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Using GIS Applications for Census Data in Watershed Analysis

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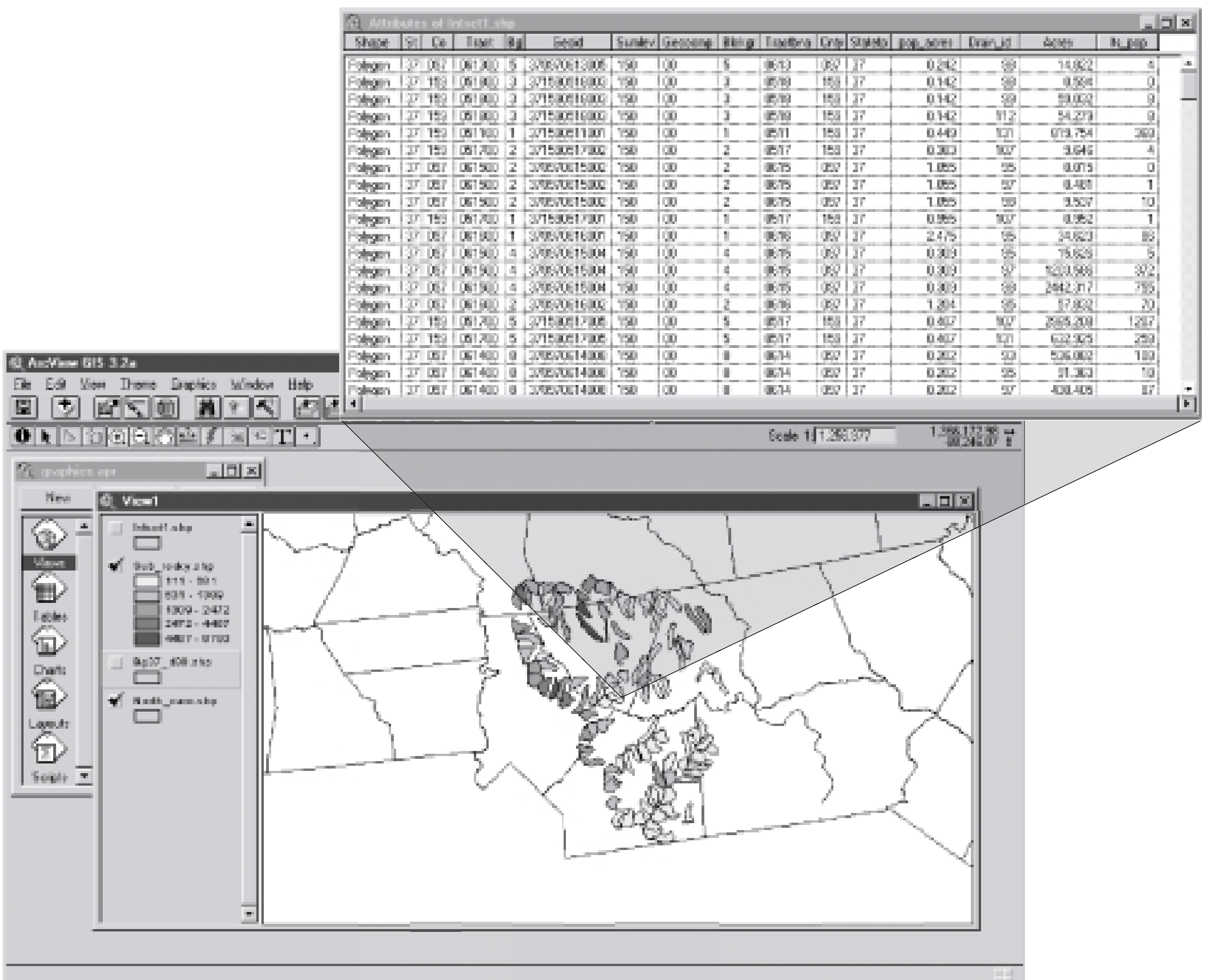

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Watershed Science Institute
National Cartography and Geospatial Center

Purpose

This technical note describes the use of sociodemographic data in watershed studies by outlining a basic method for processing and using U.S. Census 1990 Tiger/Line data. A recommendation of data sources and methods of data use are discussed to promote demographic analysis within special study watersheds. One aspect of this technical note is to improve accuracy of watershed census data through use of Geographic Information Systems (GIS) capabilities.

Introduction

Watershed research and applying conservation practices within watersheds are based on more geographic and scientific data than ever before. Environmental factors, such as water quality, wildlife and fish habitat, soil erosion, and air pollution, and constituent indicators are identified and monitored closely to show changes in overall watershed health. However, to look at environmental factors without their relationship to human conditions is shortsighted. Environmental data assessments taken in local watersheds can be enhanced or augmented with population data and sociodemographic characteristics. Sociodemographic data can strengthen the overall understanding of many aspects of watershed studies.

Descriptive demographics of the study area are routinely a part of watershed inventories. They are useful for the understanding of the economic and social characteristics of the human aspect of SWAPAH (soil, water, air, plant, animal, and human). Demographics identify important social characteristics, which may assist in planning by providing a better understanding of the project effects on society or groups in the study area. They are useful for identification of limited resource communities, and the data provides for the social accounts required by the National Environmental Protection Act (NEPA).

This information allows us to better consider environmental justice concerns. Further, the expanding capabilities of GIS allow planners to integrate increasing amounts of spatial data and use more sophisticated computational models. Thereby the capacity to use demographics in watershed studies continues to improve and to also become more accurate.

Generally, U.S. census population data do not coincide with watershed boundaries. The census information is collected and published based on political boundaries, such as counties, or on a smaller scale in tracts or blocks. Estimating the watershed population and associated demographic characteristics relies upon various approaches, none of which provide for good accuracy.

One approach is to identify the counties in the watershed, and obtain census data for each of the counties. What follows is a description of the social characteristics for the watershed by simply discussing the aggregated counties' data. Sometimes planners would more sharply define the watershed population data by means of visual adjustments based upon comparisons of county and watershed maps. One aspect of this technical note is to improve accuracy of watershed census data through use of GIS capabilities.

Watershed planning also relies on manual delineation with hardcopy maps of watershed boundaries. Natural resource data are collected and recorded for watersheds using various manual-mapping techniques. Many areas of the country lack digital watershed data, although over time this has been diminishing, and this trend should continue to improve in the future. This lack of digital data may be caused by the need for upfront investments in time and other costs to establish the data layers needed for planning. Use of GIS will become more cost effective as more and more natural resource data layers become available. Cross Agency sharing of this type of information will also assist planning. As the technology itself develops and improves the capacity for better planning at reduced cost will be substantial.

Eventually, the use of an all GIS approach for watershed planning will be the Agency norm. This achievement would be consistent with the USDA Service Center, Geographic Information System Strategy document of August 1998. In part it says,

> Integrating GIS technology into service center business operations is crucial for service centers to provide timely program delivery, reduce customer burdens, and remain cost effective. As customers increasingly apply GIS technology within their own operations, they expect USDA Service Centers to deliver products and service that take advantage of similar technology….

The GIS Strategy document is available at

http://www.ftw.nrcs.gov/nsdi_node.html

Effective use of GIS in watershed scale studies of conservation practice applications requires a clearly defined problem, and a methodological approach to assessment and analysis. This technical note guides users on the inclusion of demographic data in watershed research, and outlines a tutorial on how to acquire, manipulate, and apply U.S. Census data to watershed studies.

A basic understanding of Environmental Systems Research Institutes' (ESRI) ArcView software and terminology, such as how to add themes, avenue scripts, and edit tables, is required to follow the examples presented in this technical note.[1]

[1/] For information on the contents of this Technical Note, contact authors Rob Veerland, National Cartography & Geospatial Center, Fort Worth, Texas, at 817 509-3374, or Tom Noonan, Watershed Science Institute, 304 293-4832 Ext. 4479.

