. During this time, copies of this TMDL were available upon request, and the public was invited to provide comments.

9.0 Appendices

9.1 References

USDA-NRCS communication on C-factors by county and crop management practices in Alabama.

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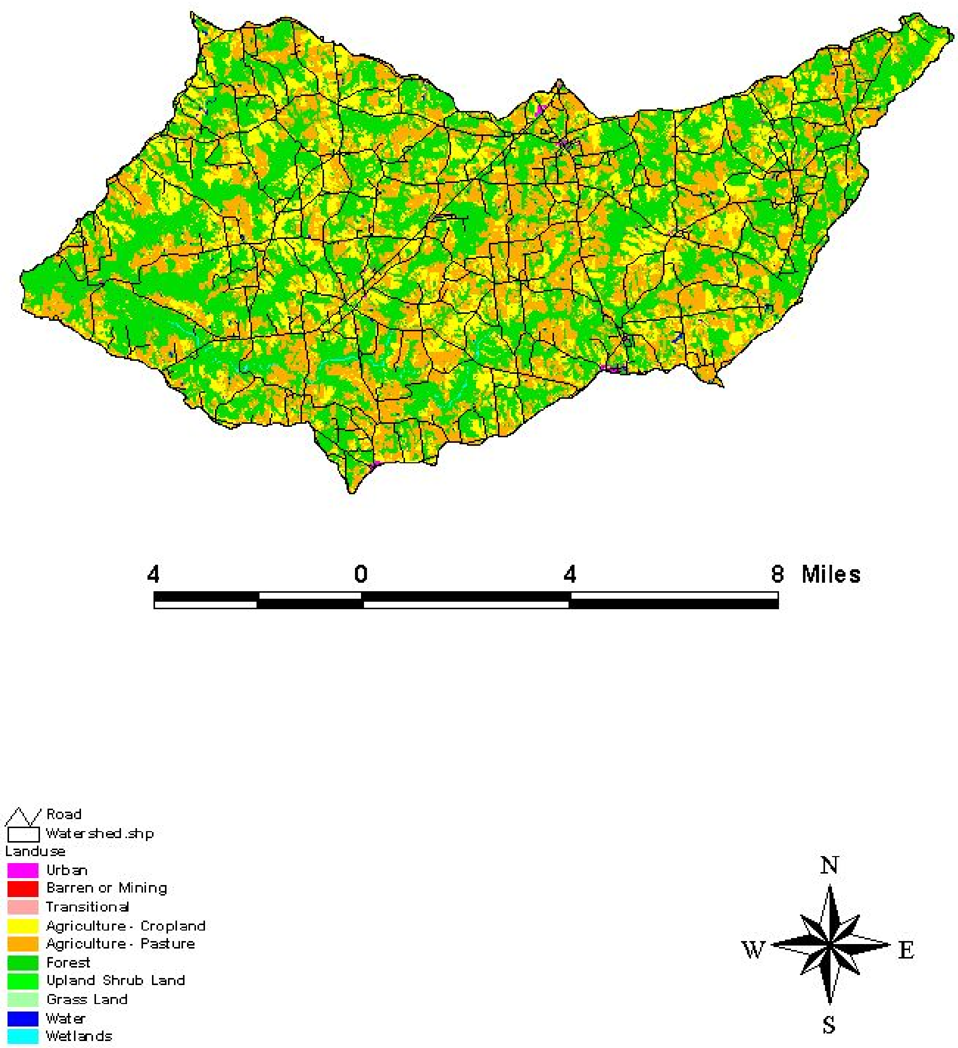
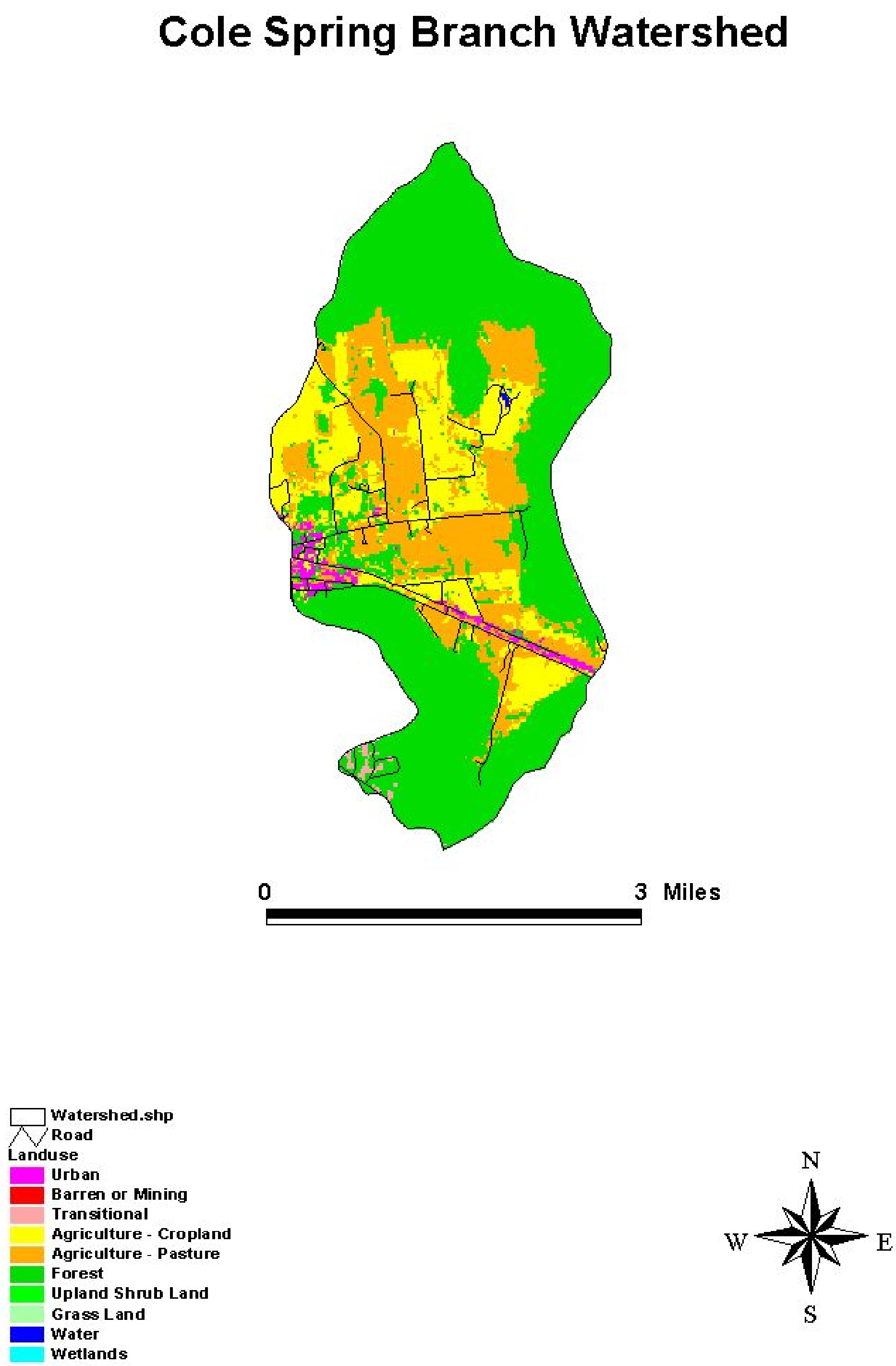
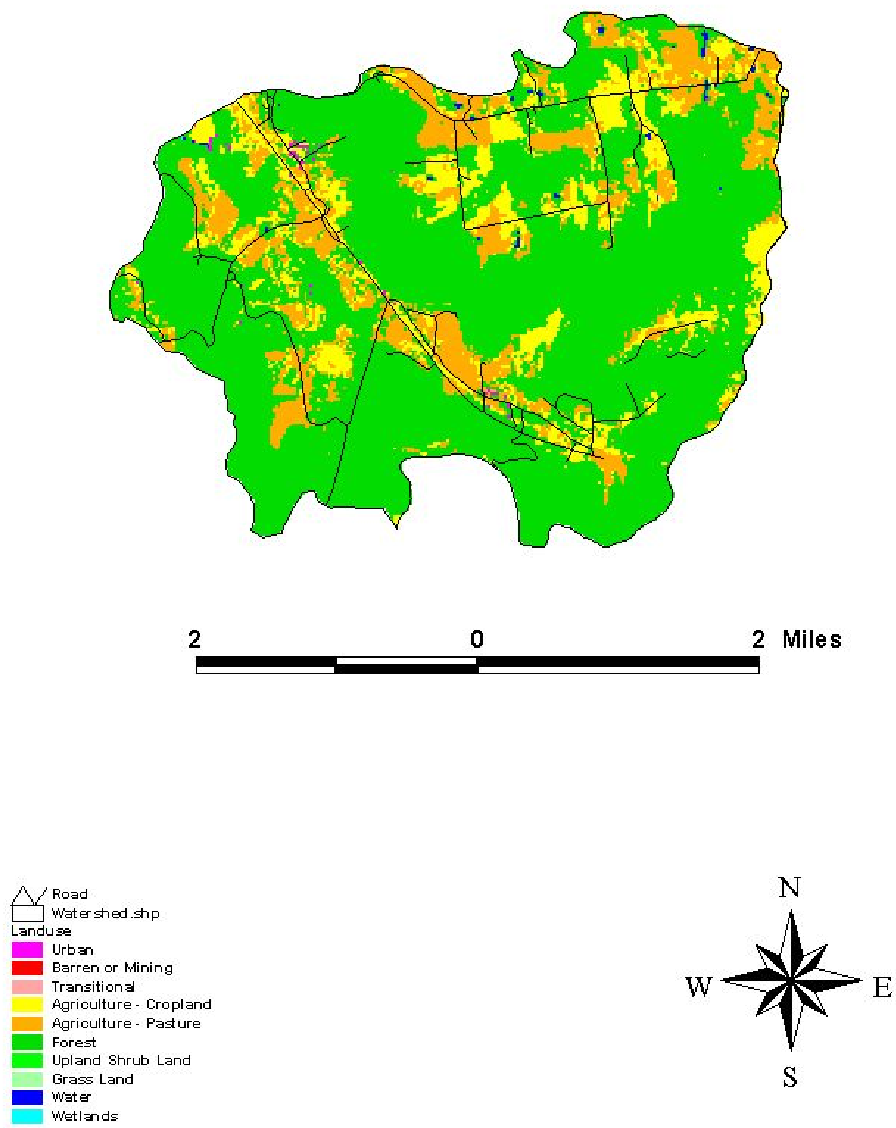
9.2 Subwatershed Land Uses with Road Coverage

Scarham Creek Watershed

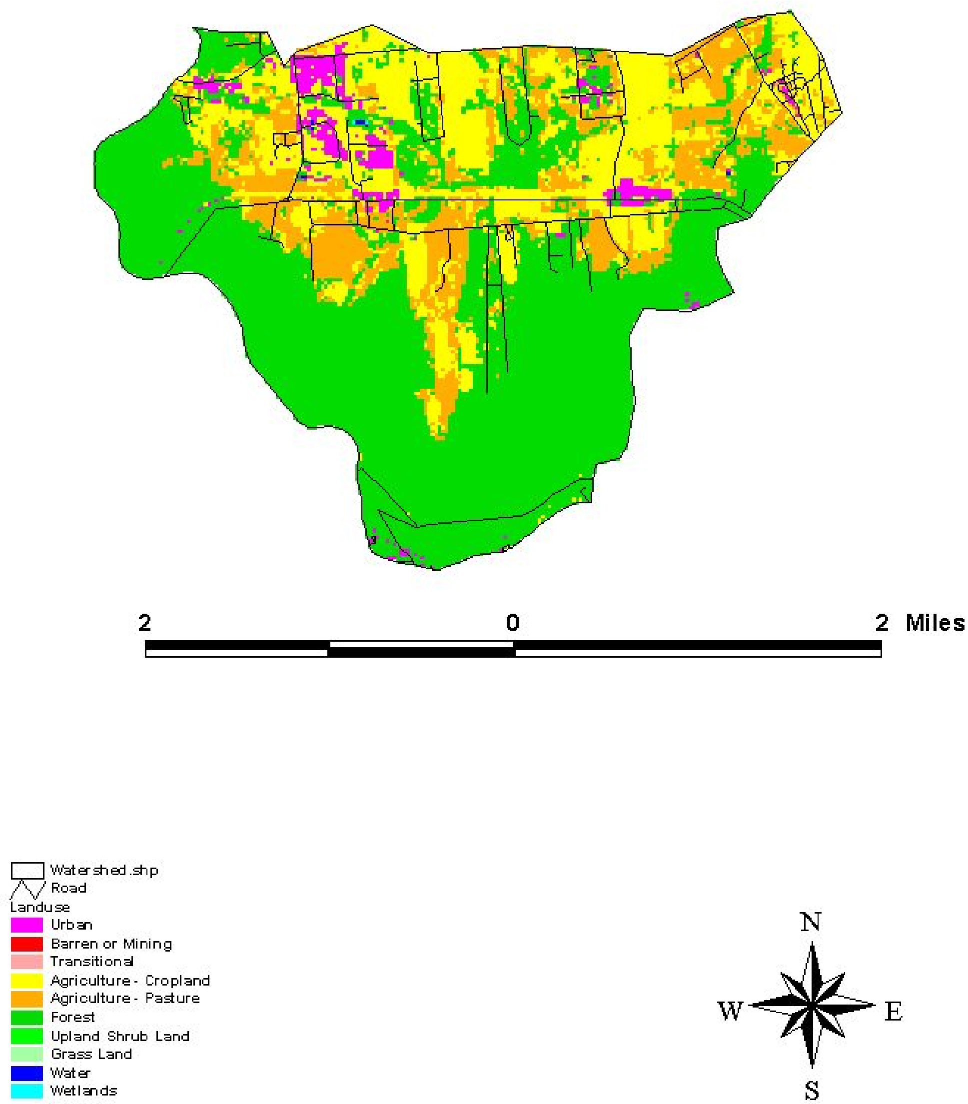



Cole Spring Branch Watershed
0
3 Miles
Watershed.shp
Road
Landuse
Urban
Barren or Mining
Transitional
Agriculture - Cropland
Agriculture - Pasture
Forest
Upland Shrub Land
Grass Land
Water
Wetlands
N
W
E
S

