USING A GEOGRAPHIC INFORMATION SYSTEM TO RANK URBAN INTENSITY OF SMALL WATERSHEDS FOR THE CHATTAHOOCHEE, FLINT, OCMULGEE, AND OCONEE RIVER BASINS IN THE PIEDMONT ECOREGION OF GEORGIA AND ALABAMA

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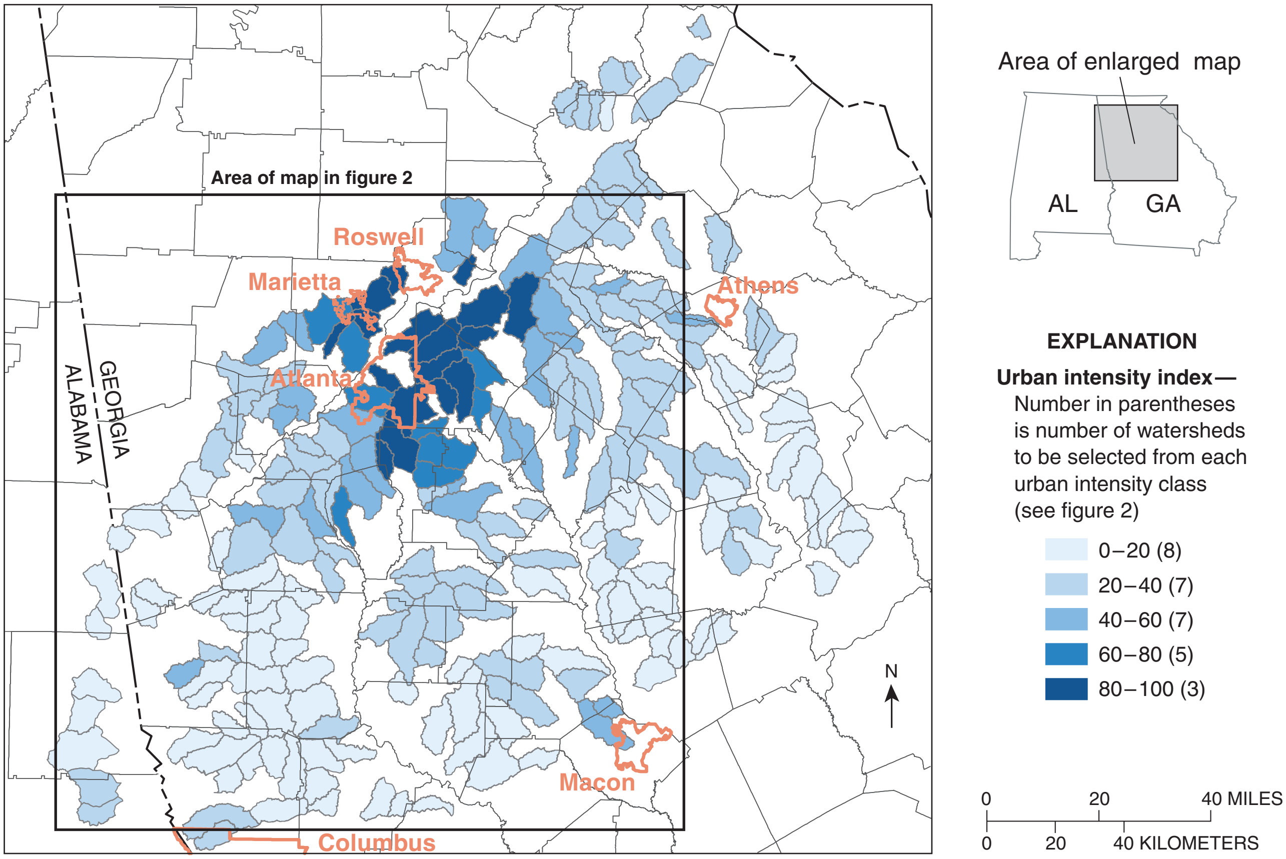
Abstract. The National Water-Quality Assessment (NAWQA) program of the U.S. Geological Survey is conducting a study of the effects of urbanization on the water quality and ecology of streams throughout the Nation. Pilot studies were conducted during 1999–2001 in the Birmingham (Ala.), Boston (Mass.), and Salt Lake City (Utah) metropolitan areas. For each of the studies a multimetric urban intensity index was developed to aid in the selection of approximately 30 watersheds representing a range, or gradient, of urban intensity. To develop the index, researchers used principal component analysis to identify population density as the most important factor in explaining statistical variation among basins with similar natural features (McMahon and Cuffney, 2000). The urban intensity index was developed based on approximately 50 socioeconomic and landscape variables with an absolute Pearson correlation of 0.5 or greater with 1997 population density.