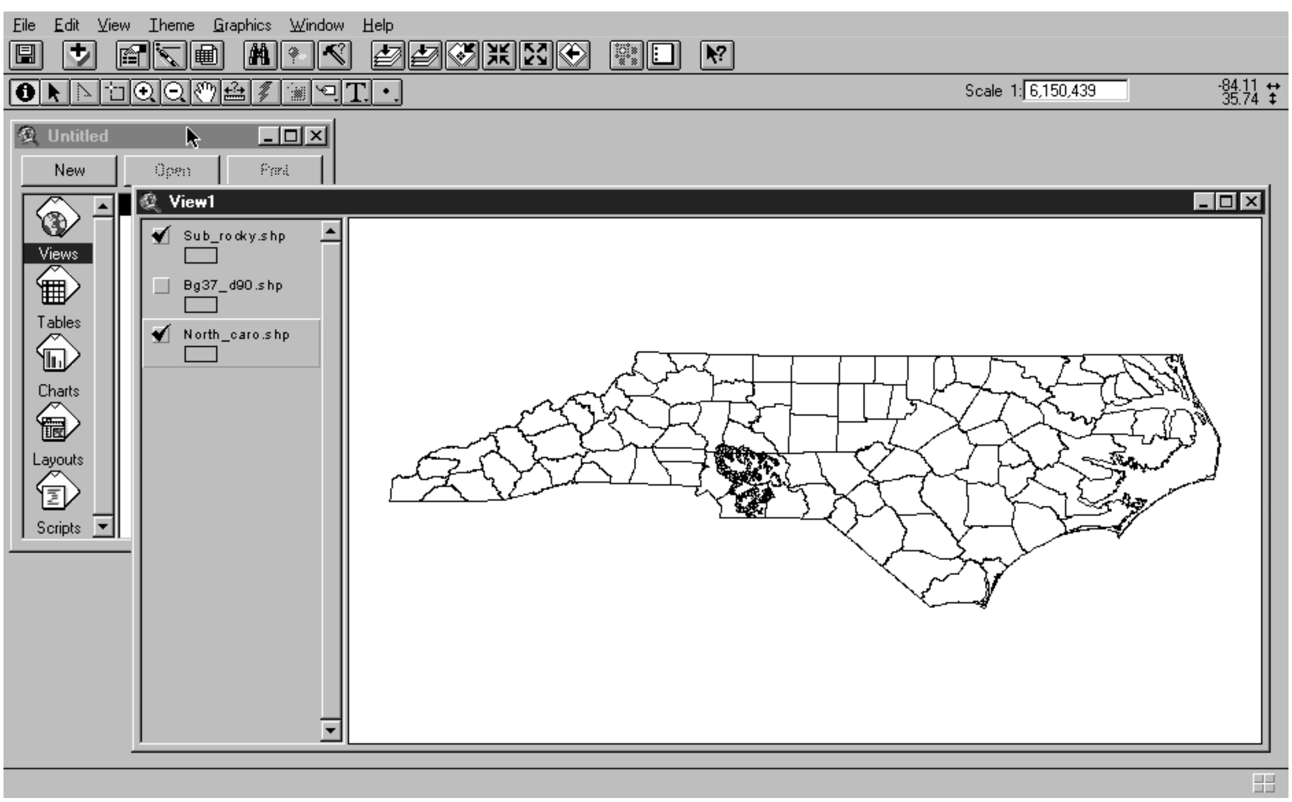
The watershed practitioner will, by following the example, access census data for the Rocky River Watershed, North Carolina, and calculate population densities for selected subwatersheds. By completing this example the user will become familiar with the processes needed to interpolate census data on watershed boundaries within a desktop GIS. This methodology is intended only to familiarize users with the process in ArcView and not as a primer on the fundamentals of demographic analysis. However, a supplemental discussion about data limitations and using a weighted average approach to estimating selected population attributes is provided.

The Rocky River Watershed, about 1,444 square miles, is located in south central North Carolina. The watershed consists of about 55 percent forest, pasture, and hayland and is impacted by the Charlotte metropolitan area. Other urban centers include Kannapolis, Albemarle, and Monroe (figure 1).

Data acquisition

This example is based on the Rocky River Watershed boundaries, which were delineated by Natural Resources Conservation Service (NRCS) North Carolina State Office personnel. The Rocky River Watershed was further subdivided into subwatersheds using the United States Geological Survey (USGS) 1:100,000 topographic mapsheets. Using these map sheets, drainage points were chosen and drainage through those points calculated to identify equal area subwatersheds. The subwatersheds were then digitized using ESRI's ArcInfo software.

Figure 1 Rocky River Watershed area, North Carolina.



To begin the tutorial, several files are necessary and a directory structure must be created. The directory structure used in this tutorial starts at the root level and is called watergis. Two subdirectories —one called original and one called working—exist under watergis. An example on the C drive would be c:/watergis/original and C:/ watergis/working. Sample data including Topologically Integrated Geographic Encoding and Referencing (Tiger) shape files and the STF1A tables in this example are available at

ftp://ftp.ftw.nrcs.usda.gov/pub/ams/watershed/

Download the file called **Rocky.zip**.

Data preparation

To begin analysis of the watershed using demographic data, a common attribute identifying state and county fips, tract, block group, and block must exist in both the STF1A data and the Tiger/Line files. STF1A data, which are extracts from the section on STF1A, will guide you through this process. Most of the Tiger/Line processing has been completed by commercial vendors and can be purchased in multiple data formats. ESRI has also made available on the Internet the U.S. Tiger/Line files in shape file format. The ArcData Online Web page is:

http://www.esri.com/data/online/index.html

The zip file containing the sample data described previously should be downloaded and located in the directory:

<drive letter>:\watergis\original

Open a new ArcView project and begin adding the themes from the directory:

<drive letter>:\watergis\original

Add each of the following three themes:

1. Bg37_d90.shp
2. North_caro.shp
3. Sub_Rocky.shp

Set the working directory to **<drive letter>:\watergis** by making the view active, selecting the **File** menu and clicking on the **Set Working Directory** option. Figure 1 shows the spatial layers that should be loaded in ArcView.

When the themes have been loaded into ArcView, the View properties must be set. This step involves setting the Projection parameters and the View units. ArcView is able to simulate different projections if the data is in a geographic coordinate system.

Use the View dropdown menu and select the View properties option. Next set each of the four properties in the popup box.

1. Map Unit: Meters
2. Distance Units: Meters
3. Projection: Category: Projections of the United States
4. Type: Albers Equal-Area (Conterminous United States)

STF1A file

Access the tables for each theme by selecting each theme then clicking **Attribute Table** button on the button bar. Open the stf1a_1.dbf file in ArcView by adding a table from the project window. The stf1a_1.dbf file is complete for North Carolina and must be queried to select the proper records to join to the Tiger shape files. In ArcView, query the stf1a_1.dbf table using the **Query Builder** (figure 2) button on the toolbar and type in the query **([Sumlev] = 150)** and **([Geocomp] = 00)**. Querying the [Sumlev] = 150 selects all records that identify blockgroups. Using logical operators, such as *and*, you can identify records that have a statewide geographic component by selecting **[Geocomp] = 00**. Export the selected records as a new .dbf table in the working directory and name the file **stf1a_1bg.dbf**.

1. Add the table named stf1a_1bg.dbf to ArcView and edit the table.
2. Add a new field called **Blkg_key** as a string field that has a width of 16.
3. Use the **Query Builder** button on the toolbar and query the field [Tractbna] with the equation ([Tractbna].count = 4).
4. Select the field Blkg_key and then use the **Calculate** button on the toolbar and type **[Tractbna] + 00** (figure 3).

Figure 2 ArcView query box.