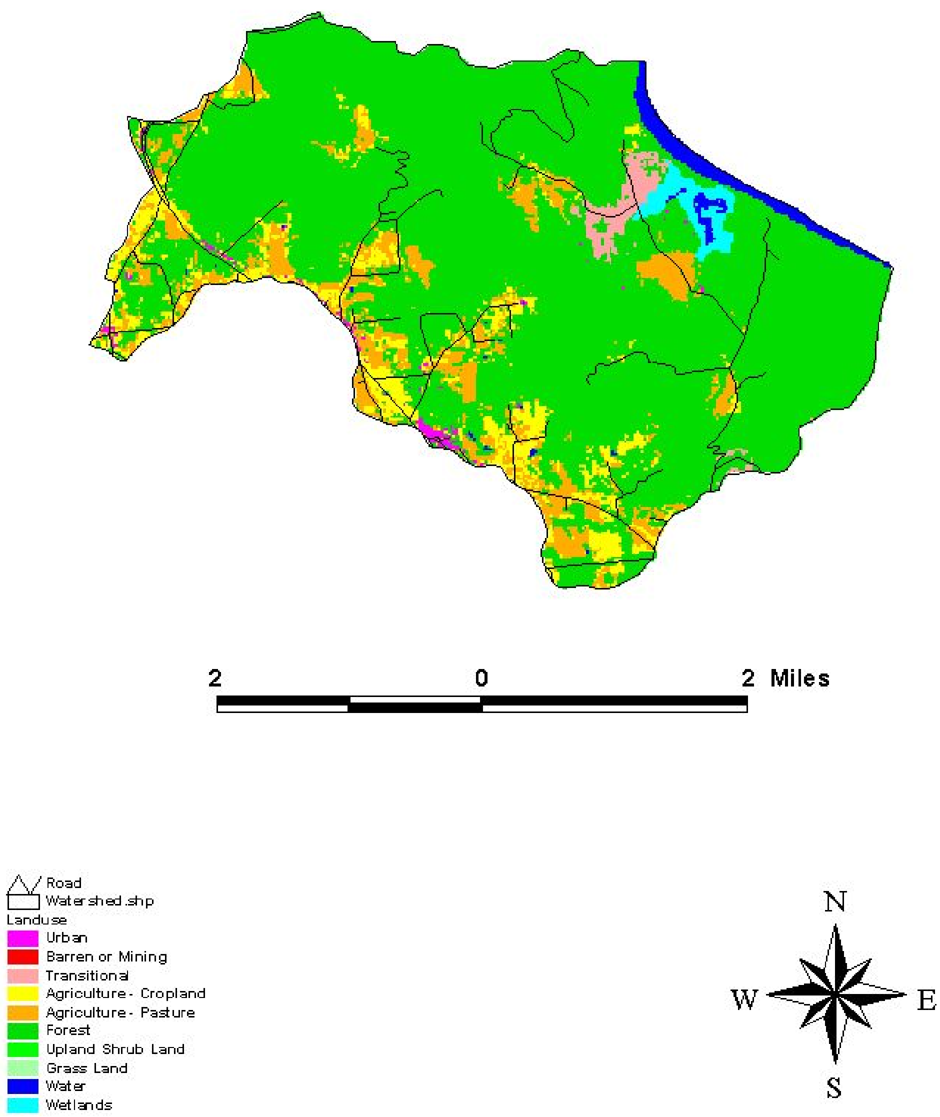
Little Paint Rock Creek Watershed



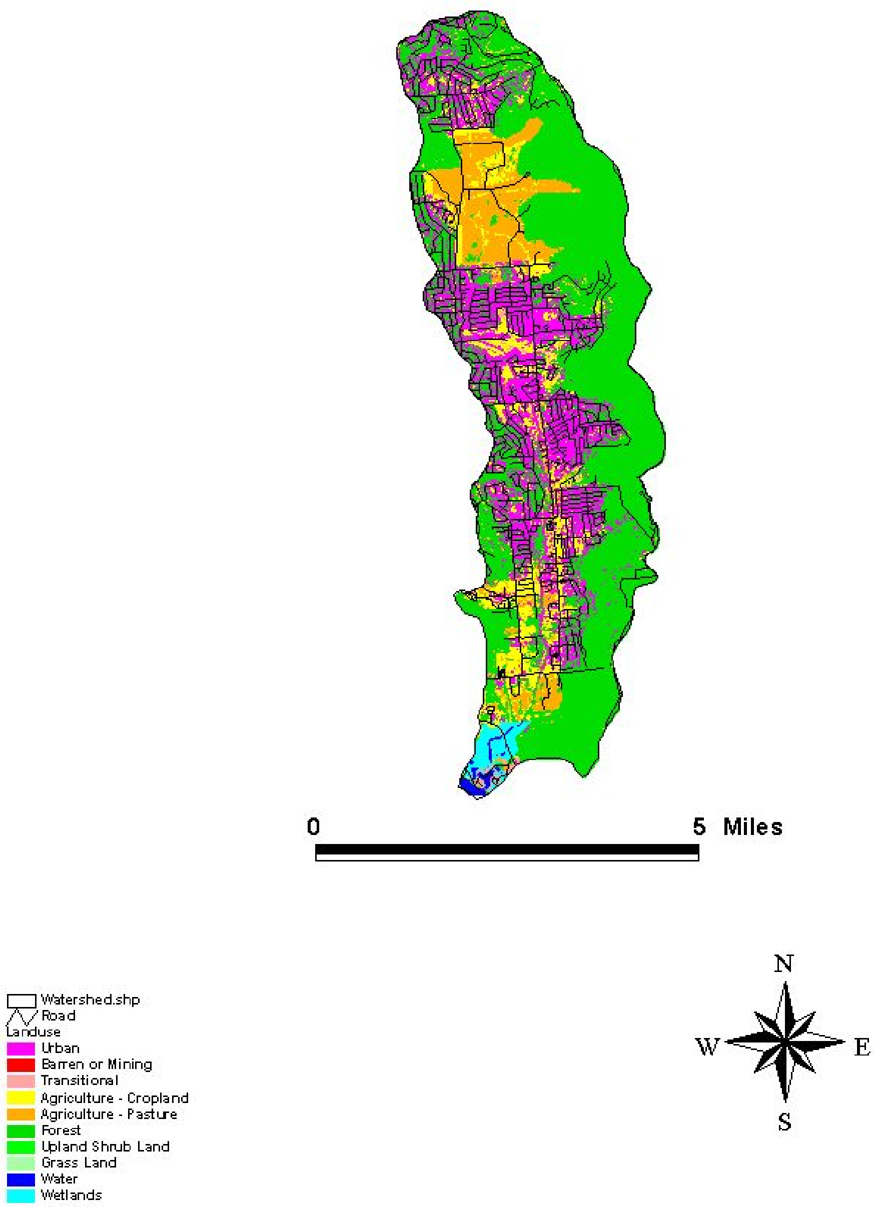
Chase Creek Watershed



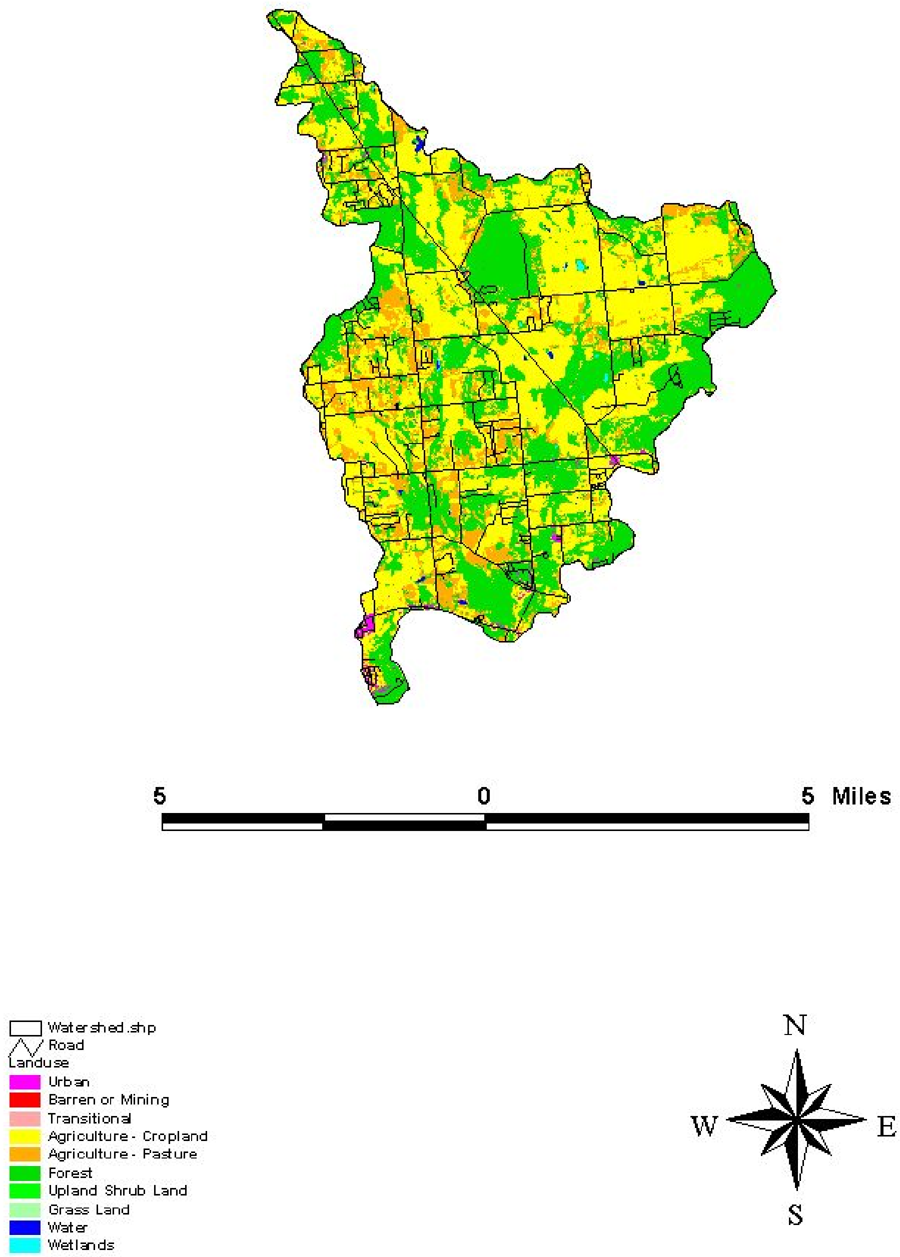
Cane Creek Watershed



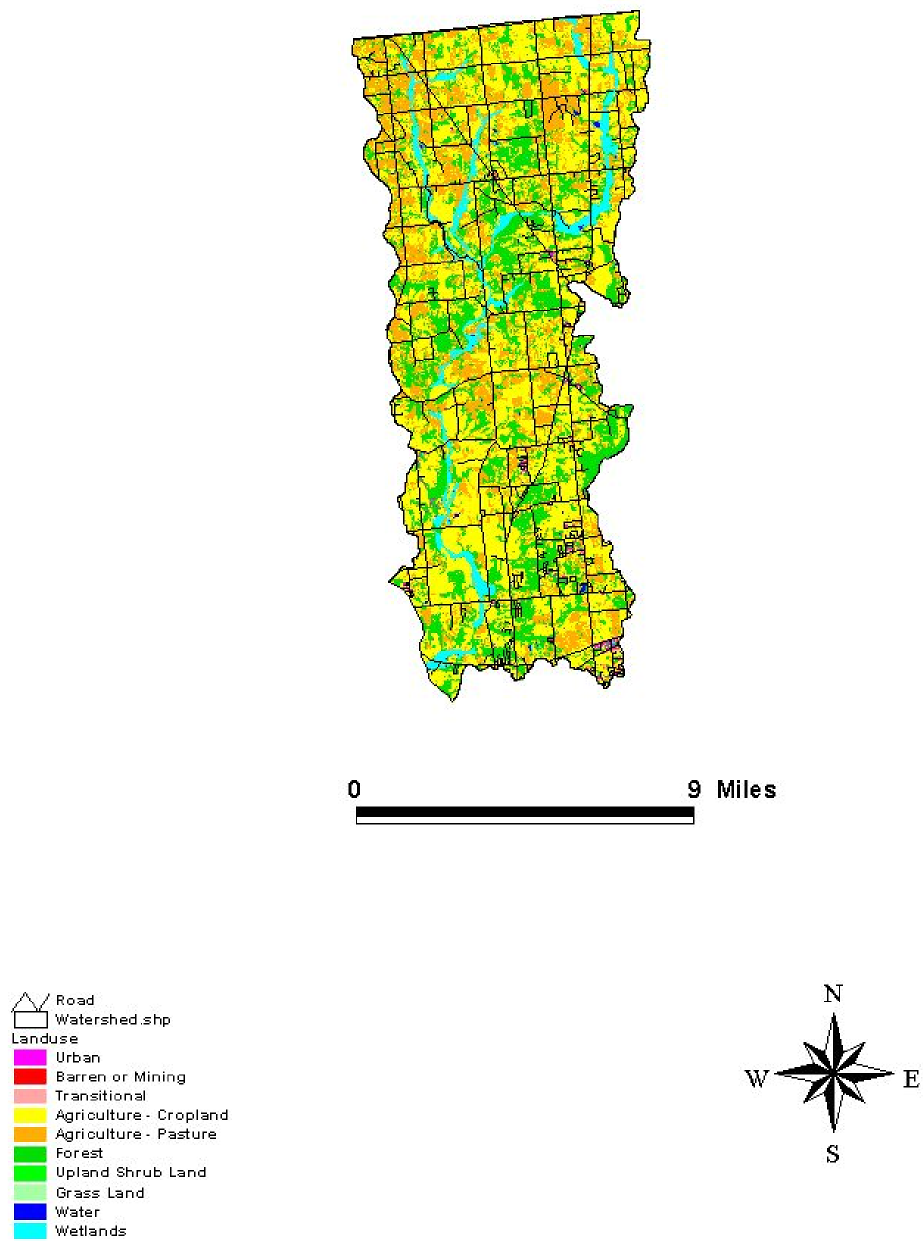
Aldridge Creek Watershed

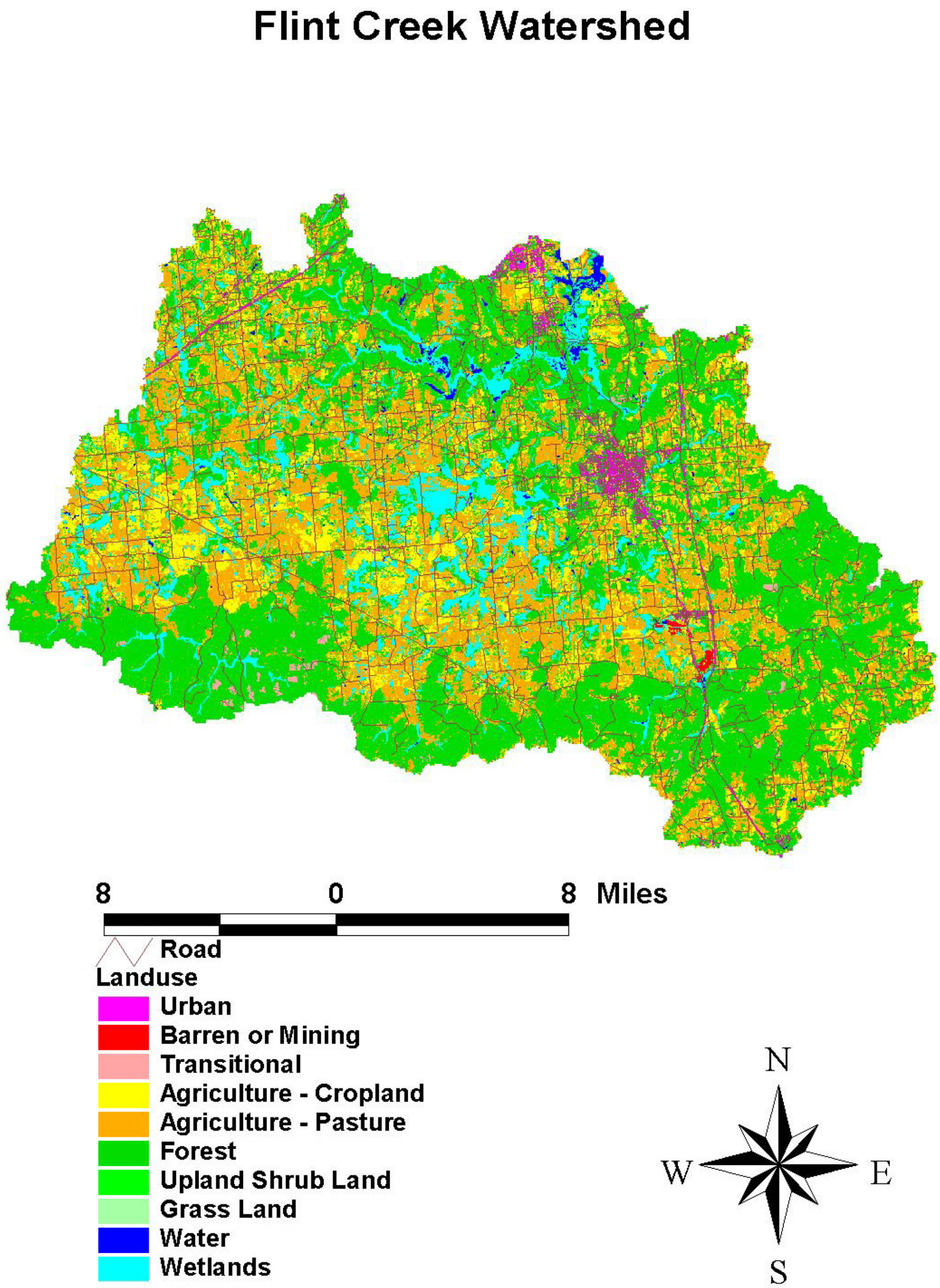


Indian Creek Watershed

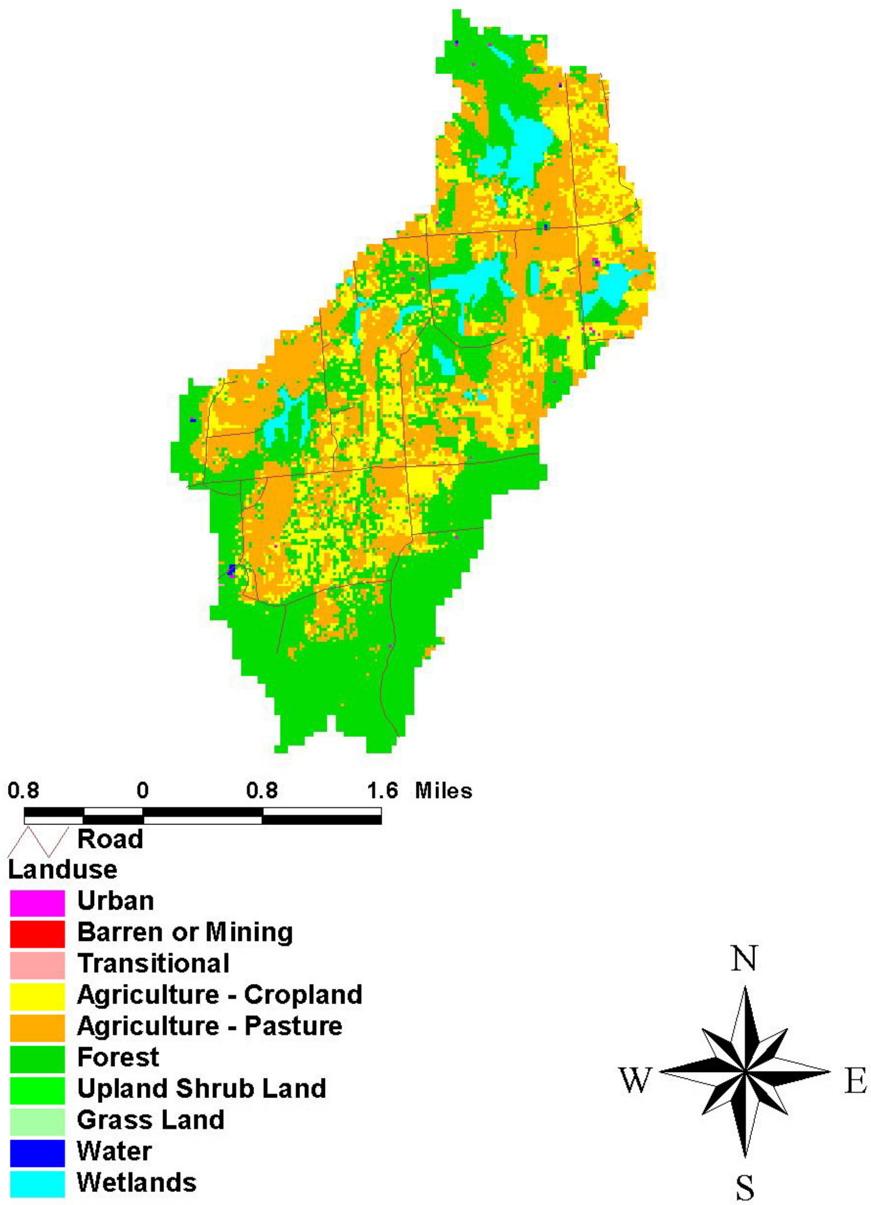


Limestone Creek Watershed

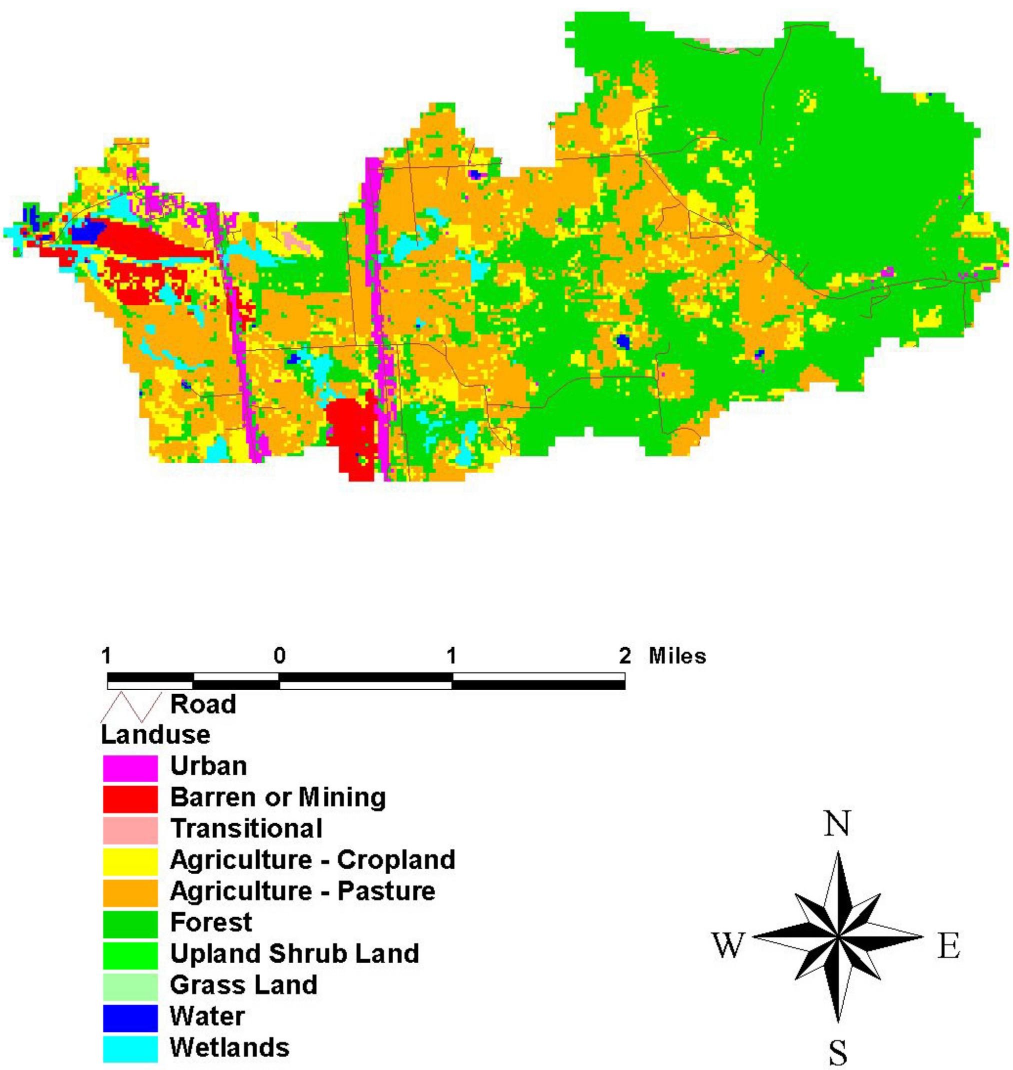


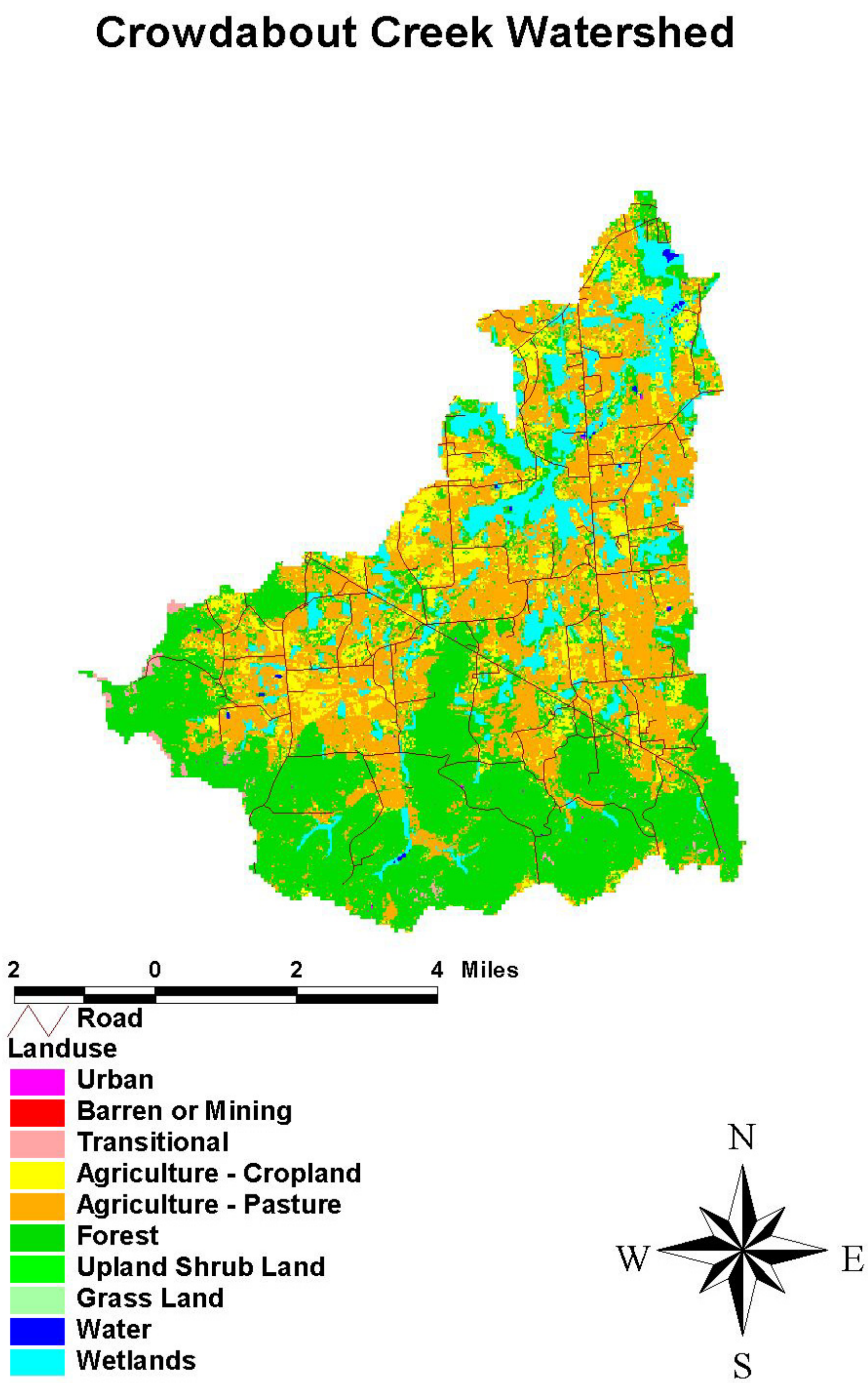

Flint Creek Watershed
8
0
8 Miles
Road
Landuse
Urban
Barren or Mining
Transitional
Agriculture - Cropland
Agriculture - Pasture