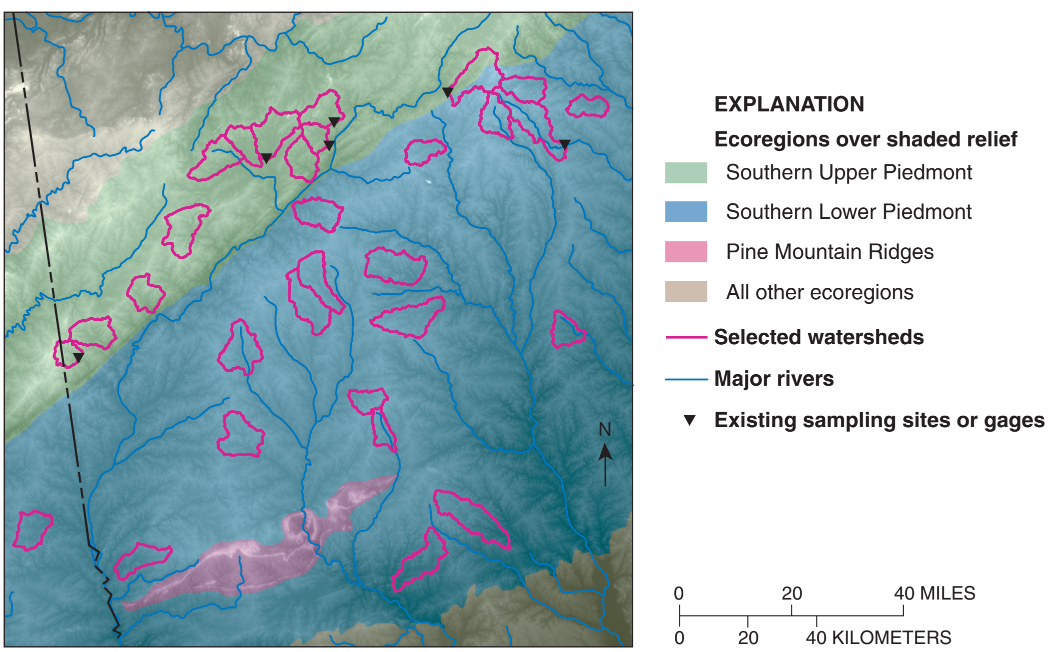
Full implementation of the urban gradient study approach in the NAWQA program began in 2002. Three metropolitan areas, including Metropolitan Atlanta, Georgia, in the Georgia/Alabama Piedmont Ecoregion, were chosen for water-quality sampling in 2003; studies are scheduled to begin in three additional metropolitan areas in 2004. For the Metropolitan Atlanta study, (geographic information system) software and digital elevation data were used to create 217 digital watersheds with areas ranging from 15–60 square miles. The urban intensity index was created to assist in selecting 30 watersheds from the initial 217. The index ranked the 217 candidate watersheds on a relative scale of 0–100 (Fig. 1). The study design required that eight watersheds be selected for sampling from the least urbanized areas (class 0–20), seven from the next two classes, five from the fourth class (60–80), and only three from the most urbanized areas (80–100). National datasets used for creating the urban intensity index included the 2000 census population density (Geolytics, 2000). Other census variables examined were 21 socioeconomic variables from the 1990 census (Geolytics, 2000), including several indices that combined census variables (McMahon and Cuffney, 2000). The Multi-Resolution Land Characteristics Consortium provided land cover/land use from Landsat Thematic Mapper satellite images collected in the early 1990s (U.S. Geological Survey, 1992). In addition, infrastructure variables derived from roads data and the U.S. Environmental Protection Agency's Toxic Release Inventory were examined (U.S. Environmental Protection Agency, 2001). Nineteen of these variables are strongly related to population density and were chosen to be part of the multimetric urban intensity index for the Metropolitan Atlanta study. The index for Metropolitan Atlanta included two population density, six socioeconomic, three road, and eight land cover variables. The index is still being modified, so the final relative watershed ranking may be slightly different.

In addition to calculating an urban intensity index for the Metropolitan Atlanta area, researchers grouped watersheds based on the digital representation of natural features, including digital elevation and its derivatives, regional soils, soil texture, ecoregions at Level IV detail, and a national hydrologic region model that uses landscape form, geologic texture, and climate. The purpose for grouping the watersheds by natural features was to minimize natural variability among the selected watersheds. Although statistical clusters of watersheds were identified based on similarities in natural characteristics, the differences among clusters were not pronounced, perhaps because the available digital data were not detailed enough to differentiate accurately among these small watersheds. One cluster of watersheds with sandy soils was eliminated from consideration. The Pine Mountain Ecoregion was also avoided because of its high stream slopes in comparison to the surrounding ecoregion.



Base modified from U.S. Geological Survey digital data, 1:100,000

Figure 1. Computer-generated watersheds symbolized by urban intensity index.



Base modified from U.S. Geological Survey digital elevation model, 1:250,000
Draft digital ecoregions from Griffith and Omernik, 1:250,000, 1999

Figure 2. Location of watersheds selected for the urban study in relation to level IV ecoregions and shaded relief.

In practice, the selection of sites with similar natural features was done primarily in the field. Habitat, stream slope at the sampling site, ecoregion, accessibility, ongoing sampling activities, and existing gages were considered as part of final site selection (Fig. 2). The selected watersheds are located in two ecoregions, the upper and lower Piedmont, which had some natural differences. To assist with later data analysis, 10 sites in the upper Piedmont were chosen across the urban intensity index and 20 sites were chosen across the index in the lower Piedmont. All sites have similar in-stream habitat and represent the range of urban conditions in the study area.

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