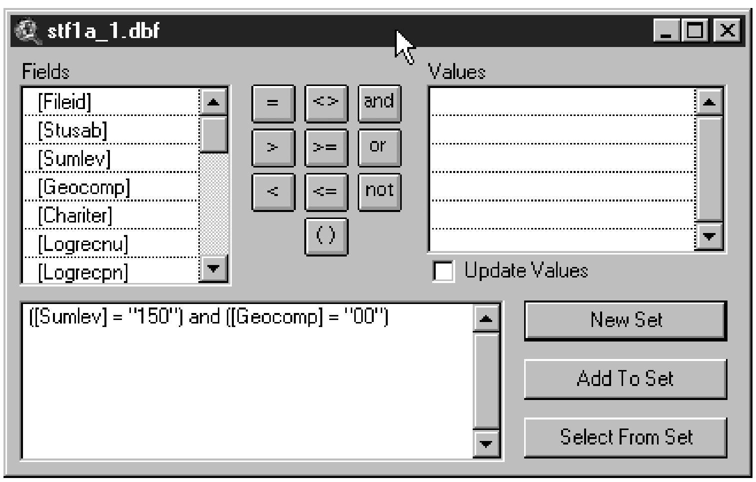
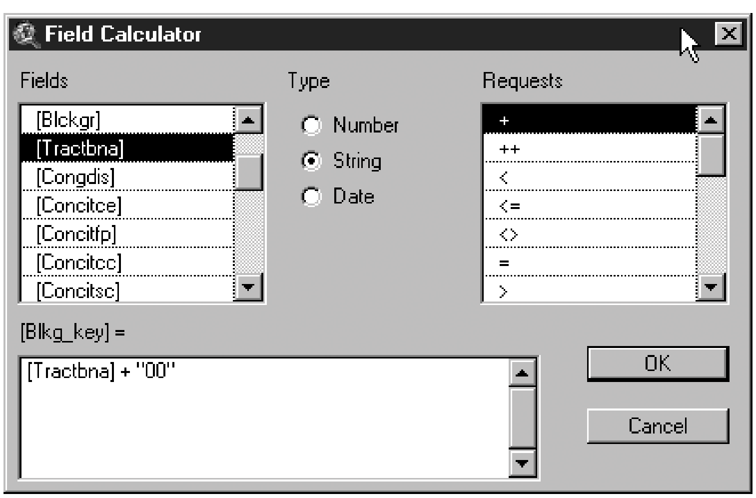


Figure 3 ArcView field calculator



5. Use the **Switch Selection** button on the toolbar to select the non-selected records.
6. Use the **Calculate** button on the toolbar and calculate the field [Blkg_key] as [Tractbna].
7. Clear the selection by using the **Select None** button on the toolbar.
8. Use the **Calculate** button on the toolbar and calculate the Blkg_key field with the equation '[Blkg_key] = [Statefp] + [Cnty] + [Blkg_key] + [Blckgr]'.
9. Save edits and stop editing.

The stf1a_gb.dbf table is a simplified version of what the user should have once the edits are saved (figure 4).

Join the table stf1a_1gb.dbf with the table of the TIGER file Bg37_d90.shp. First highlight the field **[Blkg_key]** on the Stf1a_1gb.dbf table and then the field **[Geoid]** on the Bg37_d90.shp table. Be sure that the table Attributes of BG37_d90.shp is active window. Use the **Join** button on the toolbar to perform a one-to-one relationship join.

Figure 4 Simplified version of table following editing.

stf1a_bg.dbf

Fileid	Stusab	Sumlev	Geocomp	Blckgr	Tractbna	Cnty	Statefp	Blkg_key
STF1A	NC	150	00	1	020101	001	37	370010201011
STF1A	NC	150	00	2	020101	001	37	370010201012
STF1A	NC	150	00	1	020102	001	37	370010201021
STF1A	NC	150	00	2	020102	001	37	370010201022
STF1A	NC	150	00	3	020102	001	37	370010201023
STF1A	NC	150	00	4	020102	001	37	370010201024
STF1A	NC	150	00	1	0202	001	37	370010202001
STF1A	NC	150	00	2	0202	001	37	370010202002
STF1A	NC	150	00	3	0202	001	37	370010202003
STF1A	NC	150	00	4	0202	001	37	370010202004
STF1A	NC	150	00	5	0202	001	37	370010202005
STF1A	NC	150	00	1	0203	001	37	370010203001
STF1A	NC	150	00	2	0203	001	37	370010203002
STF1A	NC	150	00	3	0203	001	37	370010203003
STF1A	NC	150	00	4	0203	001	37	370010203004
STF1A	NC	150	00	5	0203	001	37	370010203005
STF1A	NC	150	00	6	0203	001	37	370010203006
STF1A	NC	150	00	7	0203	001	37	370010203007
STF1A	NC	150	00	8	0203	001	37	370010203008
STF1A	NC	150	00	1	0204	001	37	370010204001
STF1A	NC	150	00	2	0204	001	37	370010204002
STF1A	NC	150	00	3	0204	001	37	370010204003

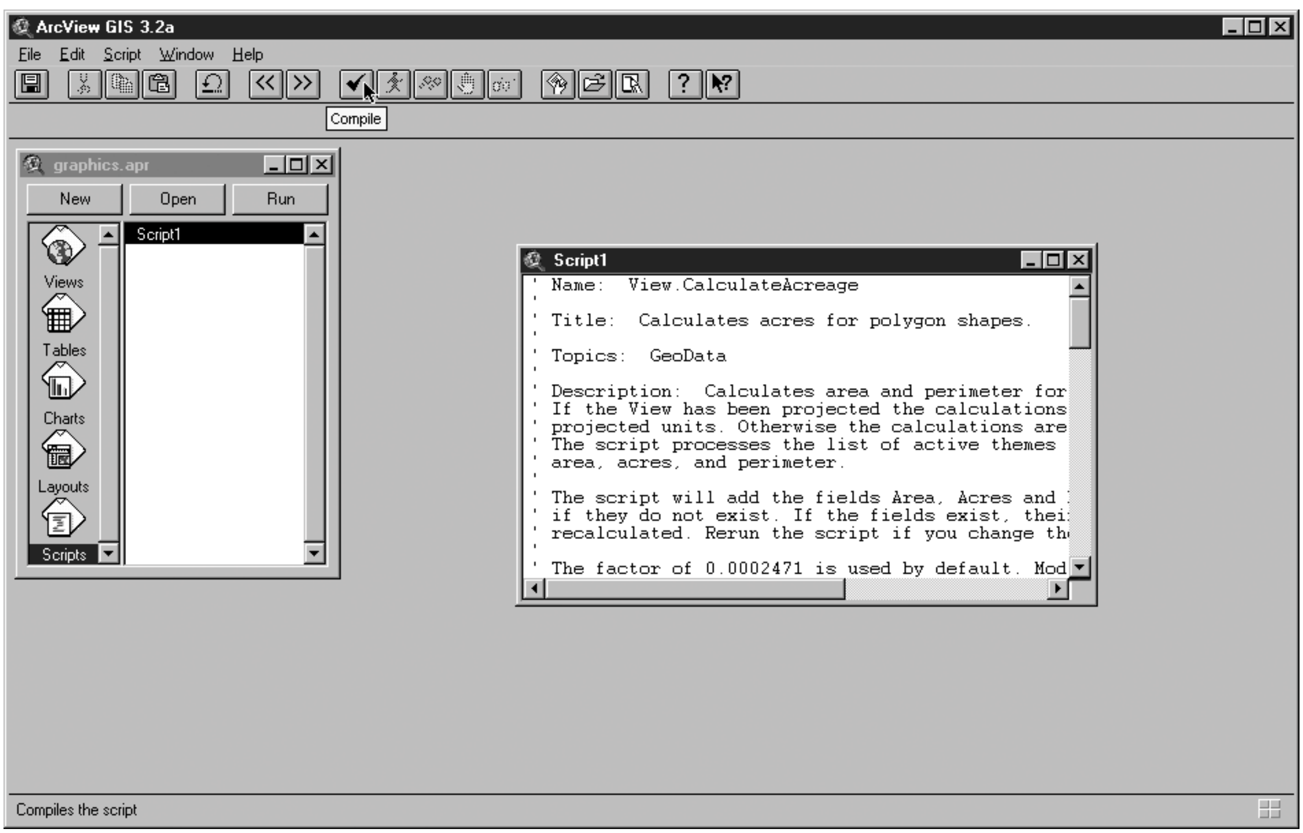
The next step is to calculate feature geometry for each theme. An avenue script can be added to the project to calculate the [Area], [Perimeter], and [Acres] for each polygon. ESRI has placed an avenue The <drive letter>:\ designation is the drive on which ArcView has been installed. If you are using a Network version of ArcView, contact your system administrator to find the script. To run this process, add the script calcare.ave to ArcView and compile it using the **Compile** button on the toolbar (figure 5).