Forest
Upland Shrub Land
Grass Land
Water
Wetlands
N
W
E
S

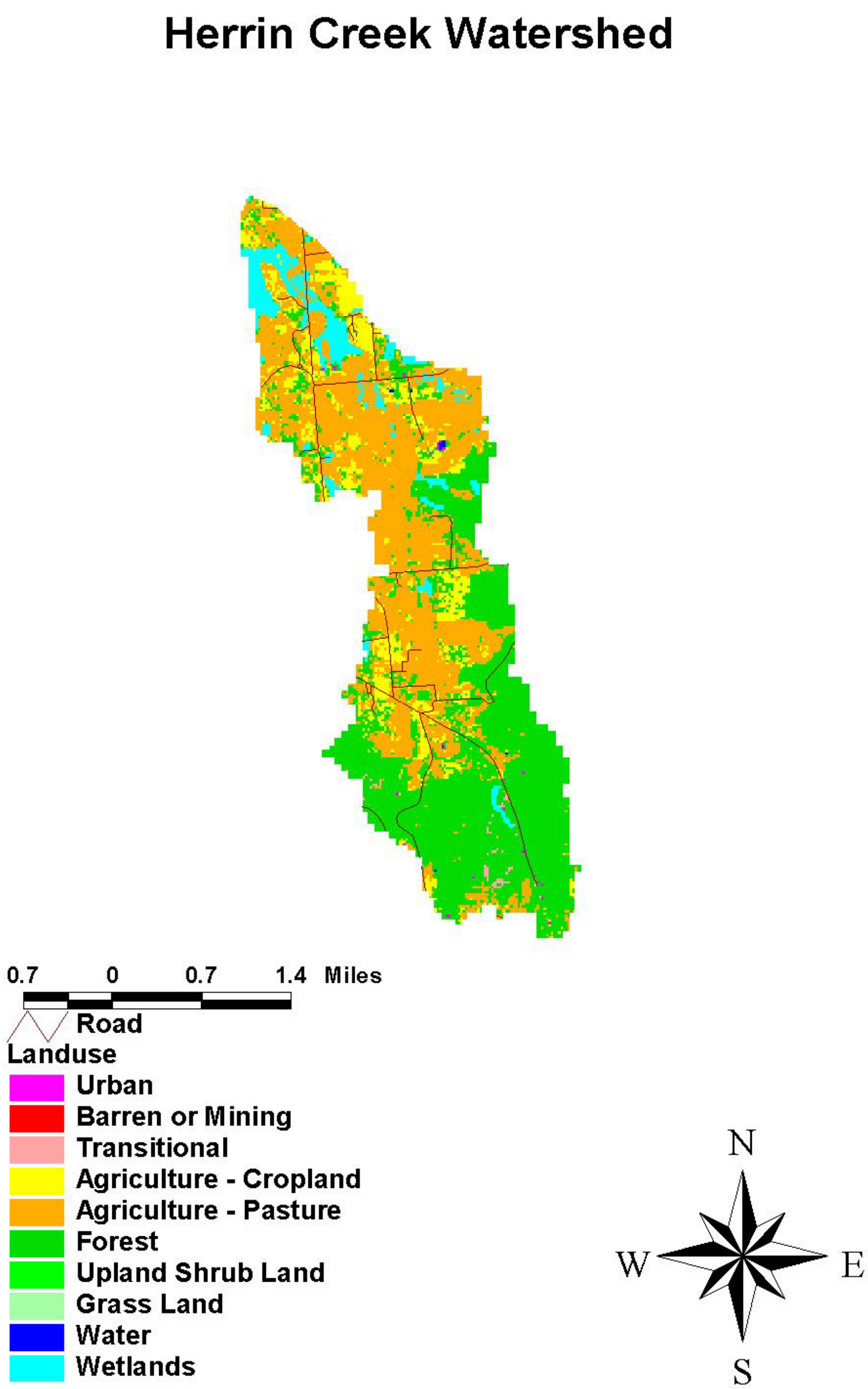
Mack Creek Watershed



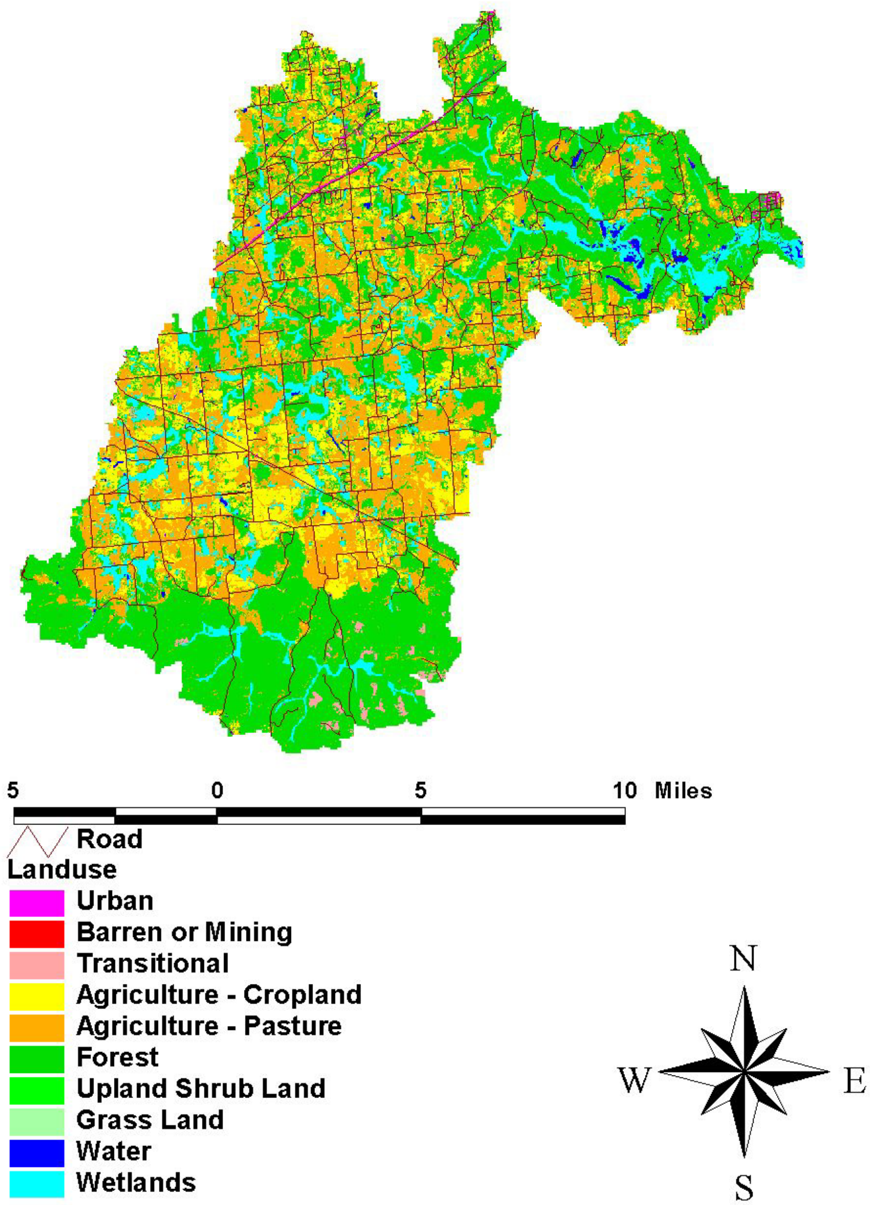
Robinson Creek Watershed



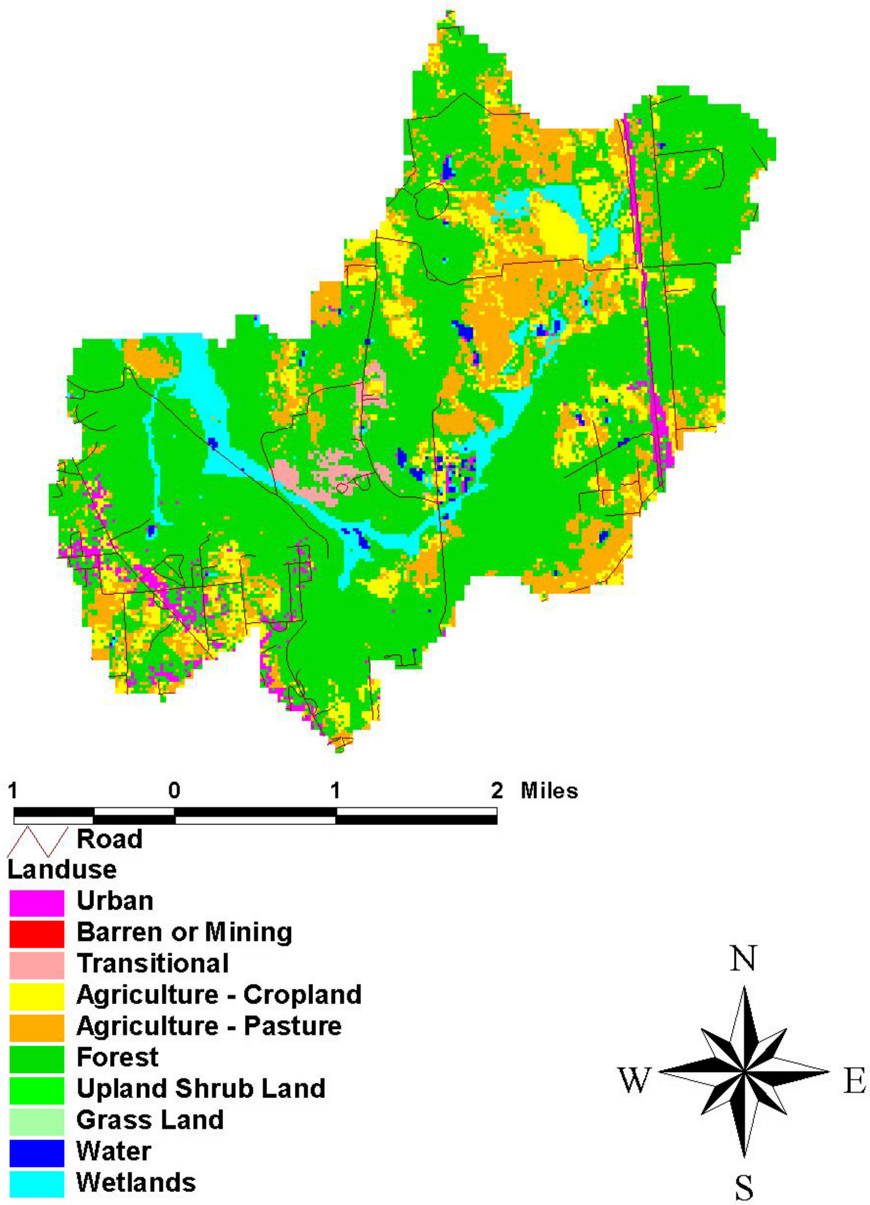

Crowdabout Creek Watershed
2 0 2 4 Miles
Road
Landuse
Urban
Barren or Mining
Transitional
Agriculture - Cropland
Agriculture - Pasture
Forest
Upland Shrub Land
Grass Land
Water
Wetlands
N
W
E
S


Herrin Creek Watershed
0.7 0 0.7 1.4 Miles
Road
Landuse
Urban
Barren or Mining
Transitional
Agriculture - Cropland
Agriculture - Pasture
Forest
Upland Shrub Land
Grass Land
Water
Wetlands
N
W
E
S