Directions on how to run the script are available in the script header. The View properties, such as projection, and units must be set to receive correct values from this script. Set the projection to **Albers** and the units to **Meters** for this example.

1. Make the View active.
2. Select the theme **Bg37_d90.shp** and then holding the shift key select the theme **Sub_Rocky.shp**.
3. Make the script active and click the **Run** button on the toolbar.

The table for each theme selected should now have a field for [Area], [Perimeter], and [Acres].

Figure 5



The next step is to determine the population density per acre. Begin by making the table Attributes of Bg37_d90.shp editable and adding a new field called [pop_acre] as a numeric field that has a width of 16 and 3 decimal places.

1. Calculate [pop_acre] = [P0010001] / [Acres].

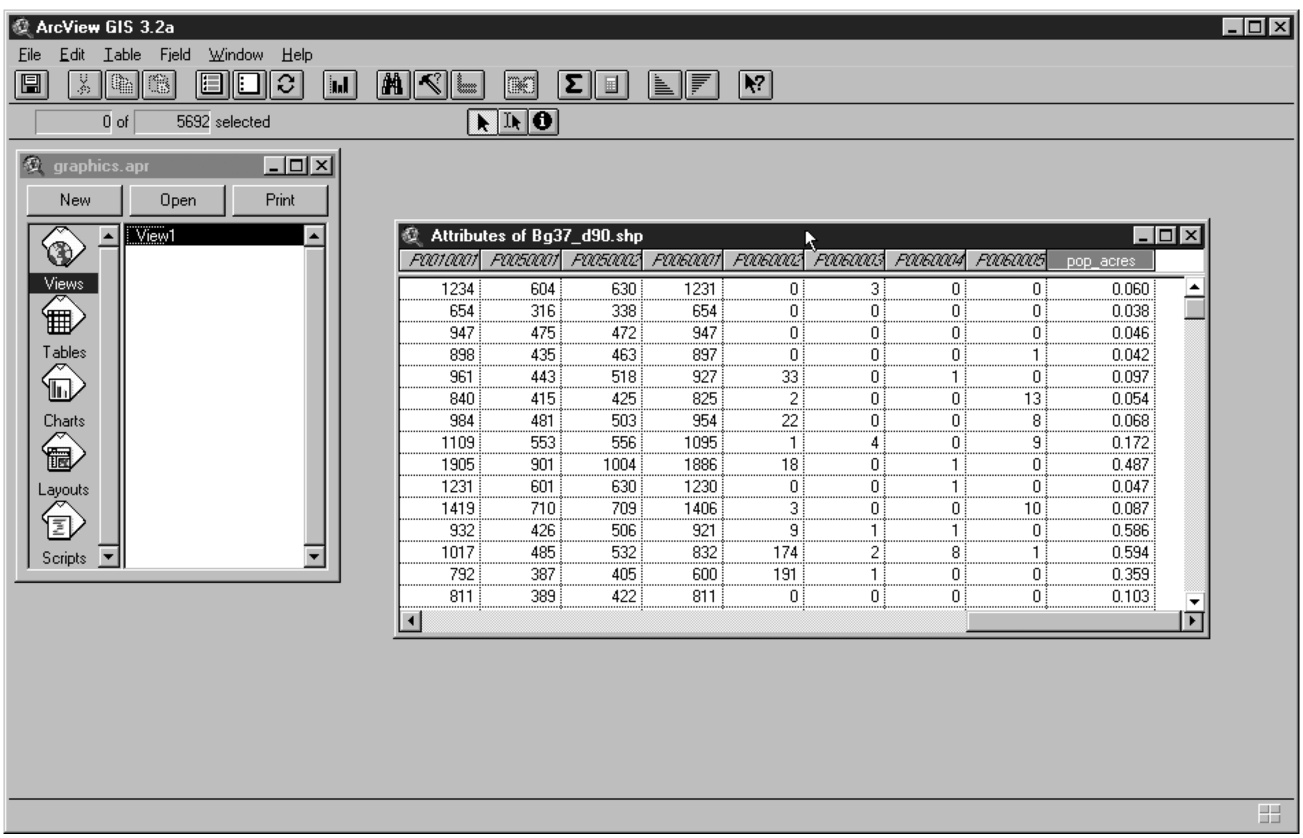
Figure 6 shows the result of the table calculation.

Data analysis

Now that the data are organized and the STF1A data has been joined with the 1990 TIGER/Line files, analyses can begin of individual subwatersheds. The following description uses simple areal interpolation. An even population distribution throughout the blockgroup and subwatershed is assumed. Areal interpolation transfers a percentage of evenly distributed population from the blockgroup boundaries to the subwatershed boundaries.

Select the **GeoProcessing wizard** under the View menu, a new window will open. Select the **Intersect** option. Enter the TIGER/Line file **Bg37_d90.shp** as the input theme and the overlay subwatershed theme as **Sub_Rocky.shp**. Specify the output file as **<drive letter>:\watergis\working\itsct1.shp**. When complete the file itsct1.shp contains the attributes of both the Bg37_d90.shp file and the Sub_Rocky.shp file.

Figure 6 Attributes of Bg37_d90.shp table with addition of [pop_acre].



F0010001	F0050001	F0050002	F0060001	F0060002	F0060003	F0060004	F0060005	pop_acres
1234	604	630	1231	0	3	0	0	0.060
654	316	338	654	0	0	0	0	0.038
947	475	472	947	0	0	0	0	0.046
898	435	463	897	0	0	0	1	0.042
961	443	518	927	33	0	1	0	0.097
840	415	425	825	2	0	0	13	0.054
984	481	503	954	22	0	0	8	0.068
1109	553	556	1095	1	4	0	9	0.172
1905	901	1004	1886	18	0	1	0	0.487
1231	601	630	1230	0	0	1	0	0.047
1419	710	709	1406	3	0	0	10	0.087
932	426	506	921	9	1	1	0	0.586
1017	485	532	832	174	2	8	1	0.594
792	387	405	600	191	1	0	0	0.359
811	389	422	811	0	0	0	0	0.103

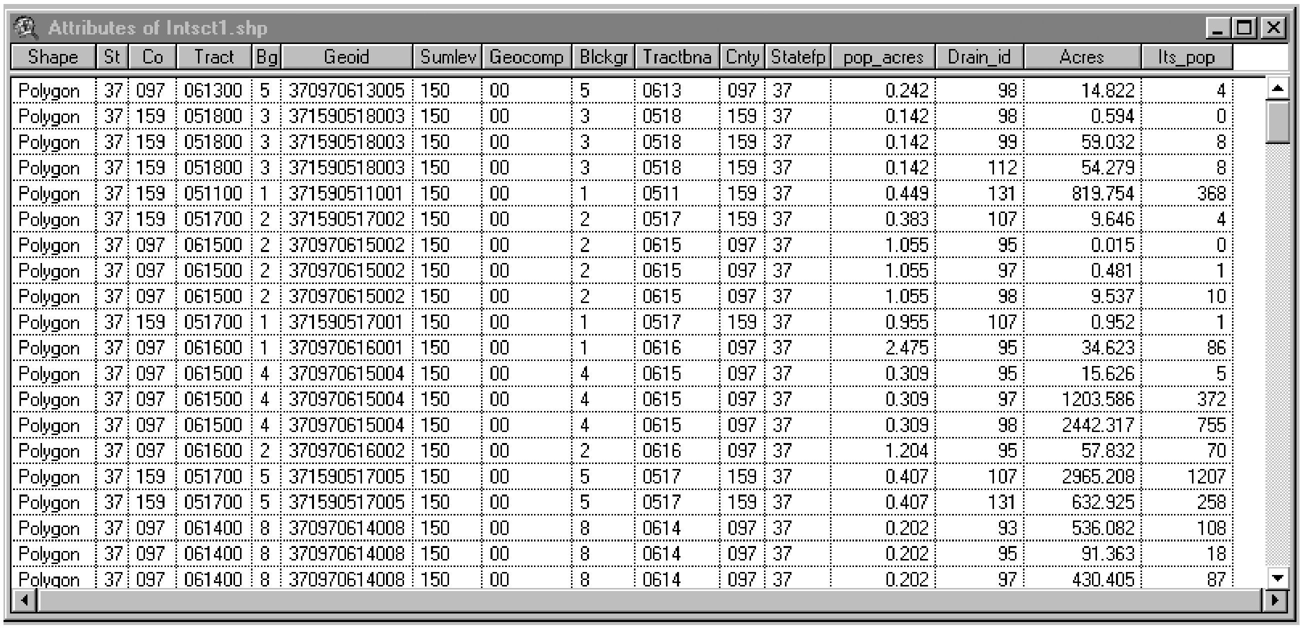
Run the 'calcacre.ave' script on the itsct1.shp file to create new items for [Area], [Perimeter], and [Acres]. Edit the attributes of itsct1.shp by clicking the **Open Theme Table** button on the toolbar and set the table to start editing. Add a new field called [Its_pop] as a numeric field with a width of 16 and 0 decimal places.

1. Calculate [Its_pop] = [pop_acre] x [Acres].

Figure 7 is a simplified version of the table.

Calculate the population for each subwatershed by summarizing—select the [Drain_id] column and then use the **Summarize** button on the toolbar. Next, select the [Its_pop] in the **Field** box and sum in the **Summarize by:** box. Save the summary as sub_population.dbf in the <drive letter>:\watergis\working\ directory (figure 8).

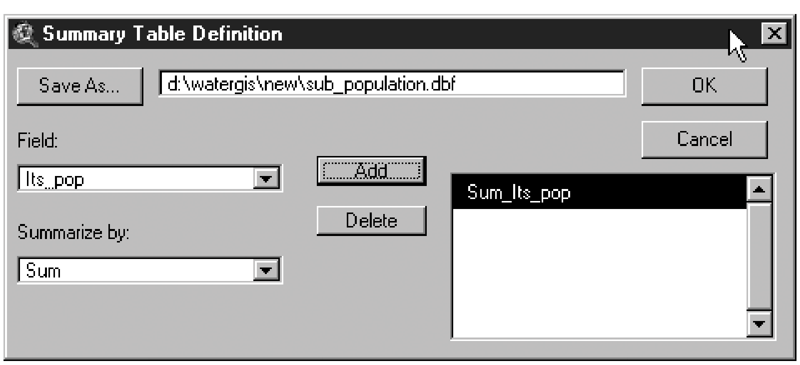
Figure 7 Simplified version of **Open Theme** table.



Attributes of Intsct1.shp

Shape	St	Co	Tract	Bg	Geoid	Sumlev	Geocomp	Blckgr	Tractbna	Cnty	Statefp	pop_acres	Drain_id	Acres	Its_pop
Polygon	37	097	061300	5	370970613005	150	00	5	0613	097	37	0.242	98	14.822	4
Polygon	37	159	051800	3	371590518003	150	00	3	0518	159	37	0.142	98	0.594	0
Polygon	37	159	051800	3	371590518003	150	00	3	0518	159	37	0.142	99	59.032	8
Polygon	37	159	051800	3	371590518003	150	00	3	0518	159	37	0.142	112	54.279	8
Polygon	37	159	051100	1	371590511001	150	00	1	0511	159	37	0.449	131	819.754	368
Polygon	37	159	051700	2	371590517002	150	00	2	0517	159	37	0.383	107	9.646	4
Polygon	37	097	061500	2	370970615002	150	00	2	0615	097	37	1.055	95	0.015	0
Polygon	37	097	061500	2	370970615002	150	00	2	0615	097	37	1.055	97	0.481	1
Polygon	37	097	061500	2	370970615002	150	00	2	0615	097	37	1.055	98	9.537	10
Polygon	37	159	051700	1	371590517001	150	00	1	0517	159	37	0.955	107	0.952	1
Polygon	37	097	061600	1	370970616001	150	00	1	0616	097	37	2.475	95	34.623	86
Polygon	37	097	061500	4	370970615004	150	00	4	0615	097	37	0.309	95	15.626	5
Polygon	37	097	061500	4	370970615004	150	00	4	0615	097	37	0.309	97	1203.586	372
Polygon	37	097	061500	4	370970615004	150	00	4	0615	097	37	0.309	98	2442.317	755
Polygon	37	097	061600	2	370970616002	150	00	2	0616	097	37	1.204	95	57.832	70
Polygon	37	159	051700	5	371590517005	150	00	5	0517	159	37	0.407	107	2965.208	1207
Polygon	37	159	051700	5	371590517005	150	00	5	0517	159	37	0.407	131	632.925	258
Polygon	37	097	061400	8	370970614008	150	00	8	0614	097	37	0.202	93	536.082	108
Polygon	37	097	061400	8	370970614008	150	00	8	0614	097	37	0.202	95	91.363	18
Polygon	37	097	061400	8	370970614008	150	00	8	0614	097	37	0.202	97	430.405	87

Figure 8 Summary table definiion.



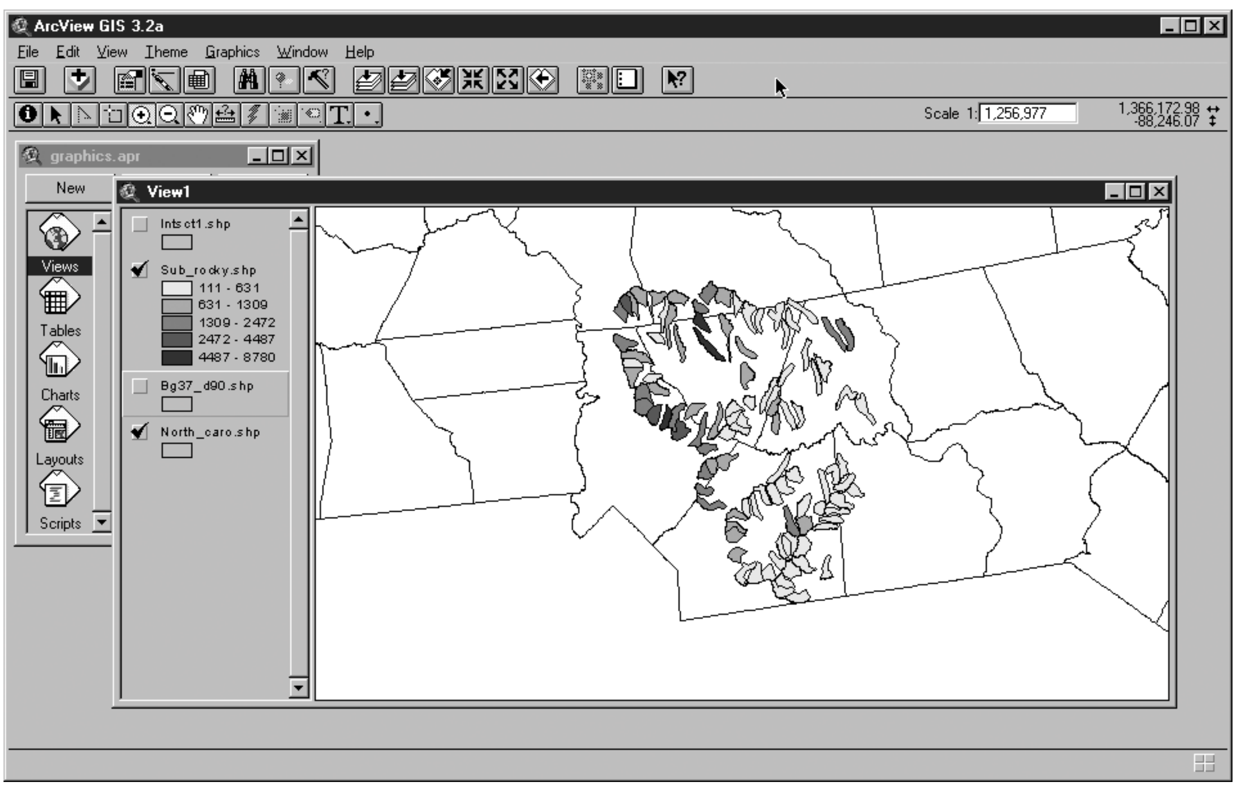
Next, add a table and select **sub_population.dbf** as the file to open. Join the Sub_population.dbf table by selecting the [Drain_id] and then selecting the table for the Sub_Rocky.shp. Select the [Drain_id] column and click the **Join Tables** button on the toolbar. Now the total population can be displayed for each subwatershed by displaying the theme with a graduated color legend using the 'Sum_its_po' column (figure 9).