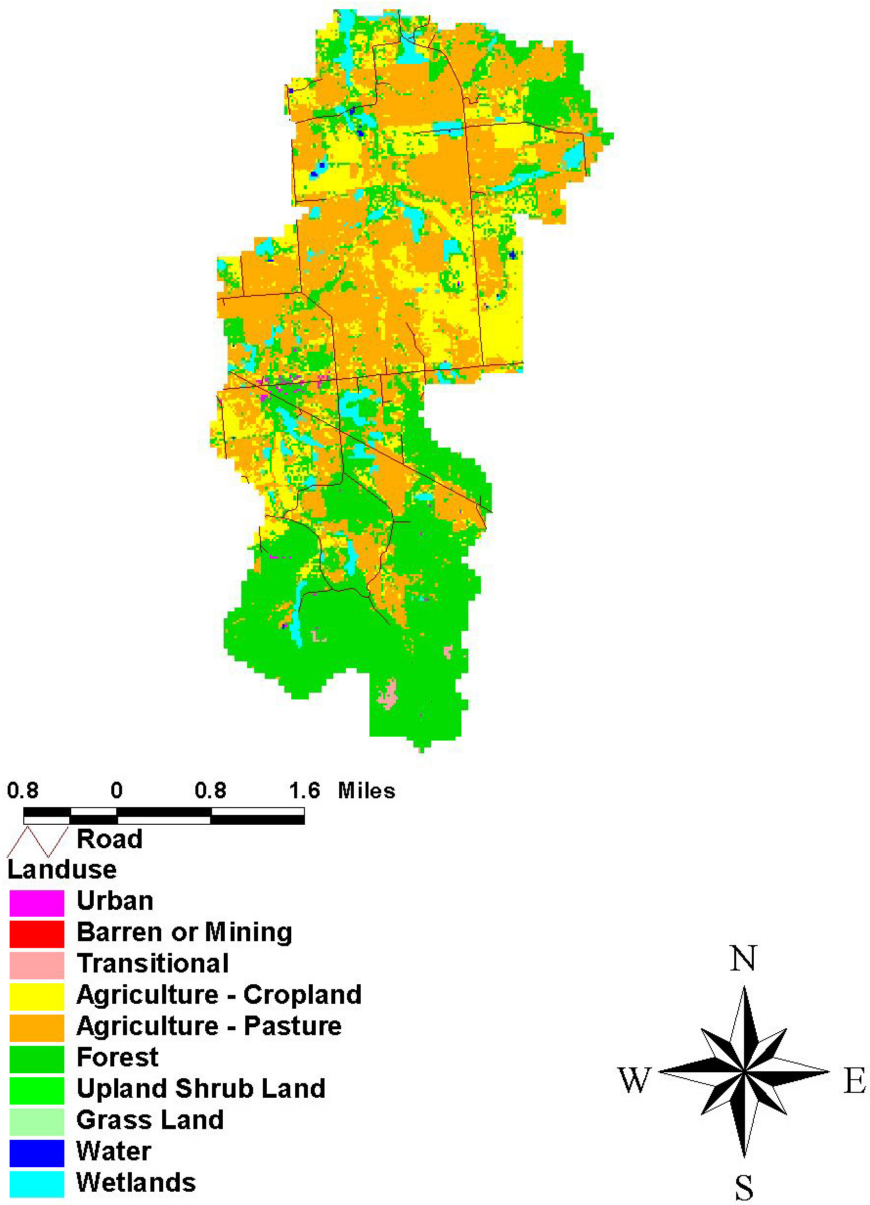
West Flint Creek Watershed



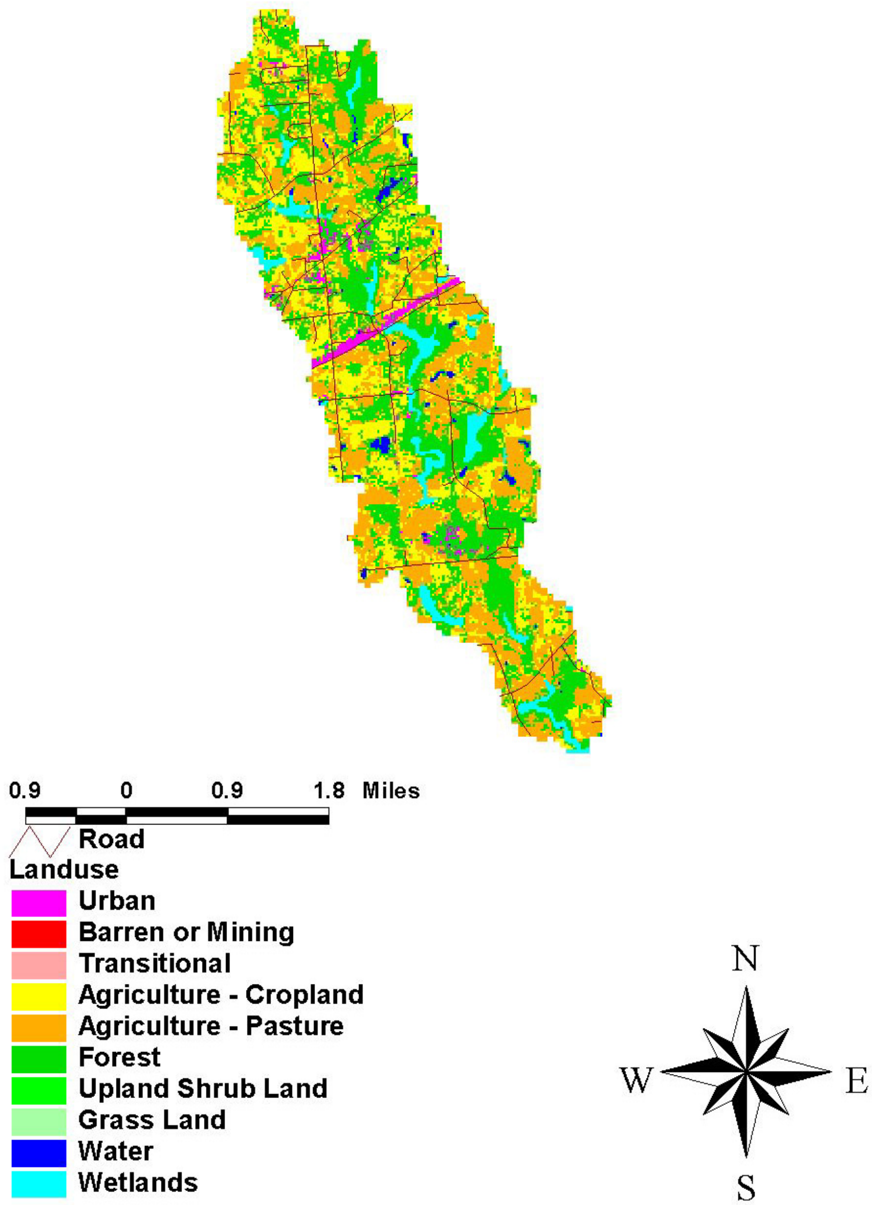
Village Branch Watershed



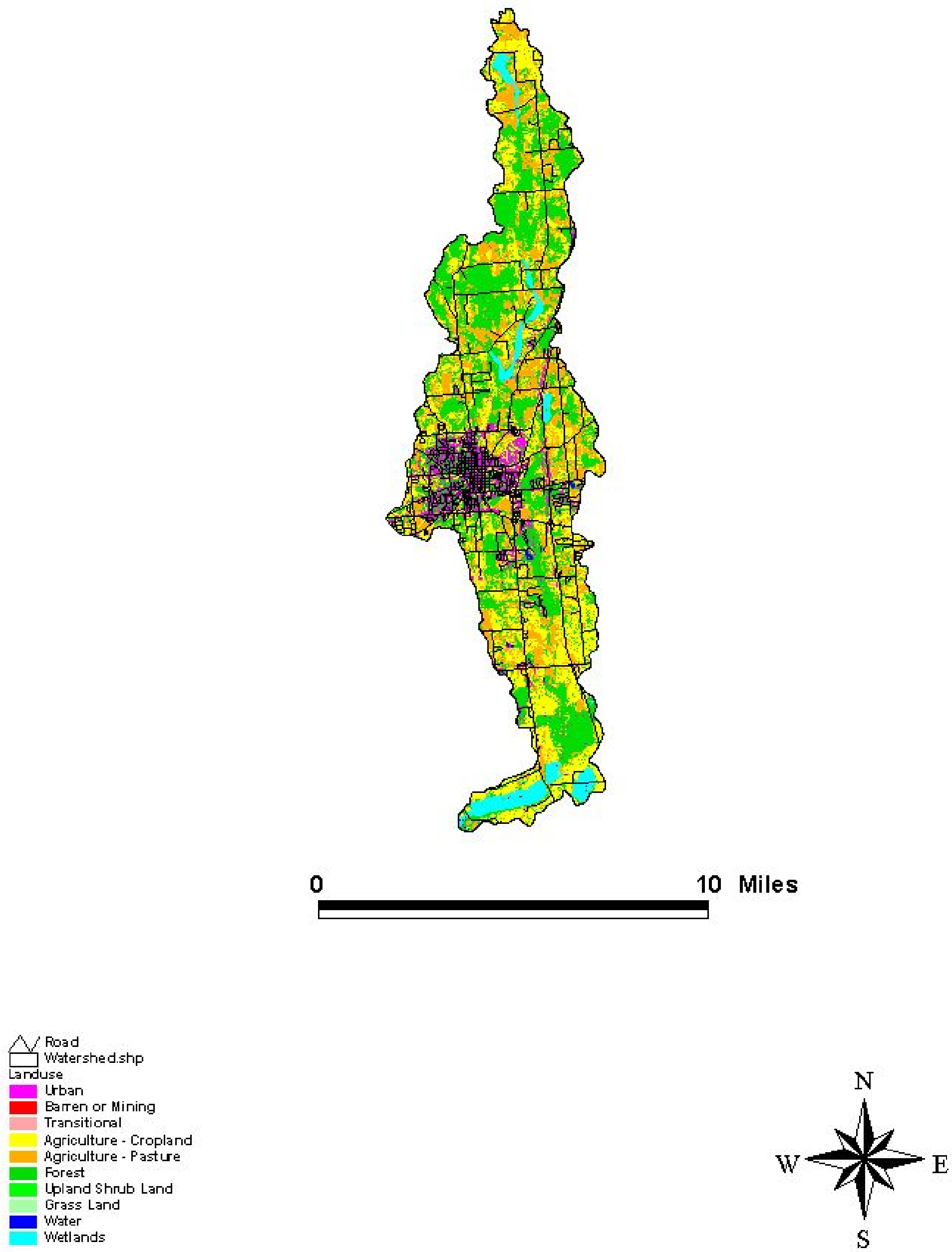
Mcdaniel Creek Watershed



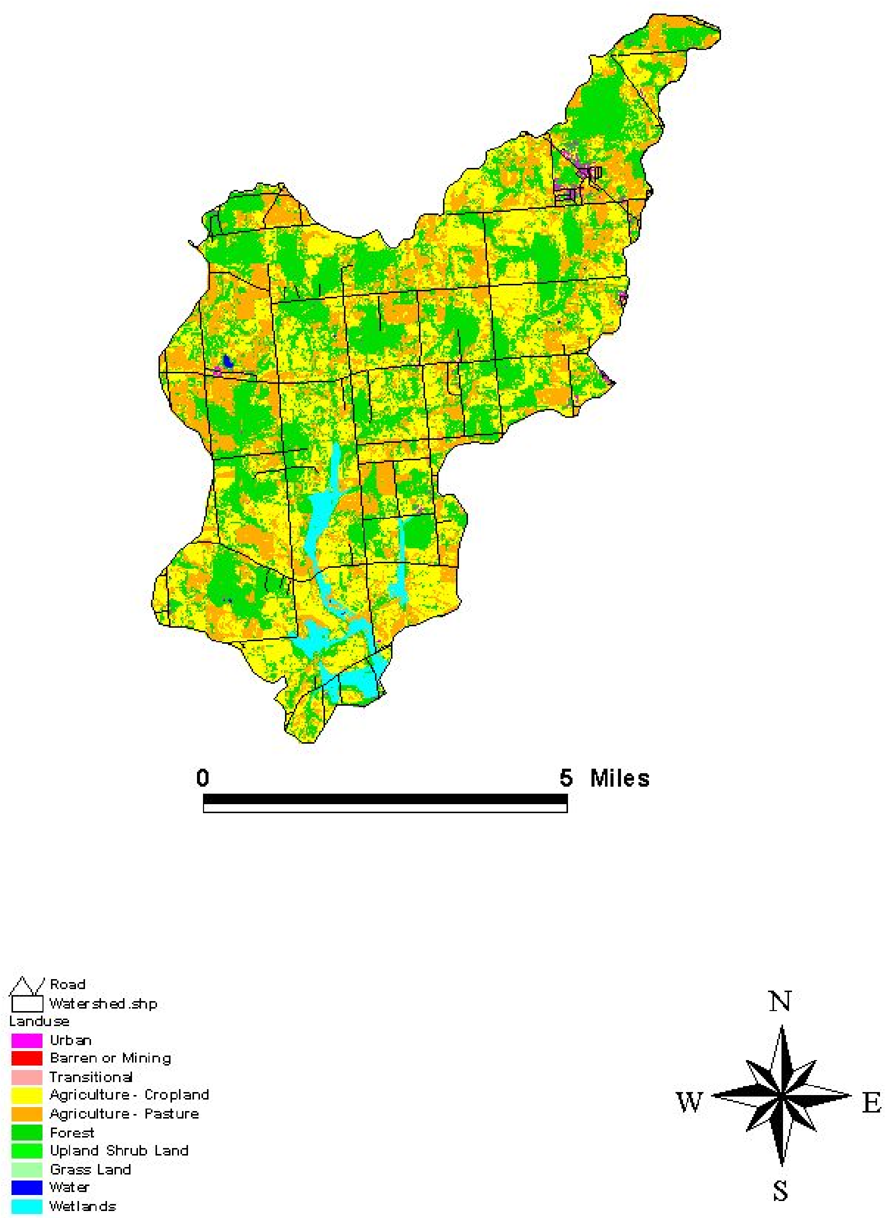
Flat Creek Watershed



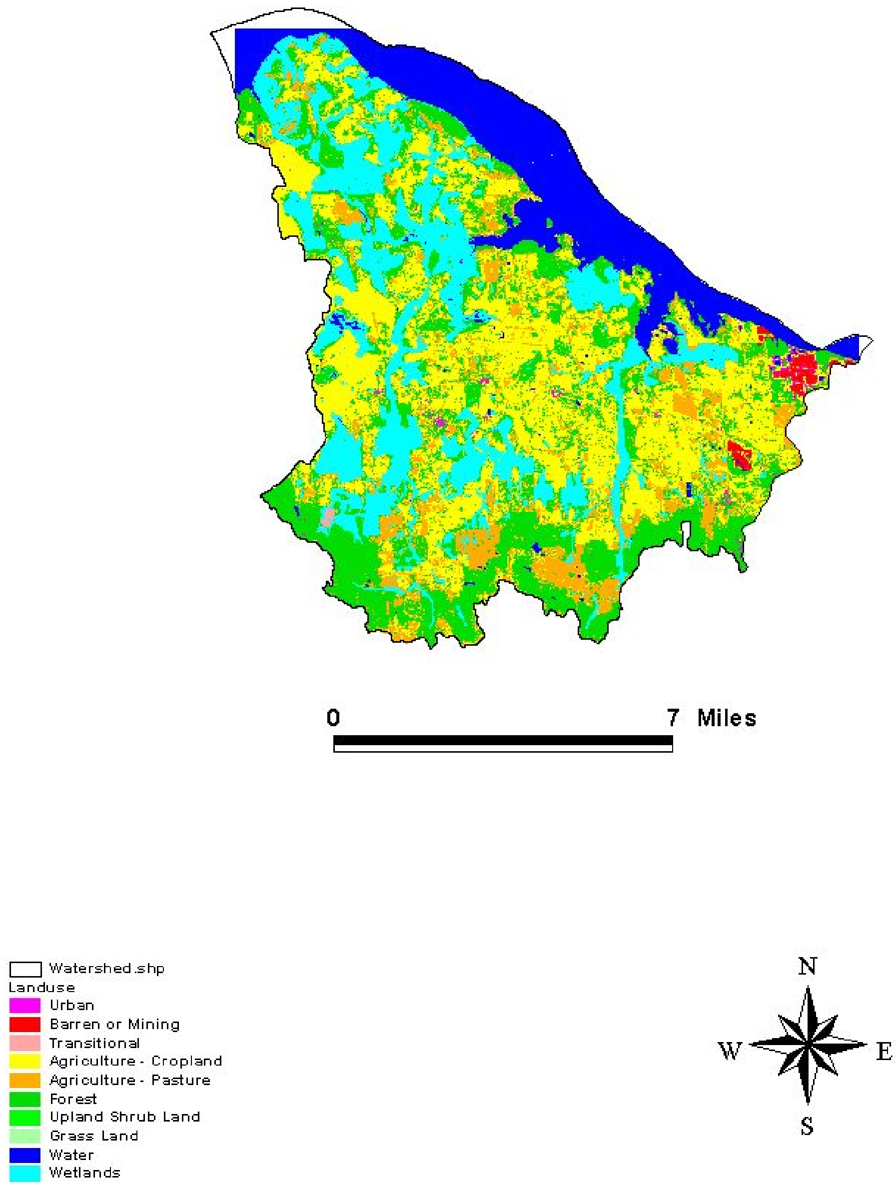
Swan Creek Watershed



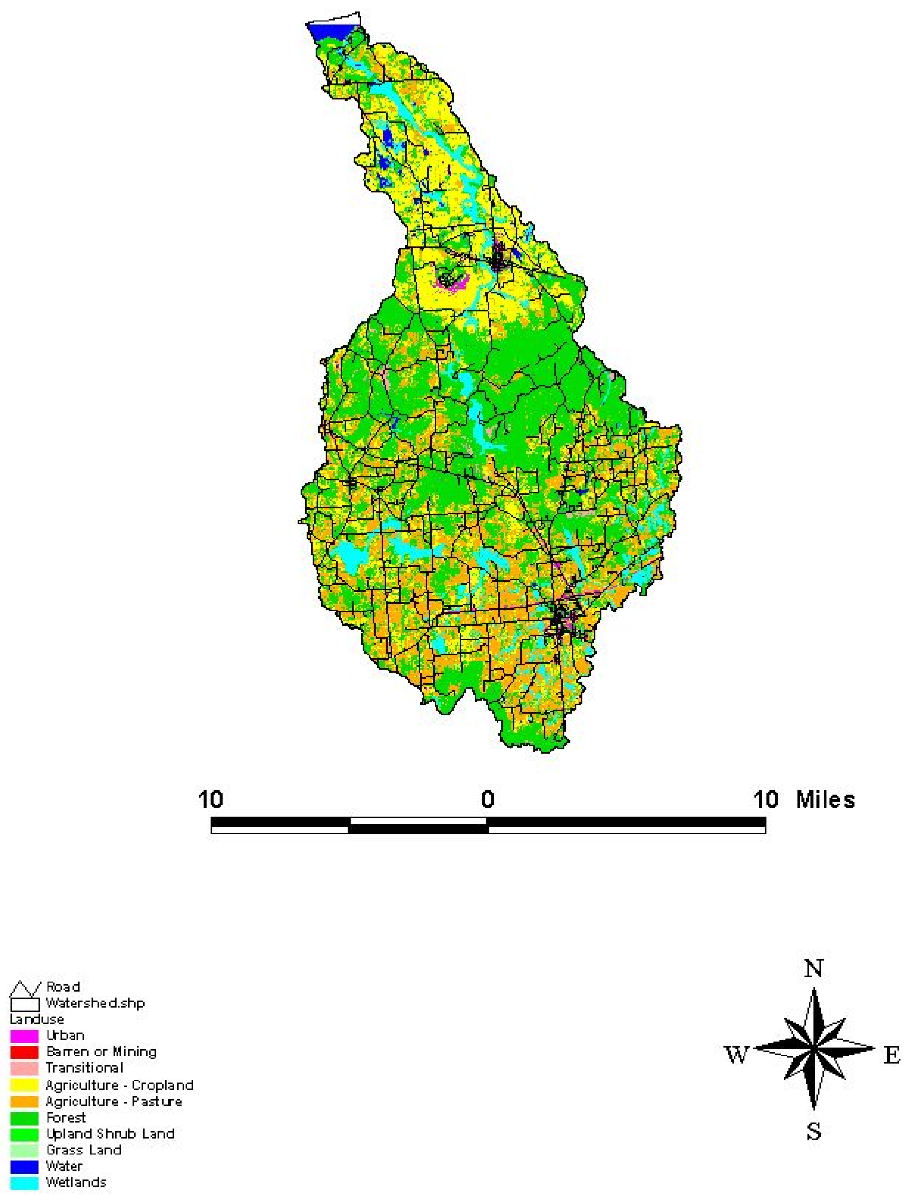
Round Island Creek Watershed



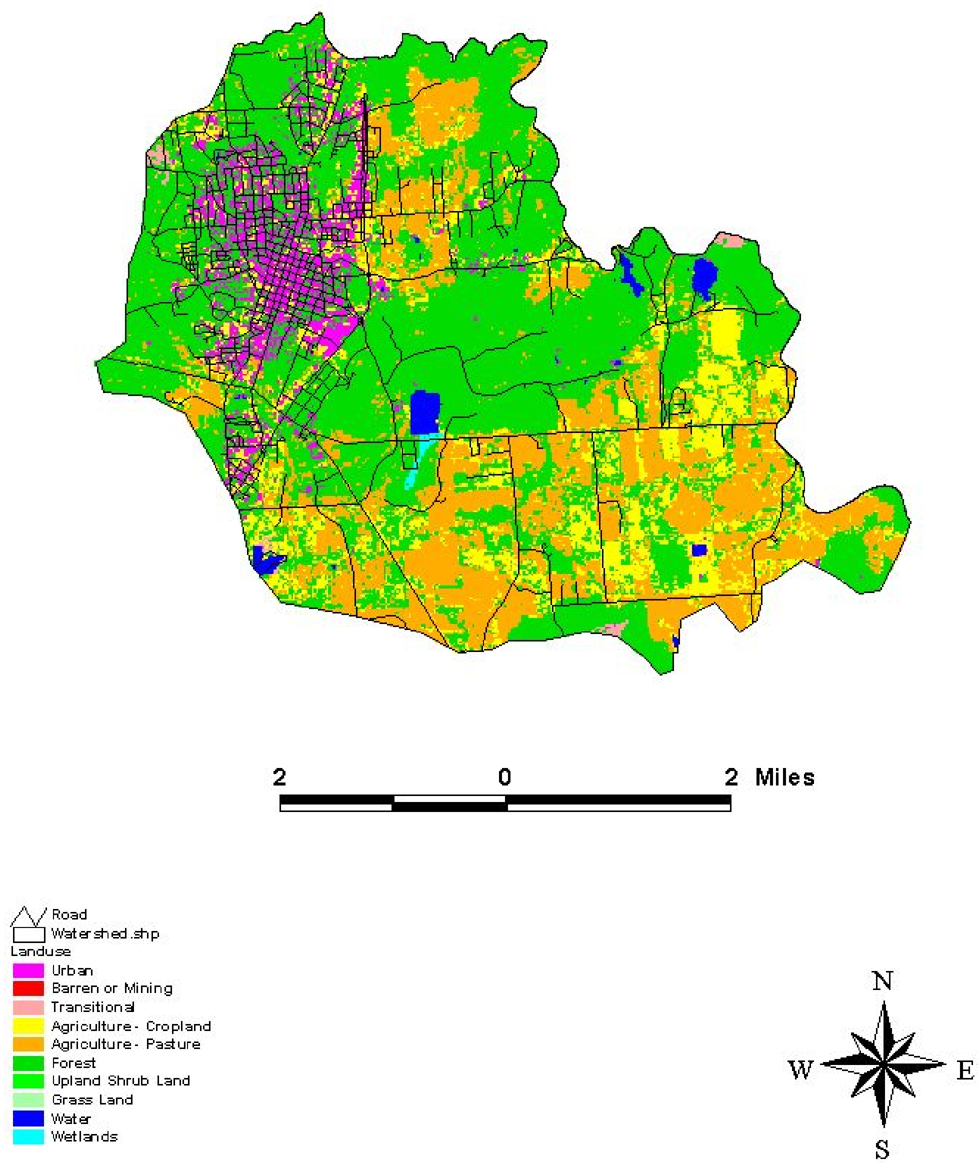
Mallard Creek Watershed