Data issues

The example above describes how to use areal interpolation to distribute a single population characteristic from census block groups to subwatersheds. To add other census characteristics to the study add a new field for each attribute of interest and repeat the process.

Areal interpolation relies on the assumption of evenly distributed population throughout the blockgroup. Other methods are available to assign population characteristics to different boundaries, such as Dasymetric mapping. Dasymetric mapping is a process of displaying population distributions within each subwatershed. See Steven Holloway, James Schumacher, and Roland Redmond's article *People and Place: Dasymetric Mapping Using Arc/Info* (1999) for an example of this mapping technique. Concerns over issues, such as the effect of the Modifiable Areal Unit Problem (MAUP) and ecological fallacy, are also important when using census data across boundaries. Results of the process used here are shown in the Maps and tables section.

Figure 9. Selected subwatershed areas of the Rocky River Watershed, North Carolina.



Maps and tables

Three maps display demographic information for the Rocky River Watershed, North Carolina (figures 10, 11, and 12). Figure 10 has the Rocky River Watershed overlaid on the seven counties of the study area along with the selected subwatersheds. The population densities for these subwatersheds were calculated using the example methodology outlined in this technical note.

Figure 10 Estimating population attributes by a weighted average technique.

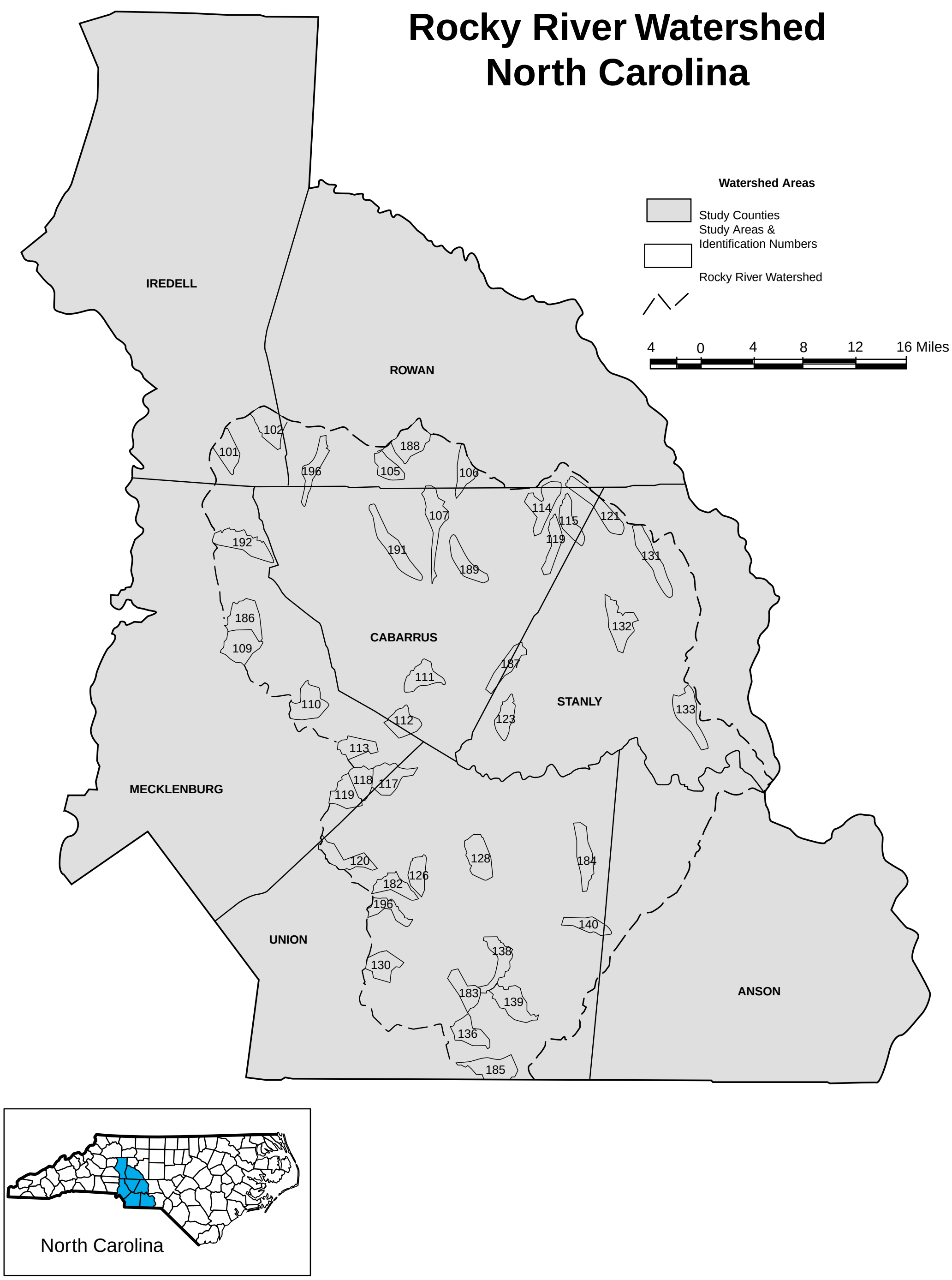
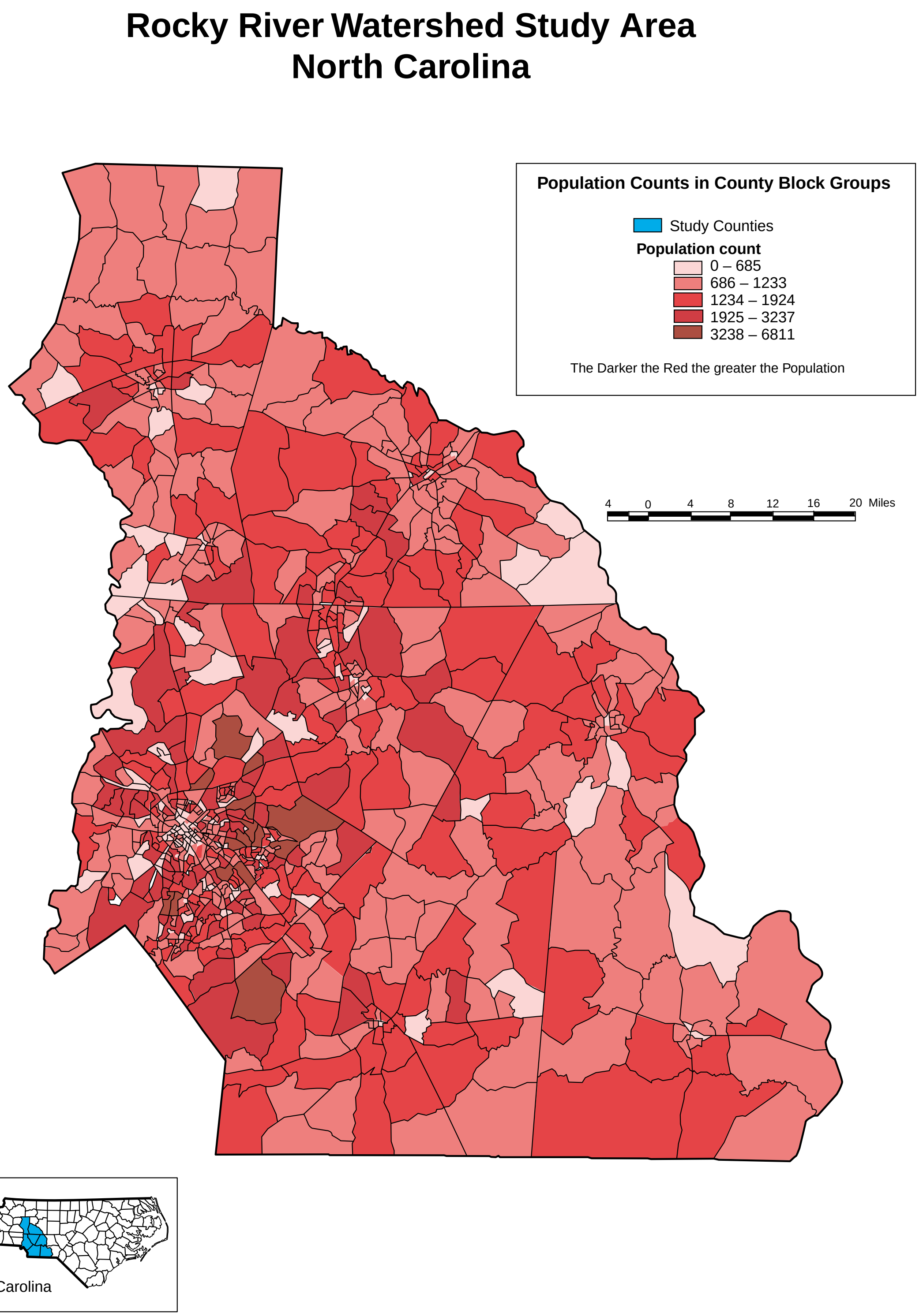


Figure 11 provides information on the calculated densities for County Block Groups of the seven counties. This information was attained using the 1990 census information as outlined in this methodology.

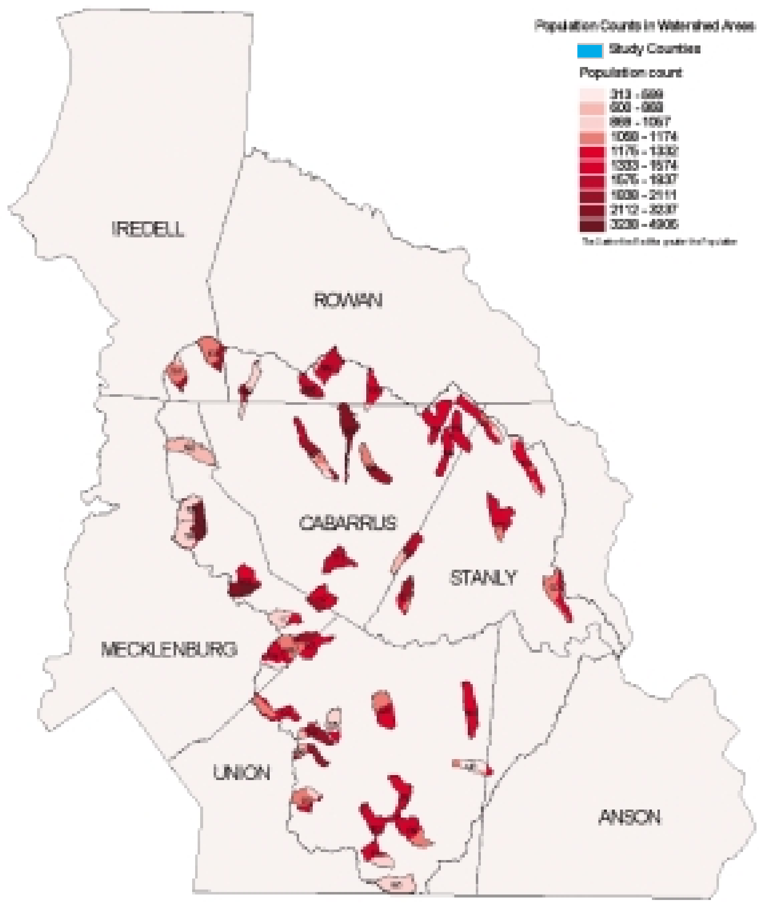
Figure 11 Rocky River Watershed study area.



The map in figure 12 displays detailed population density information for the subwatersheds.

Figure 12 Estimating population attributed by a weighted average technique.

Rocky River Watershed
North Carolina



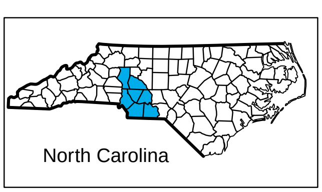


Table 1 displays the aforementioned population density for the subwatersheds, and it is specifically correlated to figure 12. Table 2 is selected population attributes for the Rocky River Watershed, such as gender and race. These attributes were generated by estimating the block group values within the watershed boundary. They may be of interest in a watershed study; however, there are some limitations of these data in the GIS environment.

The STF1A data source for this procedure is limited when estimating descriptive characteristics, such as median age, median home values or median family income.

These percentages are used in the weighted average calculations. The block census data for the target watershed is displayed in table 3 on page 17 and should be referred to during the procedural discussion.

Table 1 Population density for selected subwatersheds of the Rocky River Watersheds, North Carolina

Site identify	Population	Square miles	Population density	Site identify	Population	Square miles	Population density
101	1476	4.0	373.1	131	1473	5.7	257.0
102	1000	5.6	179.2	132	546	5.8	94.5
105	2343	3.4	691.4	133	560	6.0	93.3
106	404	3.6	112.7	136	299	4.4	68.0
107	844	5.6	150.2	138	613	4.6	134.4
109	2147	6.0	357.4	139	342	5.8	58.8
110	3514	5.9	594.7	140	300	3.4	87.8
111	421	4.2	99.2	182	1007	3.7	274.2
112	630	4.5	141.1	183	403	4.0	101.9
113	1519	3.8	398.8	184	181	5.1	35.3
114	273	5.9	46.4	185	296	5.5	54.1
115	165	3.9	41.8	186	1449	5.8	250.6
117	861	5.5	156.4	187	364	4.1	89.2
118	1133	3.7	307.9	188	2470	5.9	420.9
119	1500	4.1	370.1	189	758	4.3	177.8
120	1753	4.9	360.7	190	576	4.0	143.0
121	441	5.8	75.8	191	8782	6.2	1,410.5
123	698	3.4	203.1	192	672	6.2	108.6
126	467	3.4	137.8	196	711	3.2	222.9
128	553	5.7	97.7	199	282	3.7	76.2
130	753	4.4	170.5				

Note: Population, square miles, and population density determined by use of GIS .

Table 2 Selected population data including the Rocky River Watershed, North Carolina

Population	United States	North Carolina	Rocky River, Wisconsin
General	248,709,873	6,628,636	426,658
White	199,686,070	5,008,491	349,599
Black	29,986,060	1,456,323	71,316
Other	19,037,743	163,822	994
Hispanic (any race)	22,354,059	76,726	3,234
Gender:			
Male	121,239,418	3,214,290	207,690
Female	127,470,455	3,414,347	218,968

Source: U.S. 1990 Census data

Estimating population attributes by a weighted average technique

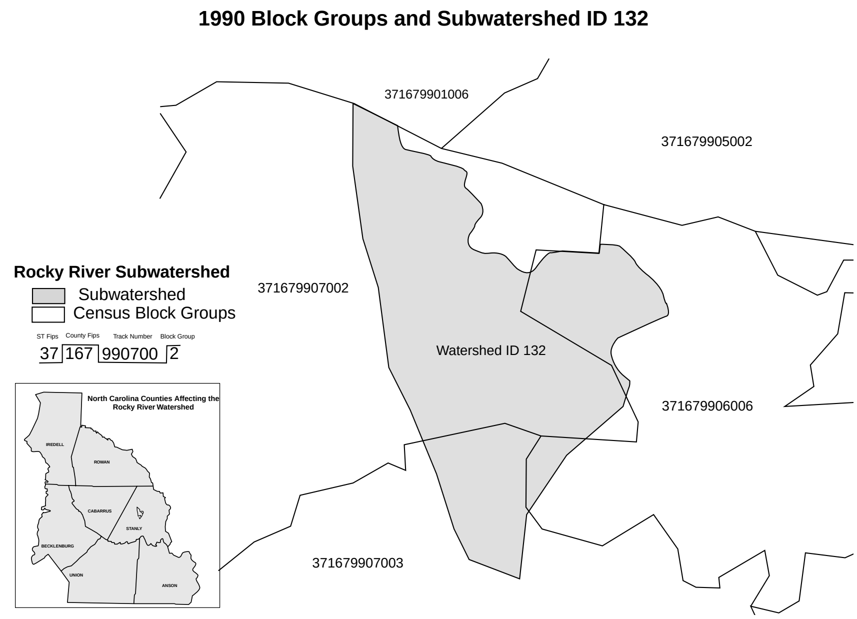
A procedure for estimating census block group data using weighted averages is demonstrated using data from subwatershed 132 of the Rocky River Watershed. This subwatershed is situated in Stanly County, in the northeast part of the watershed (figure 13). The calculations for population estimate for subwatershed 132 were covered in this technical note for the section on population density. Overlaying the areas of Rocky River subwatersheds and census block groups determined in GIS provide the percentage of area in each block group that lies within the watershed boundry.