Bignance Creek Watershed

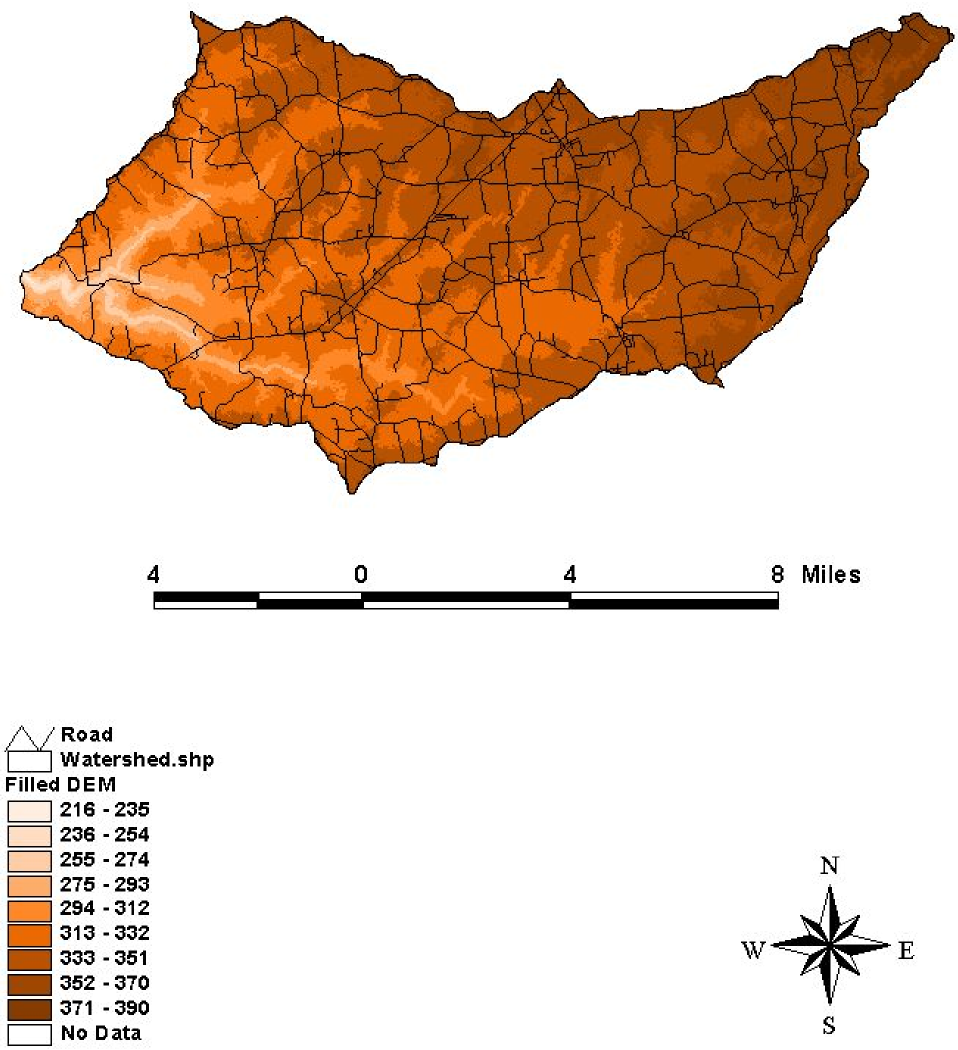


Harris Creek Watershed

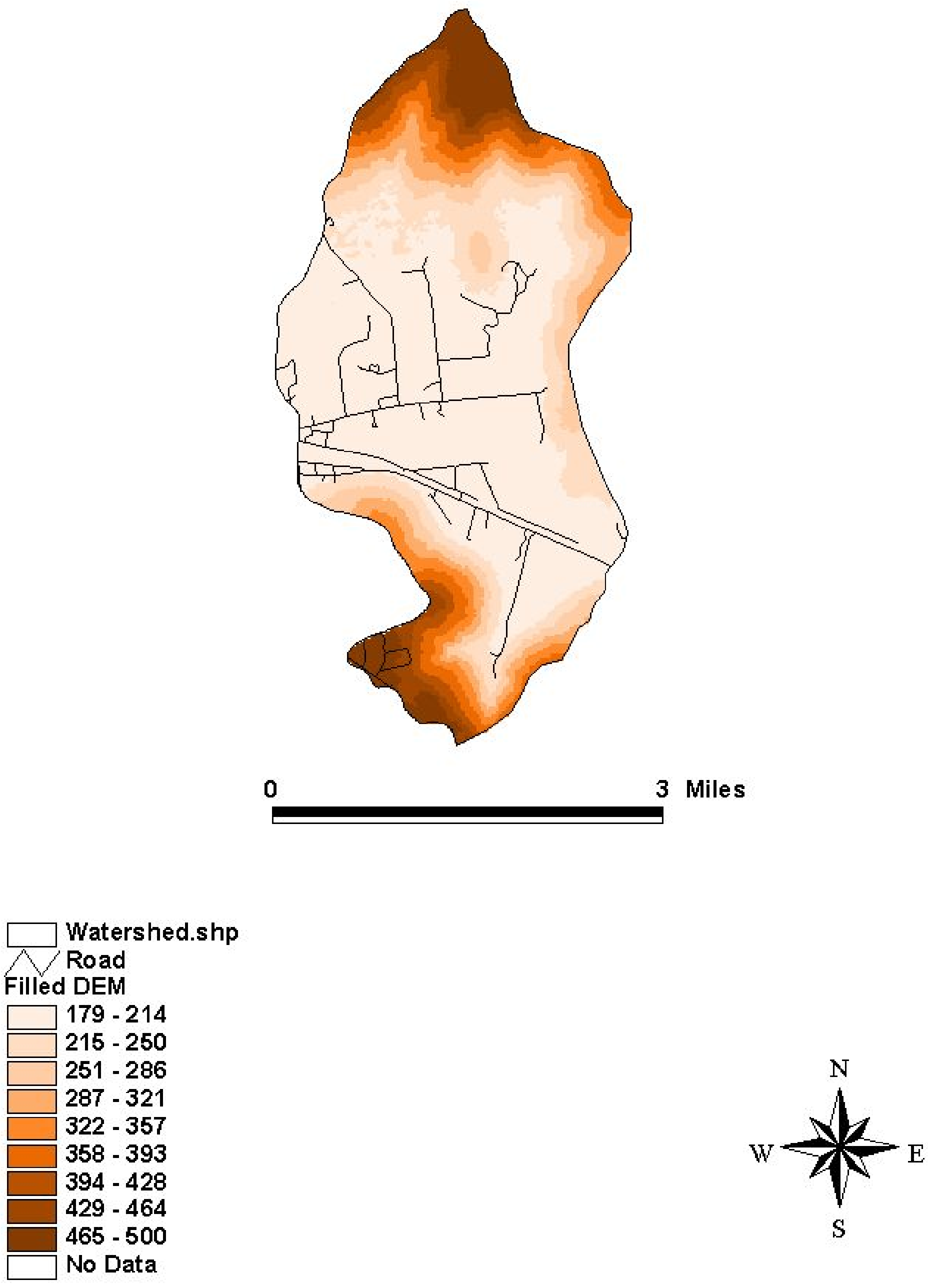


9.3 Subwatershed Elevations with Road Coverage

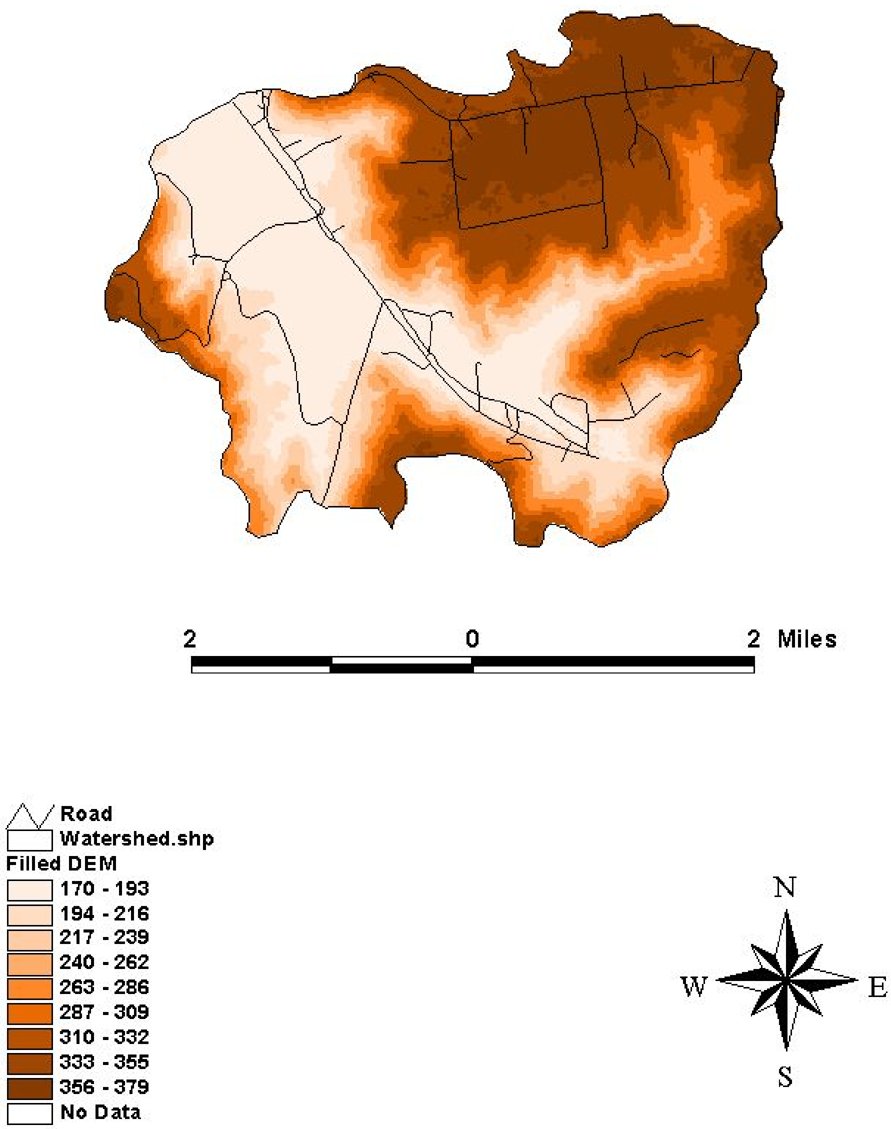
Scarham Creek Watershed



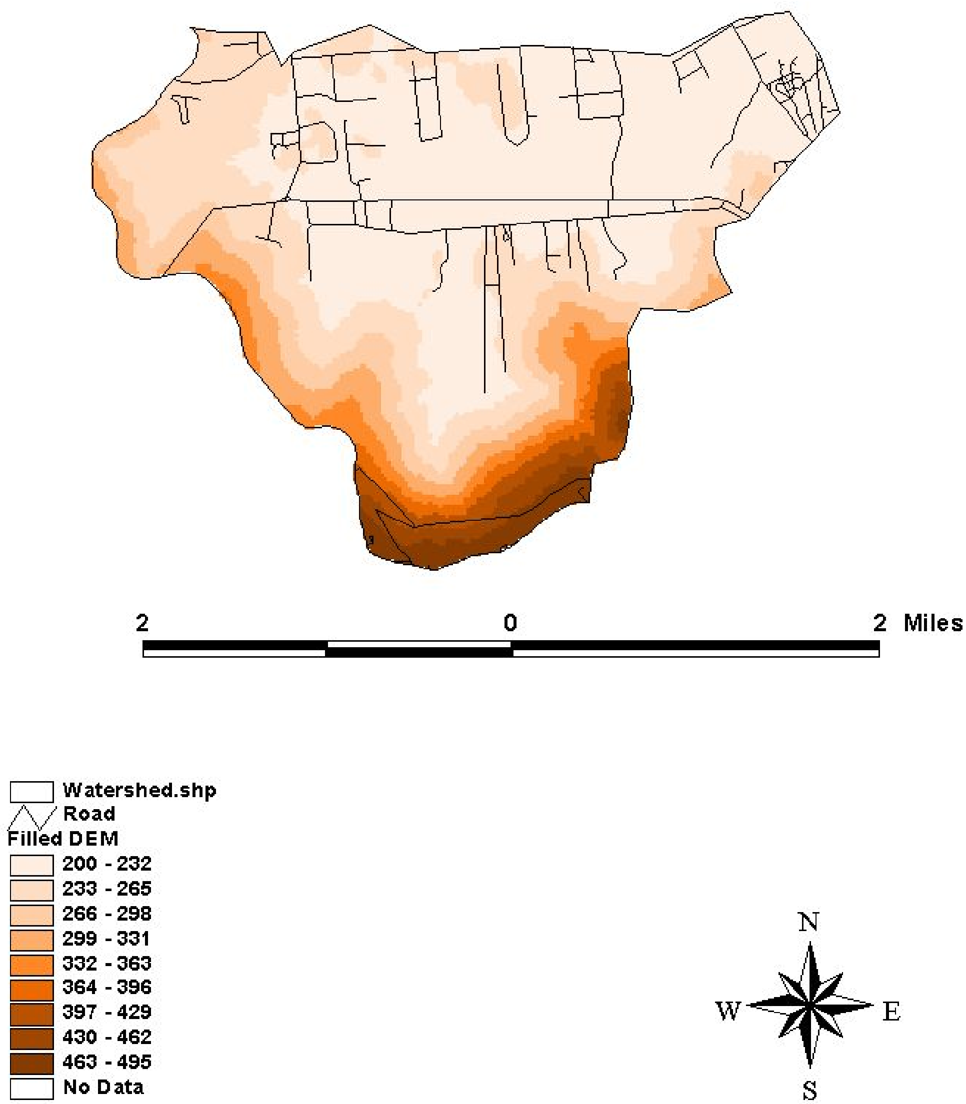
Cole Spring Branch Watershed

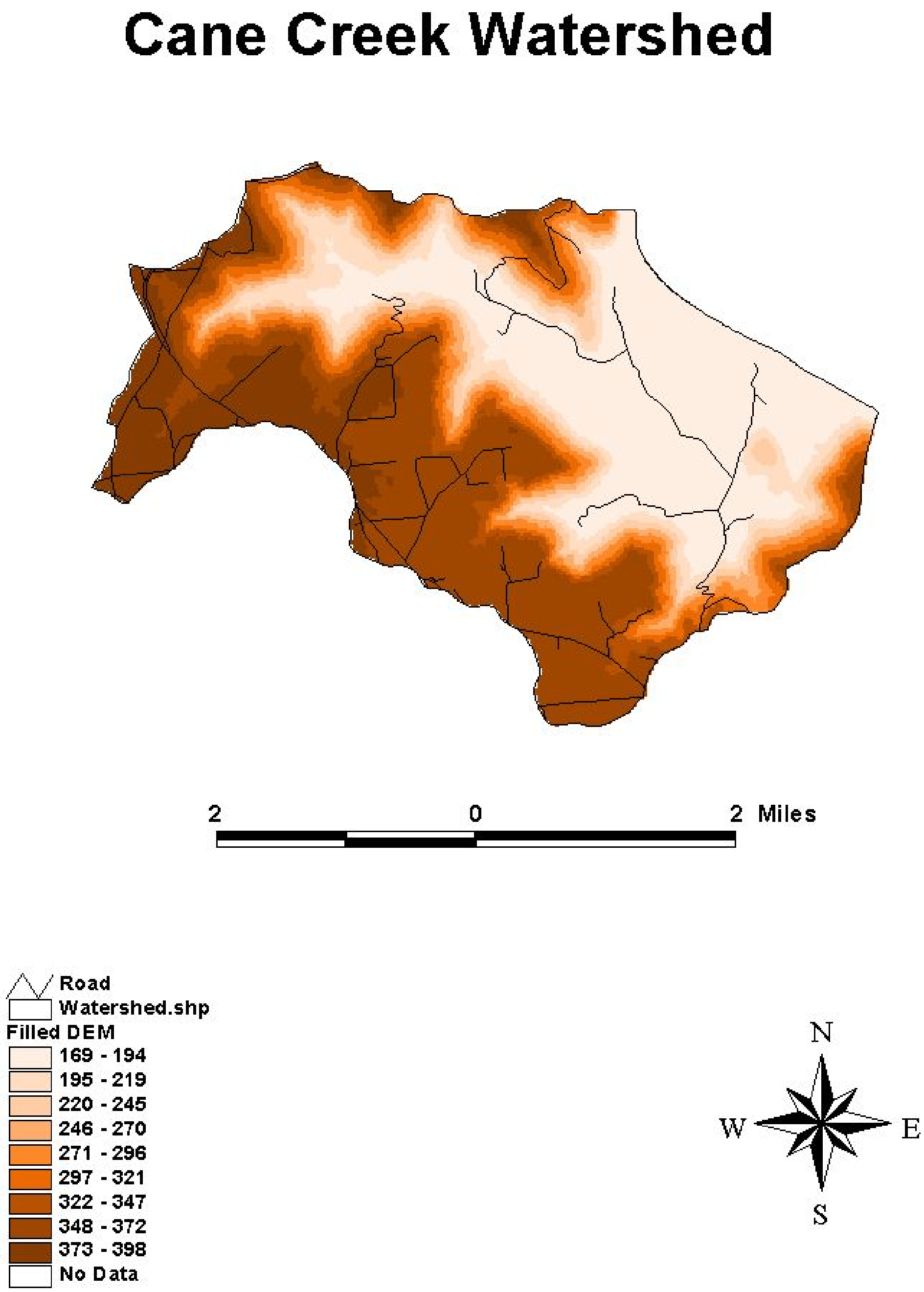


Little Paint Rock Creek Watershed

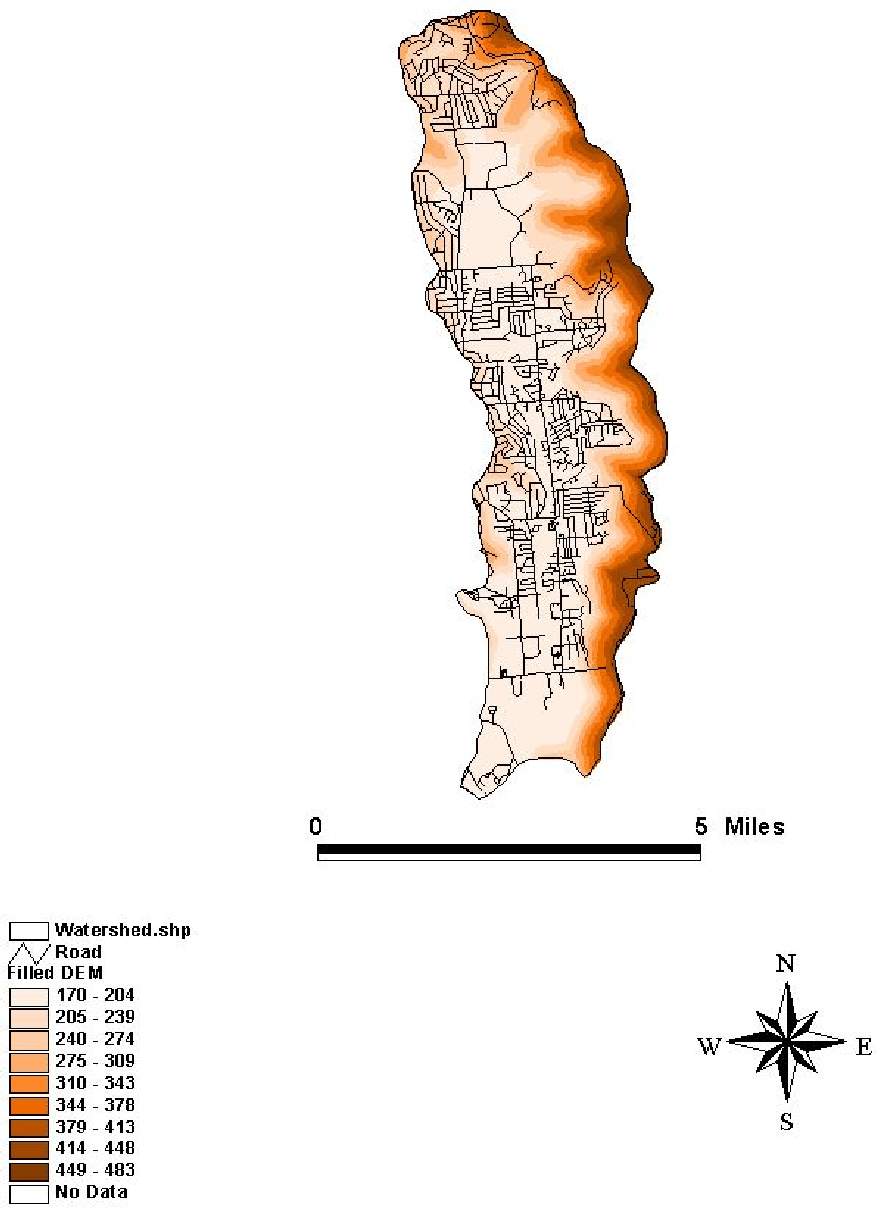


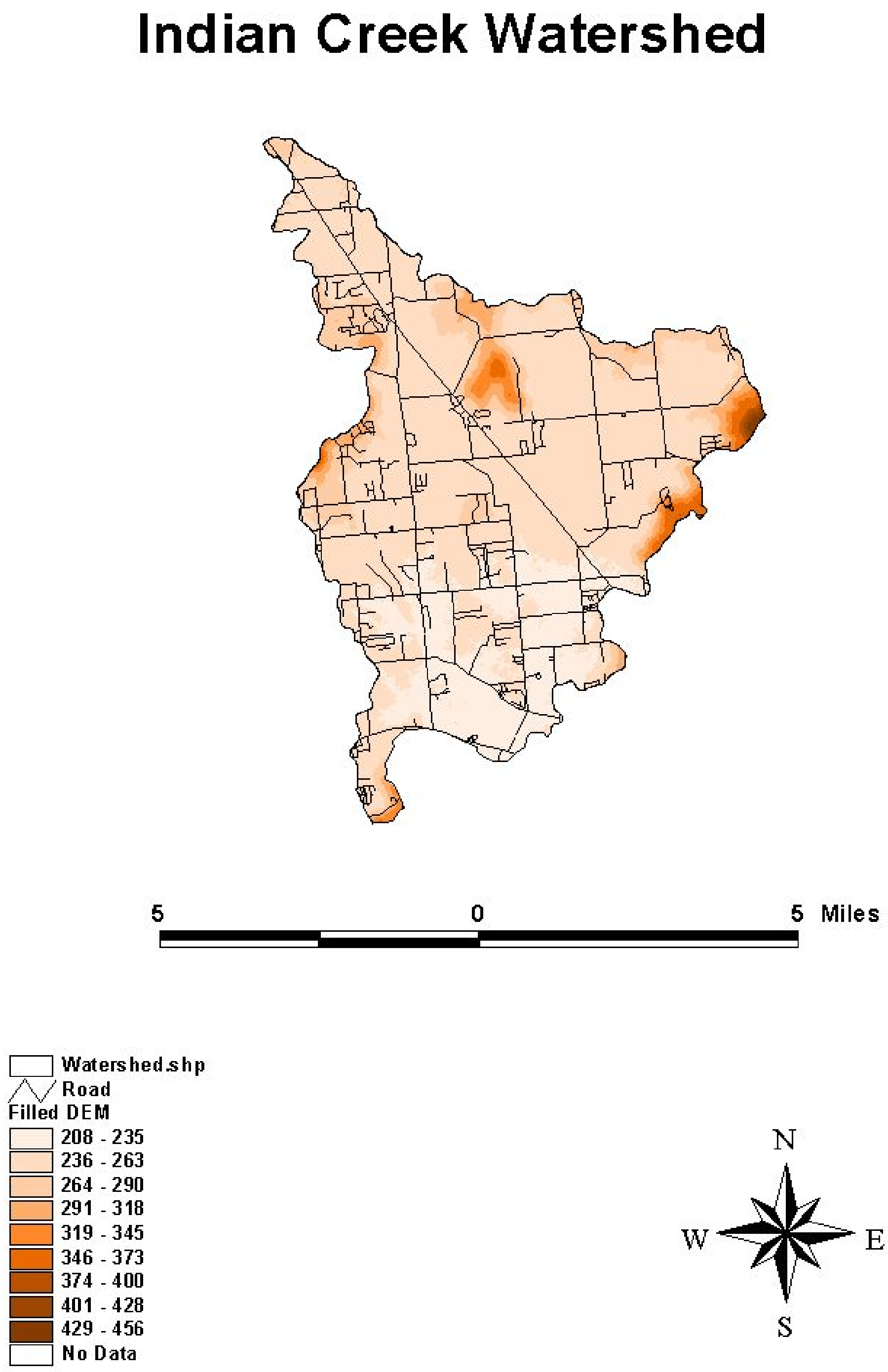