Census block group and block data are available from the U.S. Bureau of the Census on CD ROM or from the World Wide Web. The selected population and attributes used in this technical note are displayed in the bottom portion of table 3. These data include total population, median age, the number specified owner-occupied house units, median house values, number of families, and median family income. The figures in this table are used to estimate the median age, median house values, and median family income.

Currently, census block data may be obtained by using the following procedure:

- Go to the U.S. Census homepage at **www.census.gov**
- Click on the **American FactFinder** link
- Select the box with Data Sets
- Click on **1990 Summary tape file**
- Select 1990 Summary Tape File 1 (STF 1) – 100-Percent data
- Click on **List all Tables**
- Select DPI – General Population and Housing Characteristics: 1990
- Click on **Next** (located at the top of the list of table titles)
- For block group data, check box **Show All**
- Select block group
- Select a State
- Select a county
- Select a census tract
- Select the Block Group(s)
- Click on **Add**
- Click on **Show Table**

Figure 13 Overview at watershed an block group



The Census Bureau Statistical Unit provides assistance to users having difficulty with this process. They can be reached at (301) 457–2422.

The percent of each block group's land area was previously calculated in a GIS as explained and is also presented in table 3. In this case 20.8 percent of block group 2 of tract 9907 is in the watershed.

The next step is to determine the population for each block group in the watershed, and to sum them to display the estimated population for the subwatershed. This is done by multiplying the population of the block group by the percentage of its area in the watershed. This approximation assumes that the population is evenly distributed throughout the block group because census data are not specifically geospatially referenced. Because block groups tend to be smaller in area in more densely populated areas, this alleviates the problem somewhat. Familiarity with the area in question through map study or on-the-ground experience can help validate these judgments. In the example the total estimated population of 546 for the target watershed 132 is displayed in the table. Any further description of the population, such as gender or race, may be estimated by the same procedure.

The attribute of median age may also be estimated for subwatershed 132 by a weighted average technique. The median age of each block group is displayed in the table. The value for 9907 BG-2 is 33.0 years. The median age for each block group is multiplied by the estimated population for each corresponding block group. These values are then summed. The result is 18,667, which is displayed in table 3. The estimated population of the watershed subsequently divides this

value. This was shown to be 546 in the preceding step. That division provides the estimated median age of 34.2 for subwatershed 132.

This process can be followed for estimating watershed values for the other selected population attributes. The median home values can be determined for the watershed. The number of units in each portion of the block groups in the watershed is determined as above. In block group 9907 BG-2, 20.8 percent of the 221 units is 45.9. The estimated number of units in the block is multiplied by the median home value of the block group, which is $58,300, yielding $2,679,934. The sum of the units from block group areas in the watershed is 91 units. The total of the median home values for the all units is $5,390,162. A division of these two values shows the estimated median home value of $58,996 for the target watershed. The median family income for the watershed was similarly estimated and is displayed as $31,792 in the table.

Table 3 1990 Census Tract Data Stanly County, North Carolina, for calculation of data for subwatershed 132

	9901 BG-6	9906 BG-6	9907 BG-2	9907 BG-3
Total block group population	1,644	1,240	1,509	1,106
Median age	34.9	35.6	33.0	36.3
Specified owner-occupied units	247	239	221	229
Median (dollars)	63,200	56,800	58,300	66,500
Families	486	374	460	349
Median family income (dollars)	26,524	26,397	34,423	32,648
Percent of BG in subwatershed 132	0.04%	13.3%	20.8%	5.9%

	9901 BG-6	9906 BG-6	9907 BG-2	9907 BG-3	Sums for sub w/s 132
Population subwatershed 132	1.0	165	314	66	546
Median age times population	35	5,874	10,362	2,396	18,667
Median age – weighted average					34.2
Owner-occupied units subwatershed 132	0.1	31.787	45.968	13.511	91
Median ($) times units	6,244.16	18,055.02	2,679,934	898,481.5	5,390,162
Median ($) – weighted average					58,996
Families subwatershed 132	0.2	49.742	95.68	20.591	166
Median ($) times families	5,156	1,313,040	3,293,593	672,255	5,284,043
					31,792

Data sources

The methodology described in this technical note can be applied to watersheds across the country by collecting the appropriate data. TIGER/Line 1990 files are accessible via the Internet at the U.S. Census Bureau's homepage at

http://www.census.gov/geo/www/cob/index.html

> The TIGER/Line files are extracts from the Census TIGER (Topologically Integrated Geographic Encoding and Referencing) database of selected geographic and cartographic information. They include files for all counties and statistically equivalent entities in the United States as well as files for Puerto Rico and Island Territories.
>
> —U.S. Department of Commerce, 1998

TIGER/Line 1998 files can be purchased from the U.S. Census Bureau. For current TIGER/Line pricing, see the U.S. Census Bureau's Web page

http://www.census.gov/geo/www/tiger/index.html

Alternate sites for downloading the TIGER/Line files include the Environmental Systems Research Institute (ESRI) at

http://www.esri.com/data/online/index/html

The Census Bureau also maintains a list of vendors who can process TIGER/Line files at

http://www.census.gov/geo/www/tiger/vendors.html

Recently, the Census Bureau began making available on their Web site the 1990 TIGER/Line files processed into ESRI Arc/Info Export files, shapefiles, and Arc/Info ungenerate ASCII files. These files can be downloaded at

http://www.census.gov/geo/www/cob/index/html

Conclusion

This technical note encourages the use of GIS technology in watershed planning. It walks the reader through a process of overlaying hydrologic unit information that has census information to obtain watershed demographics that has higher accuracy than that previously obtained. Limitations found in this process have been disclosed.

The authors do not know of a simple software fix for dividing census information within a block group along a watershed boundary that cuts through that block group. Census information itself is not geospatially referenced data. Because of confidentiality reasons, it is unlikely that it ever will be. This limitation requires judgment in the proper distribution of data on a spatial basis.

This technical note describes estimating population attributes by a weighted average technique to demonstrate how to more fully use this process. As GIS technology gets better and software improves, the goal of an all-digital watershed planning process will eventually become a reality. This technical note is but one small step along that path.

References

Holloway, Steven R., James Schumacher, and Roland L. Redmond (ed). 1999. People and Place: Dasymetric Mapping Using ARC/INFO. *In* GIS Solutions in Natural Resource Management: Balancing the Technical –Political Equation, Santa Fe, New Mexico, OnWord Press, pp. 283–291.

United States Department of Commerce, Bureau of the Census. 1998. TIGER/Line Files, 1998 Technical Documentation.

To learn more about the topics and subject described in this technical note, the reader is encouraged to consider a number of books and literature on demographics and GIS. The following books can provide a starting place to investigate GIS and demographics.

Longley, Paul, and Michael Batty. 1996. Spatial Analysis: Modelling in a GIS Environment. John Wiley & Sons, New York, New York.

Mitchell, Andy, 1999. The ESRI Guide to GIS Analysis Volume 1: Geographic Patterns and Relationships. ESRI Press.

Morain, Stan (ed). 1999. GIS Solutions in Natural Resource Management: Balancing the Technical–Political Equation. Santa Fe, New Mexico, OnWord Press.