Chase Creek Watershed



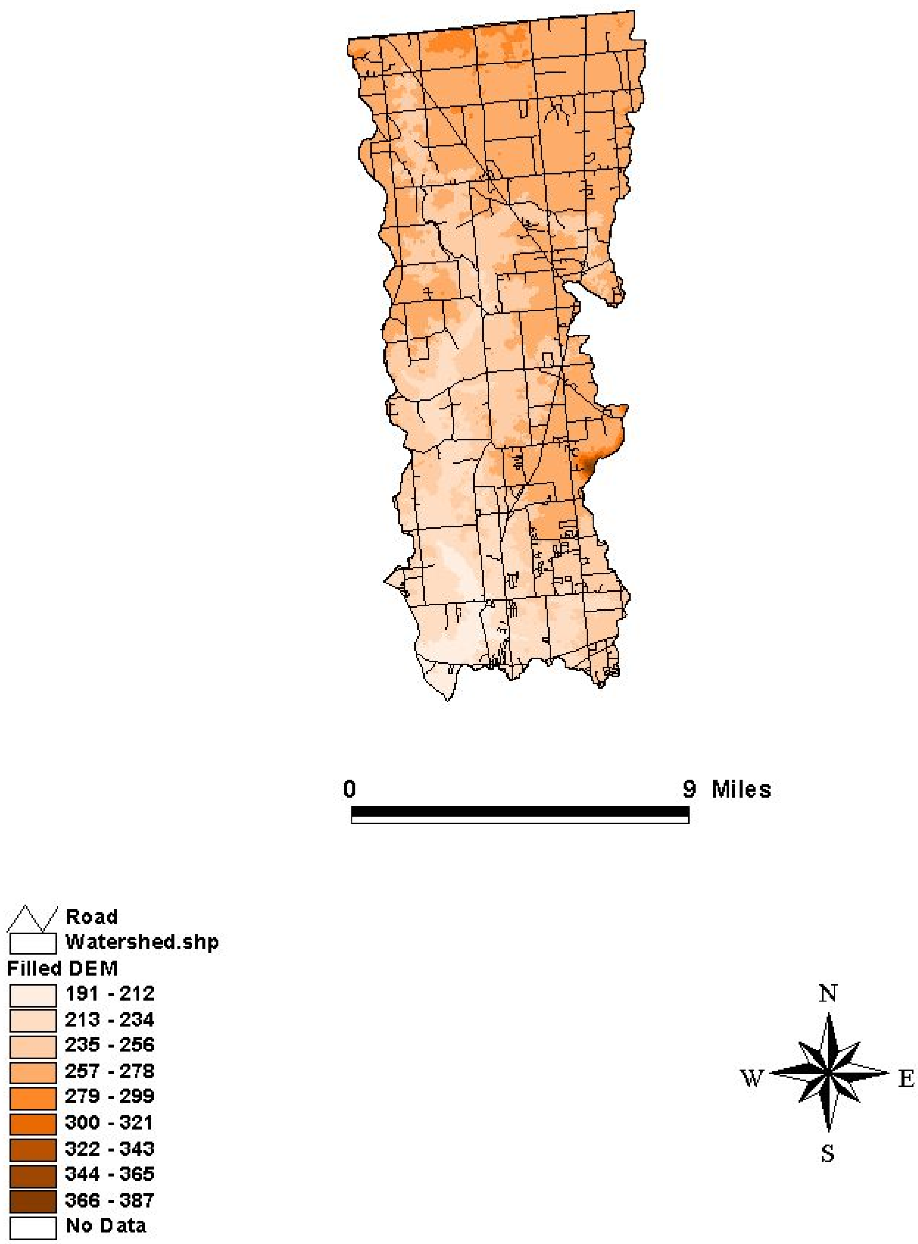

Cane Creek Watershed
2
0
2 Miles
Road
Watershed.shp
Filled DEM
169 - 194
195 - 219
220 - 245
246 - 270
271 - 296
297 - 321
322 - 347
348 - 372
373 - 398
No Data
N
W
E
S

Aldridge Creek Watershed

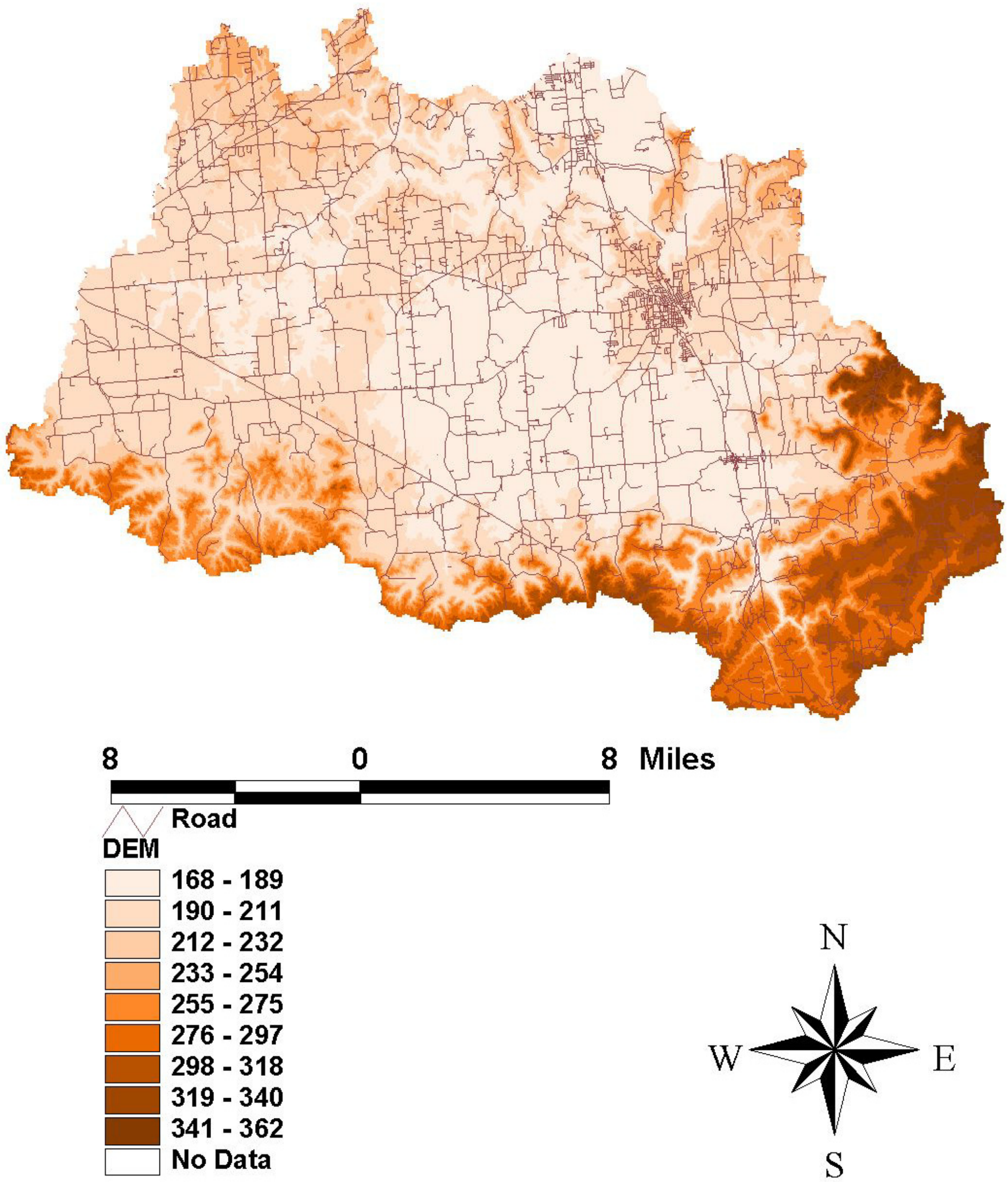



Indian Creek Watershed
5
0
5 Miles
Watershed.shp
Road
Filled DEM
208 - 235
236 - 263
264 - 290
291 - 318
319 - 345
346 - 373
374 - 400
401 - 428
429 - 456
No Data
N
W
E
S

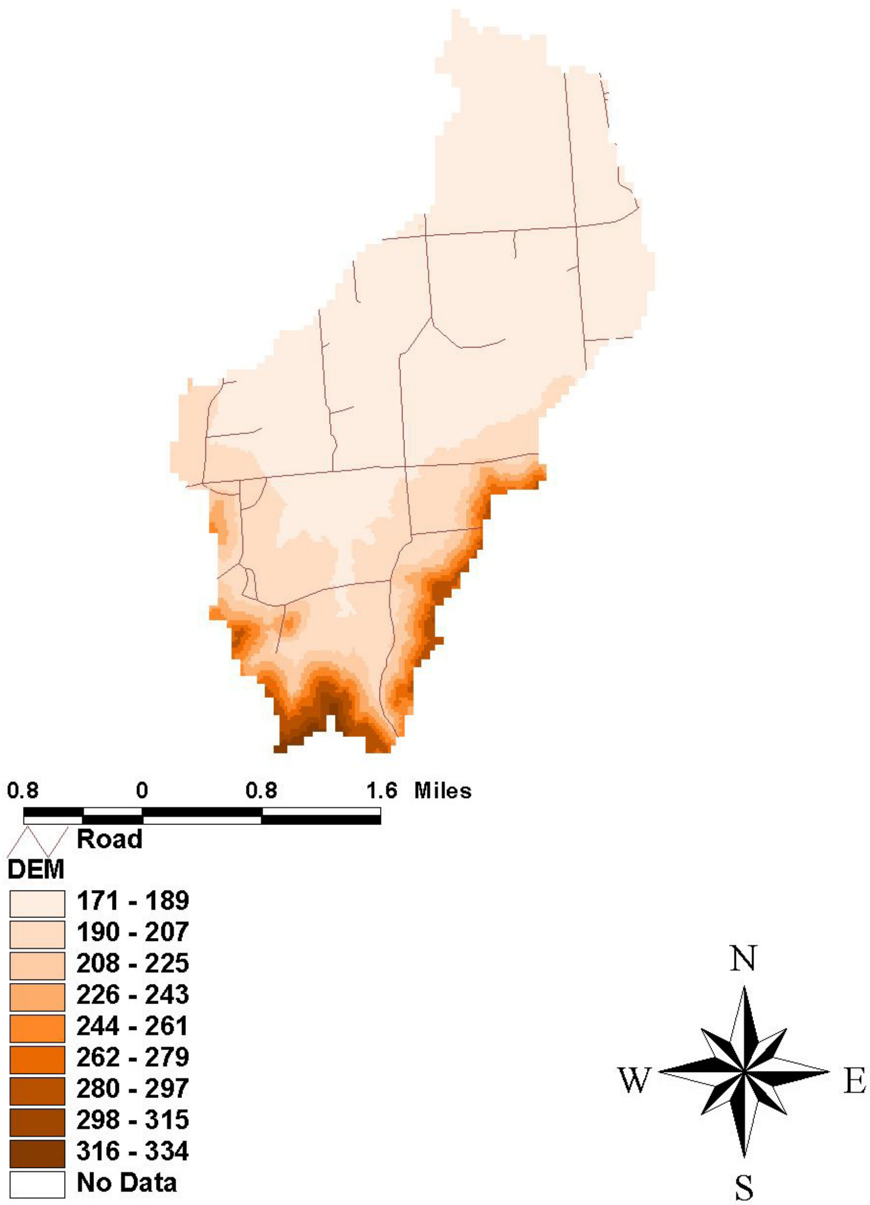
Limestone Creek Watershed



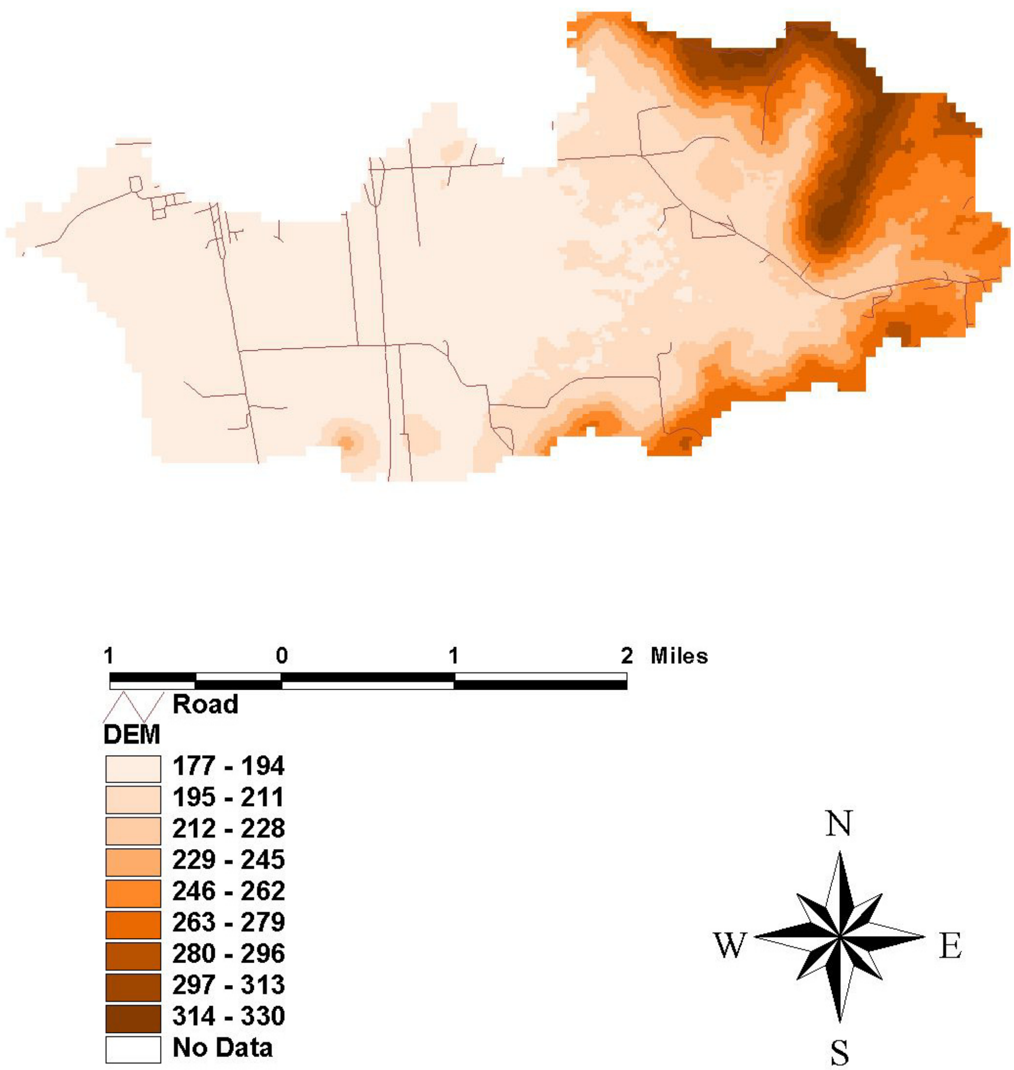
Flint Creek Watershed



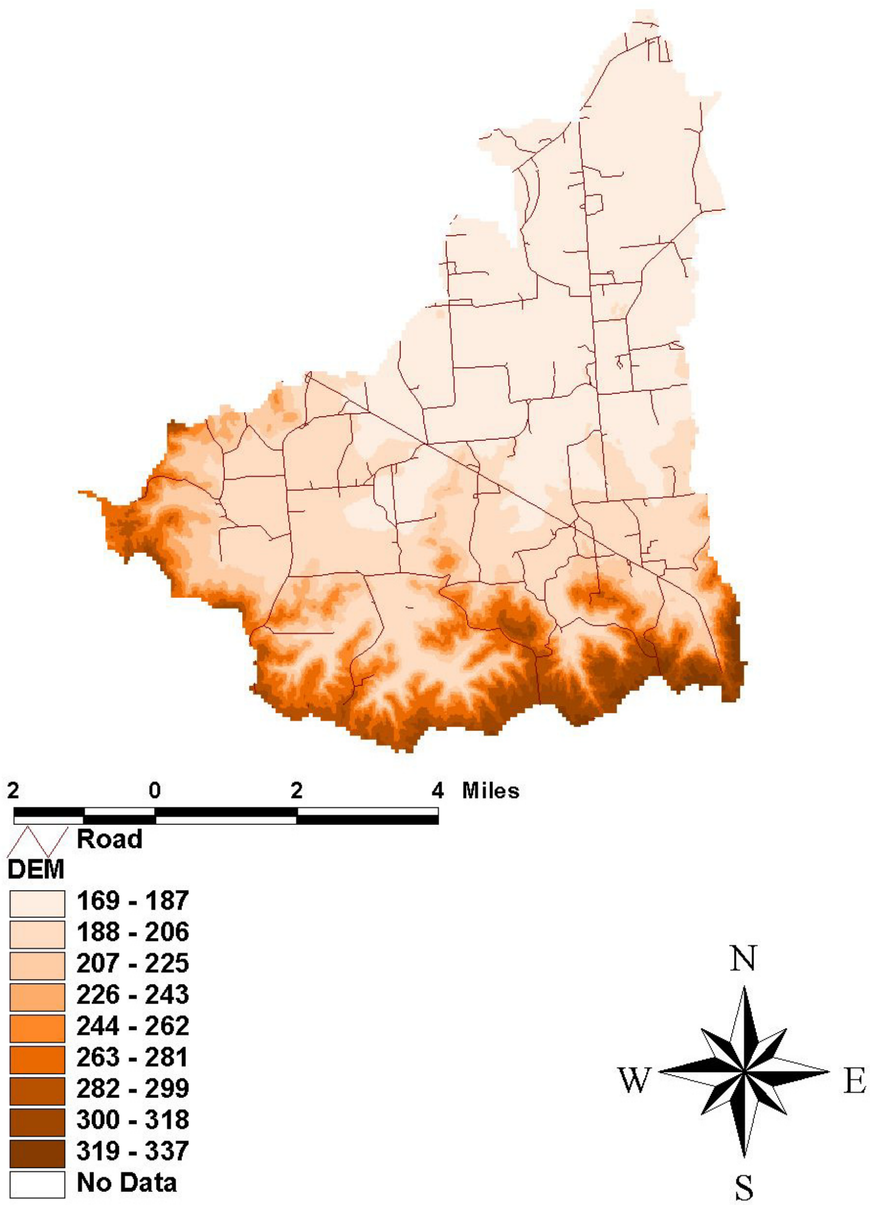
Mack Creek Watershed



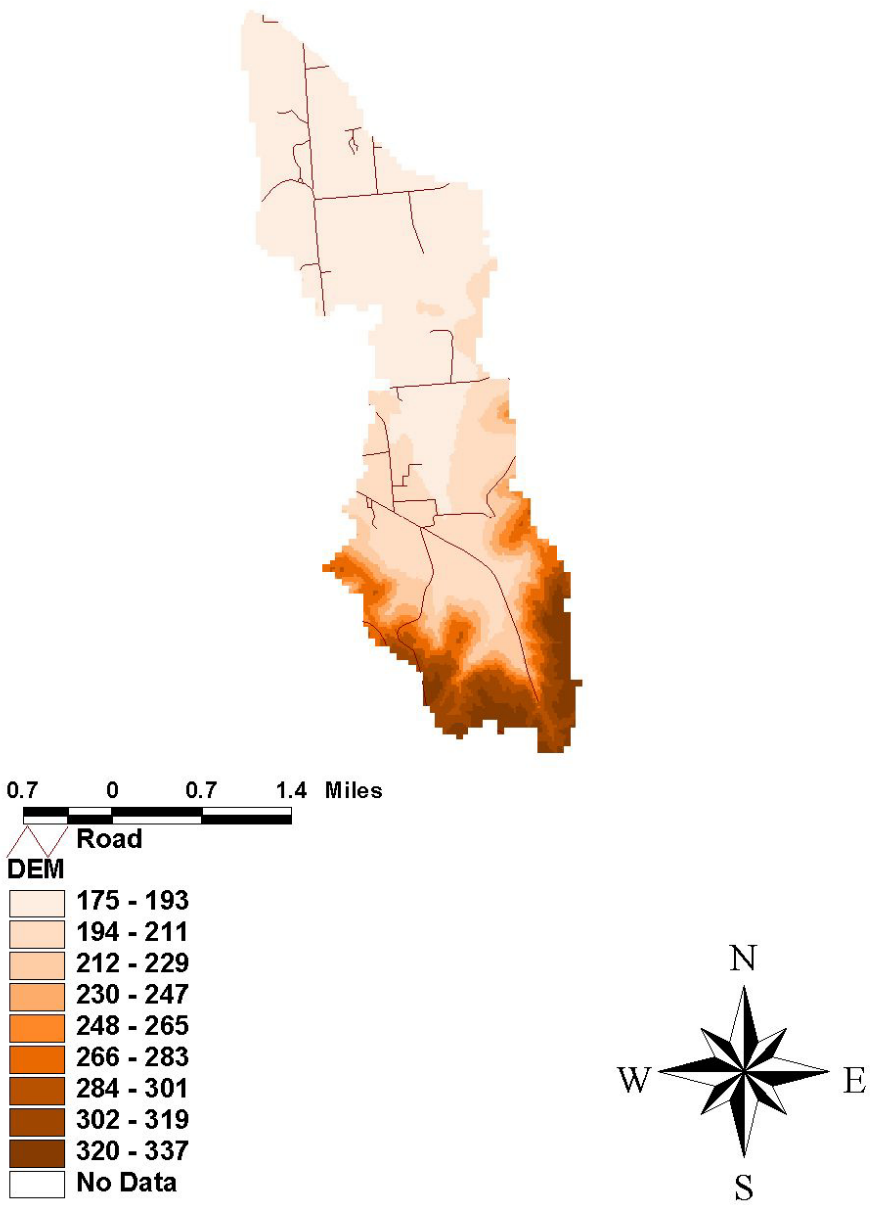
Robinson Creek Watershed

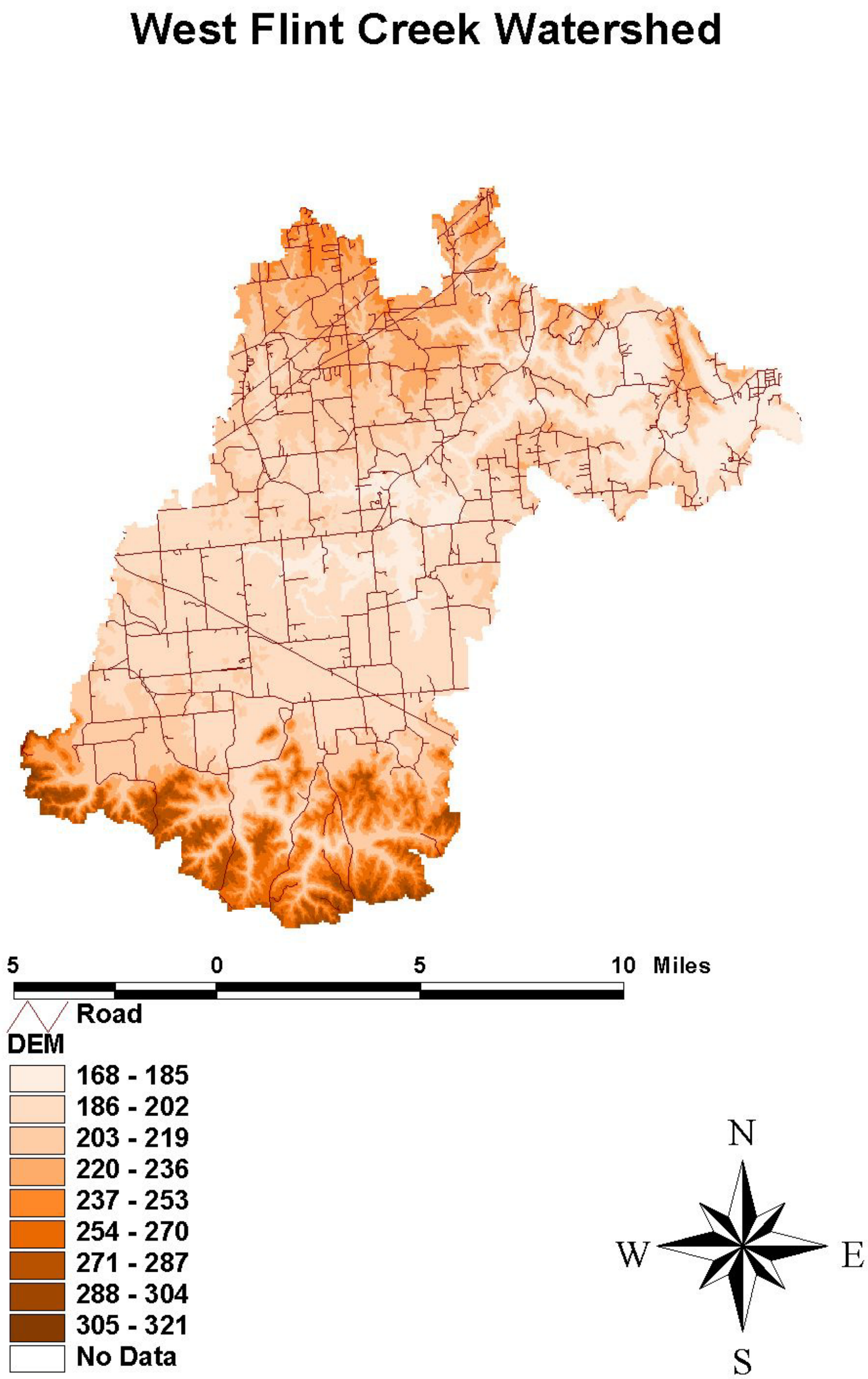


Crowdabout Creek Watershed

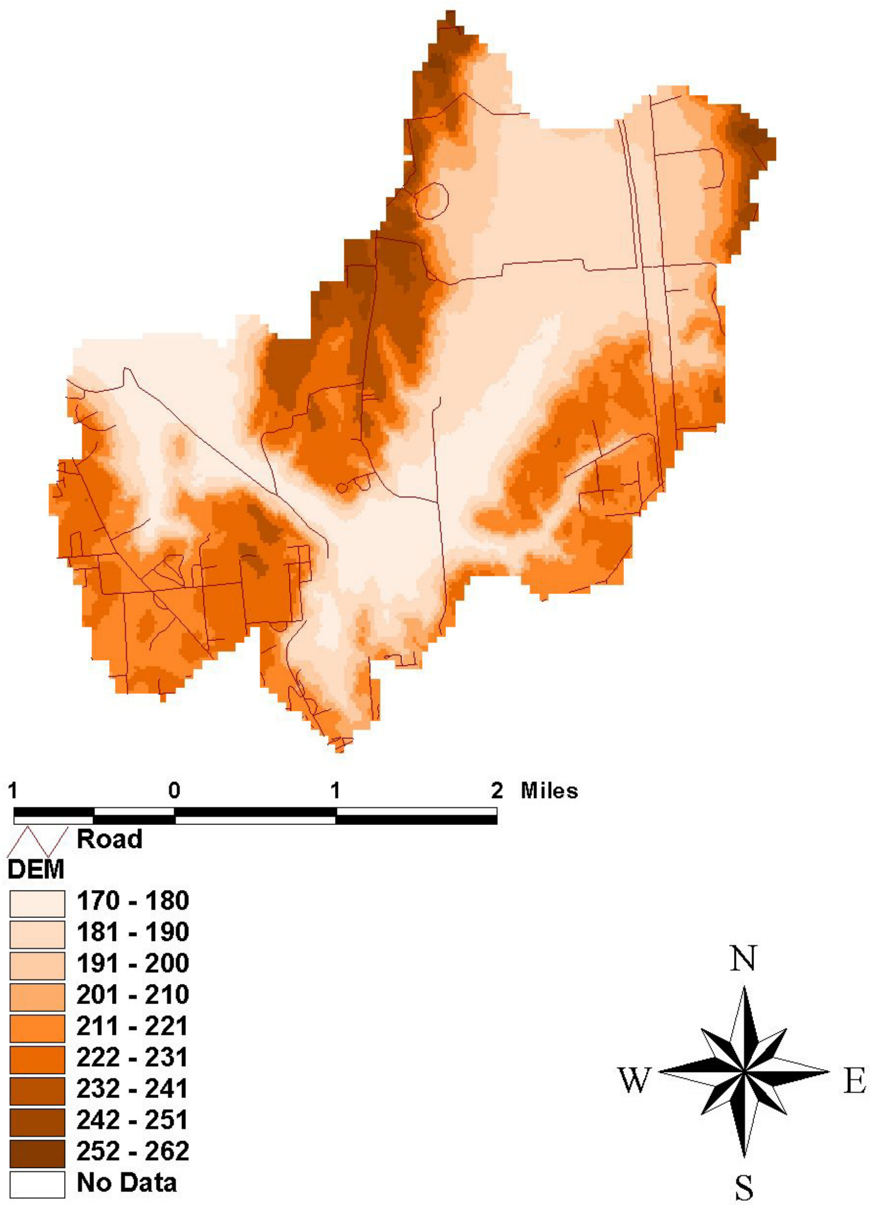


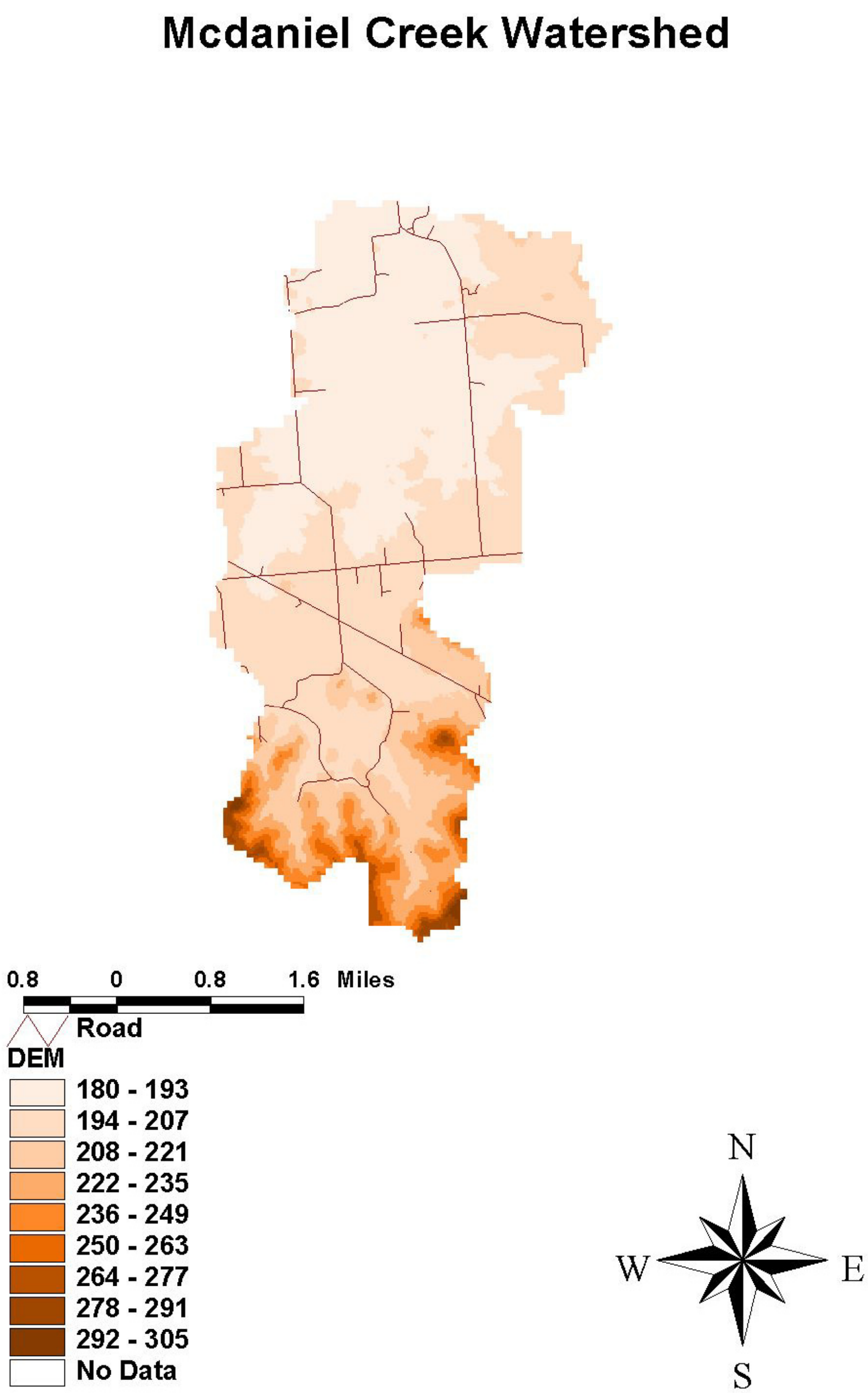
Herrin Creek Watershed

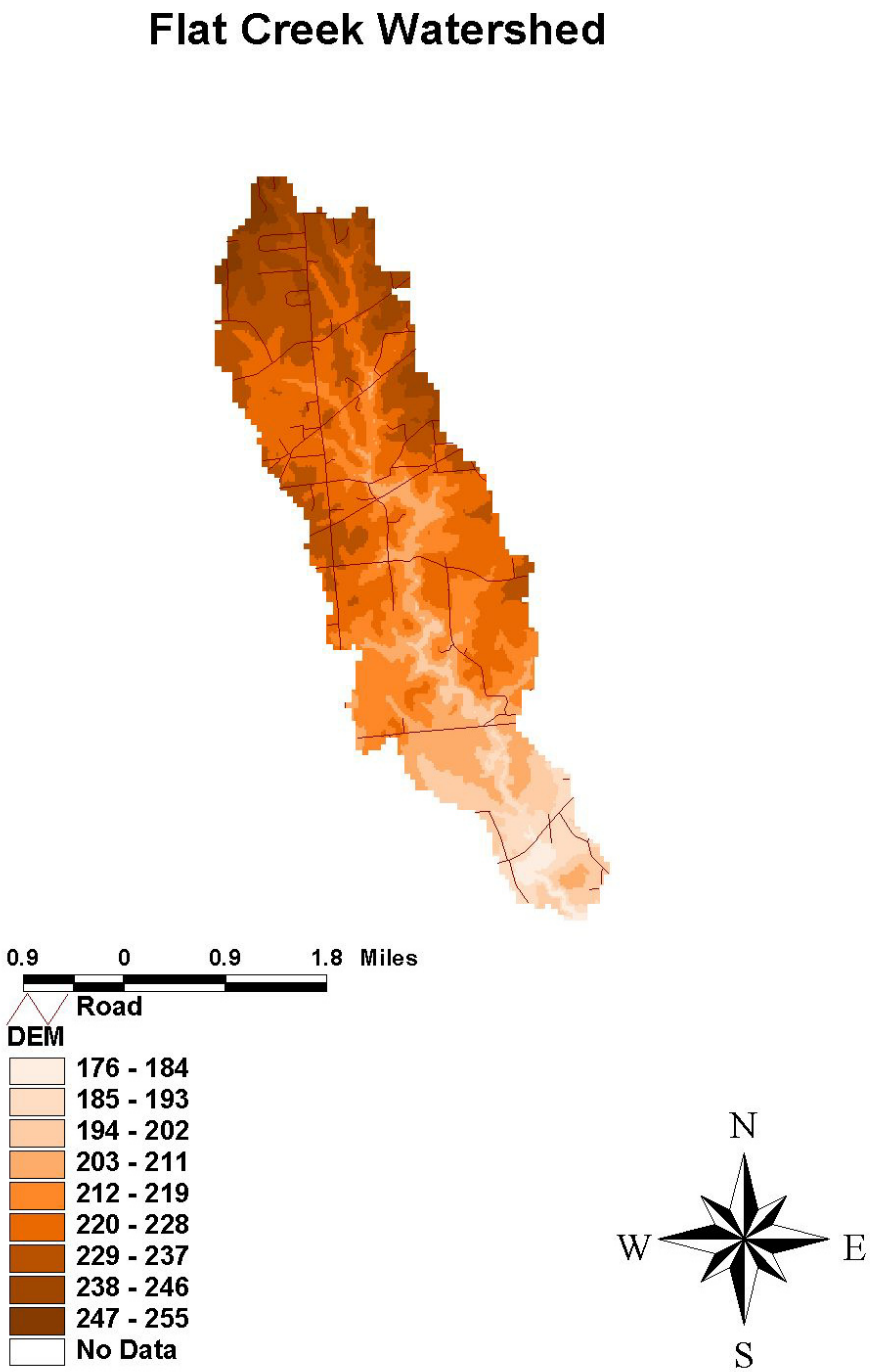



West Flint Creek Watershed
5
0
5
10 Miles
Road
DEM
168 - 185
186 - 202
203 - 219
220 - 236
237 - 253
254 - 270
271 - 287
288 - 304
305 - 321
No Data
N
W
E
S

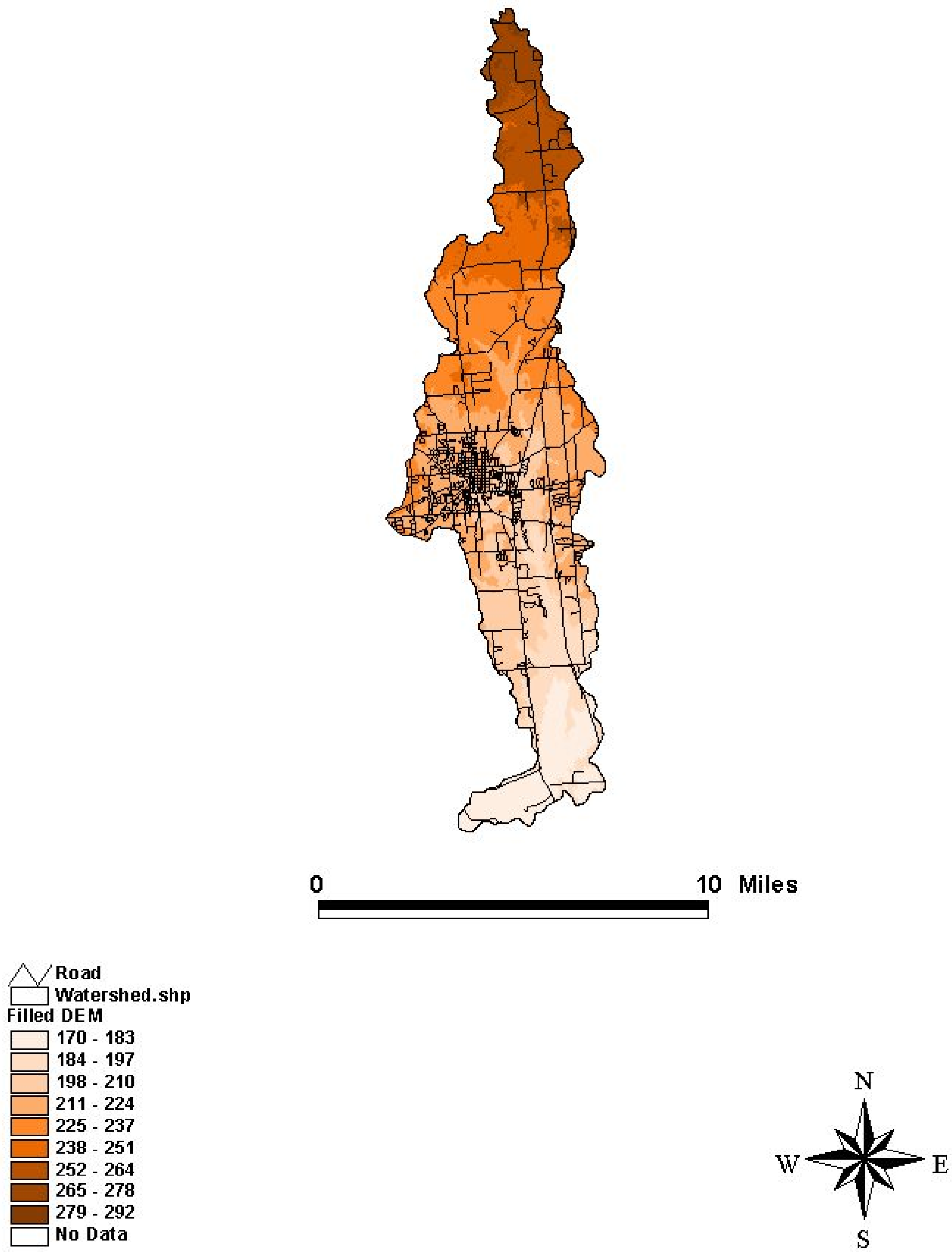
Village Branch Watershed



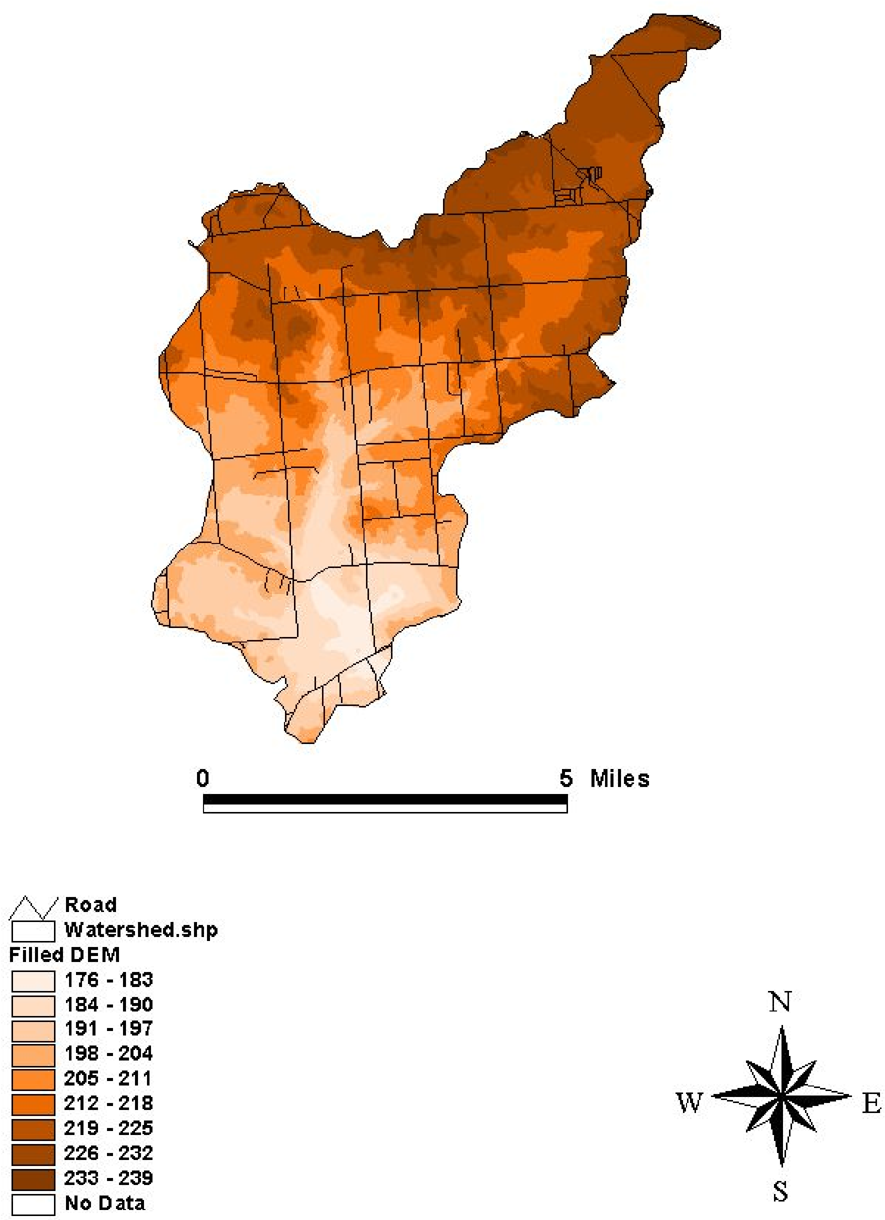

Mcdaniel Creek Watershed
0.8 0 0.8 1.6 Miles
Road
DEM
180 - 193
194 - 207
208 - 221
222 - 235
236 - 249
250 - 263
264 - 277
278 - 291
292 - 305
No Data
N
W
E
S

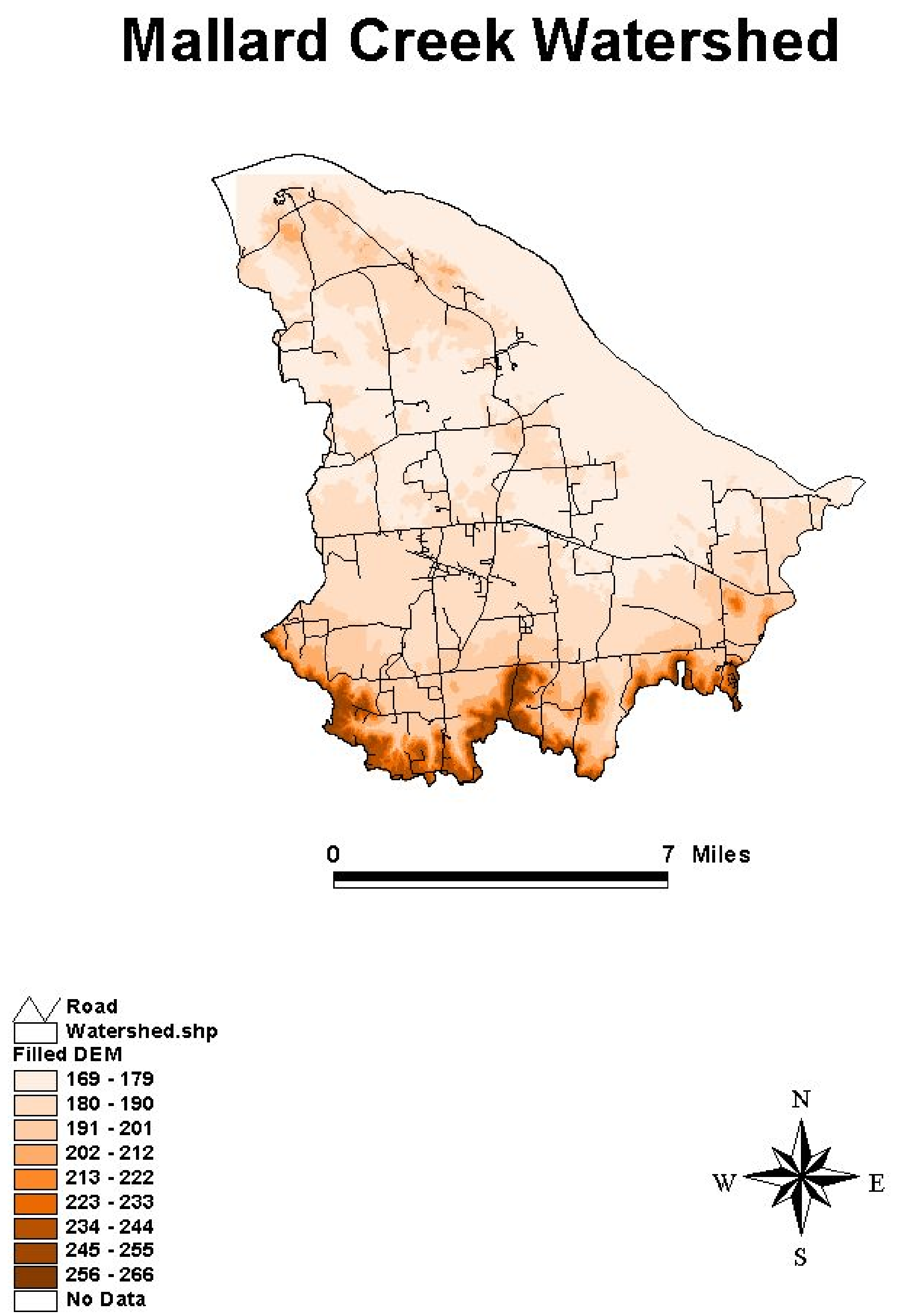

Flat Creek Watershed
0.9 0 0.9 1.8 Miles
Road
DEM
176 - 184
185 - 193
194 - 202
203 - 211
212 - 219
220 - 228
229 - 237
238 - 246
247 - 255
No Data
N
W
E
S

Swan Creek Watershed

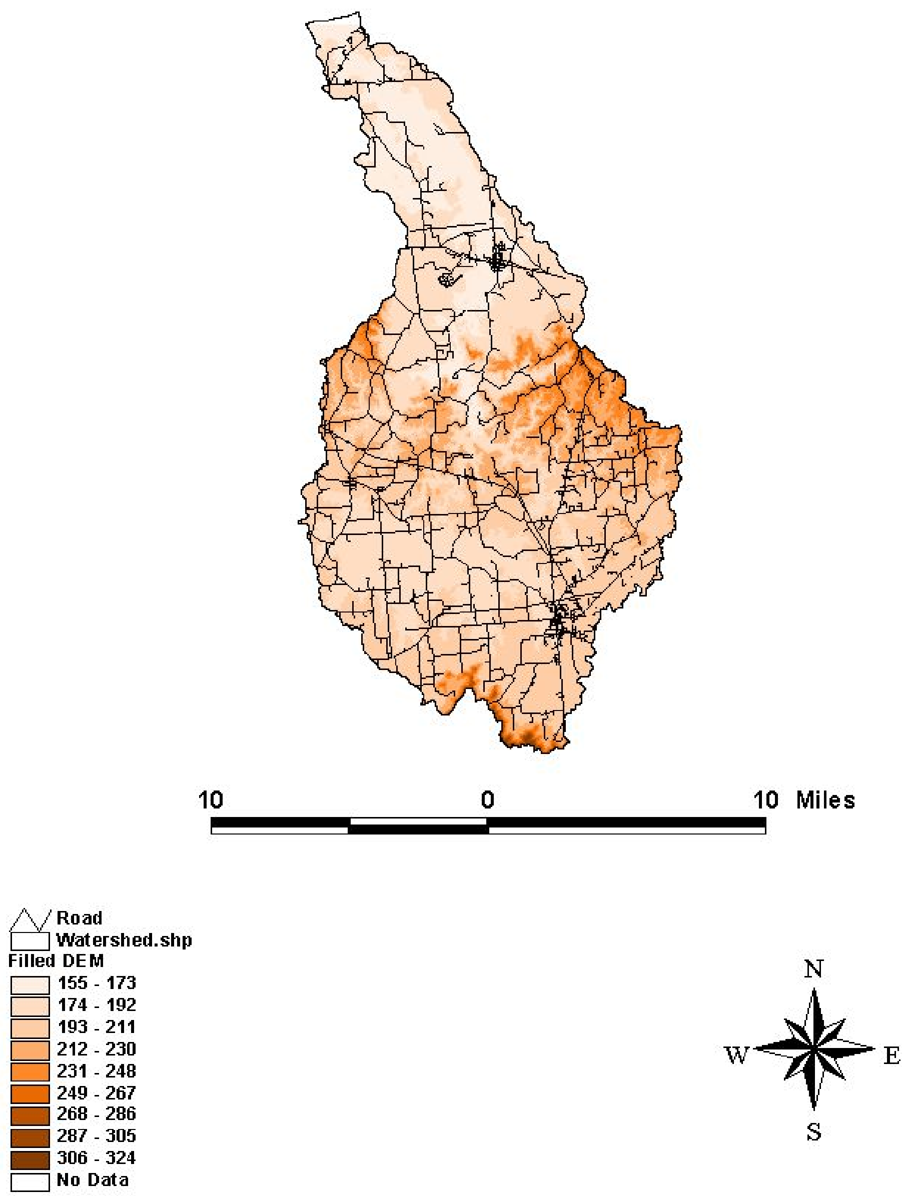


Round Island Creek Watershed




Mallard Creek Watershed
0
7 Miles
Road
Watershed.shp
Filled DEM
169 - 179
180 - 190
191 - 201
202 - 212
213 - 222
223 - 233
234 - 244
245 - 255
256 - 266
No Data
N
W
E
S

Bignance Creek Watershed



Harris Creek Watershed