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Using GIS to Examine Exurban Density Patterns in Watauga County, North Carolina

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Increasing population and land use change in rural areas are of significant importance to residents of western North Carolina. Previous studies have shown rapid growth in rural areas is associated with declines in environmental quality as well as increased home prices. This study provides an analysis of spatial density surfaces derived from land parcel data to measure exurban growth. A case study demonstrating housing trends based on density surface analysis over a nearly sixty year time period (1950-2007) is presented at two scales: across Watauga County and within a one mile buffer of the South Fork of the New River. Growth is discussed in relation to the environmental planning issues of land and water conservation strategies as well as strategies for increasing public participation in land use decision-making.

Keywords: Land parcel data, density surfaces, spatiotemporal analysis, environmental planning, rural gentrification, South Fork New River, Watauga County.

Introduction. Western North Carolina is well known throughout the southeast for its recreational amenities, including ski resorts and cool summer climate, and idyllic nature which provide a significant draw for many new and seasonal high income residents from locations across North Carolina, Georgia, South Carolina, and Florida. The increased number of second home and seasonal property owners, many benefiting directly from the southeast's profitable housing market, has led to anecdotal reports of increases in housing density among many formerly rural areas in this Appalachian region of western North Carolina. The resulting increase in housing unit density, mean housing costs, homes of large lot sizes, and number of seasonal residents has strongly affected Watauga County in particular.

The impacts of new and seasonal high income residents into this primarily rural county are similar to previous reports on rural gentrification in the western US (Dougherty 2008). Rural gentrification may be best characterized as the social and economic change in rural areas due to an influx of newer residents with significantly higher incomes. Previous studies have attempted to define the significant social and economic impacts of rural gentrification on citizens of western mountain communities (Ghose 2004, Diamond 2005) as well as areas characterized by McMansions along the mid-Atlantic and Appalachian region within range of Washington, DC and other population centers (Bruegmann 2005). The study of rural gentrification is difficult as it relies on differentiating among the driving forces of increased housing density in regions. It is therefore not surprising that few studies have produced evidence that makes this distinction in underlying processes of changing housing density and its environmental and social impacts.

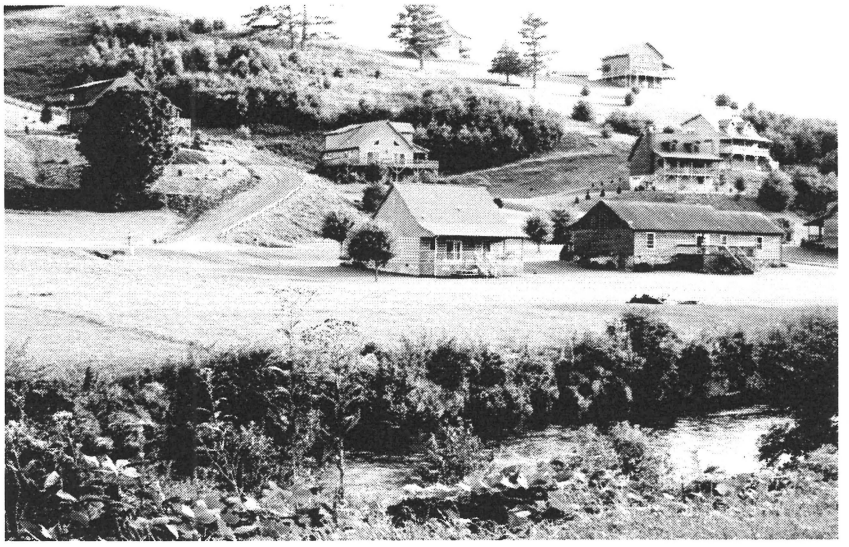


Figure 1. Home density near the South Fork New River, Watauga County, North Carolina.

Figure 2. Examples of housing construction along the South Fork New River, Watauga County.

To further investigate trends in housing growth related to recreational amenities and potential impacts on environmental quality, a case study of housing growth using density surface analysis over a nearly sixty year time period (1950-2007) in Watauga County was conducted. This study area was selected due to the fact that anecdotal reports have suggested the area is undergoing rapid housing density growth due to its scenic setting, access to water recreation activities, and proximity and commuting convenience to the growing population center of Boone (see Figures 1 and 2). Land parcel density surfaces are used to highlights hotspots of growth and potential land use conflict that may be used to address environmental planning decision-making within the county to mitigate negative consequences of rapid land use change.

Previous Work

The nature of studying housing density growth in primarily rural areas presents methodological challenges distinct from the study of higher population areas. Previous work on land use change processes has generally provided three main conclusions concerning the study of rural housing growth processes. First, studies of rural land use change based on remote sensing data are limited due to the data being too coarse to accurately depict the intricate changes occurring at lower land-use intensities and multiple data sources are required to increase the accuracy of analysis (Theobald 2001). Secondly, socioeconomic datasets derived from bounded areal units from the US Census Bureau are limited in that they do not provide adequate spatial accuracy needed to measure the rural density of housing units. Thirdly, data generated from landscape ecology focused studies tend to be primarily focused solely on areal size of land use classes, an aggregate measure that conveys little direct relation to housing density growth processes. The commonly used categories in these studies such as *fragmented* or *variegated* also limit the application to housing growth analysis in that the classification scheme is often open to the investigator's interpretation (Theobald 2001).

The limitations described in previous work suggest land parcels are the most effective source of data used to study housing density growth processes at fine resolution as they are a data source that is cost effective, highly spatially accurate, and collected at frequent temporal intervals. Previous studies have also demonstrated that density measures can be successfully used to reconstruct housing growth histories. For example, Radeloff et al. (2001) used historic census and tax parcel data to analyze housing density trends in exurban development in a study focusing on a seven-county region with a large percentage of seasonal housing in Wisconsin. Lepczyk et al. (2007) also successfully integrated housing census data and spatial statistics to display temporal progressions of growth hotspots between decades from 1940 to 2000.

Land parcel data may fall short as a useful data source in instances where historical records of parcel delineations, land uses, and building locations may be difficult to acquire or require a great deal of time digitizing and interpreting (Brown 2003, Gonzalez-Abraham et al 2007). However, the land use of a parcel can be readily approximated from the categories assigned for different tax rates, such as residential or commercial, which may vary according to methods employed by neighboring counties and municipalities. In light of their shortcomings, tax parcel data may well supply highly useful insights into processes leading to rural land use change by greatly improving projections of land use change in the context of land use planning decisions and communication to the public (Theobald et al. 1996, Theobald and Hobbs 1998, Hammer et al. 2004, Theobald 2005). In particular, previous work has described the influence of proximity to natural amenities, such as scenic views and rivers, as well as accessibility and existence of transportation and utility infrastructure on land use change (Gonzalez-Abraham et al. 2007). This research focuses on the lower density land use often referred to as *exurban,* a term referring to a special class of housing area strongly

influenced by rural amenities and not necessarily concentric within distance of an urban center. The data used rely upon land parcel analysis to approximate the extent and rate of housing density growth as indicators of the impacts of exurbanization on environmental quality. The use of land parcel data for housing density analysis enhances our understanding of interactions between socioeconomic changes due to in-migration and housing density (Theobald and Hobbs, 1998; Hammer *et al.*, 2004; Theobald, 2005).

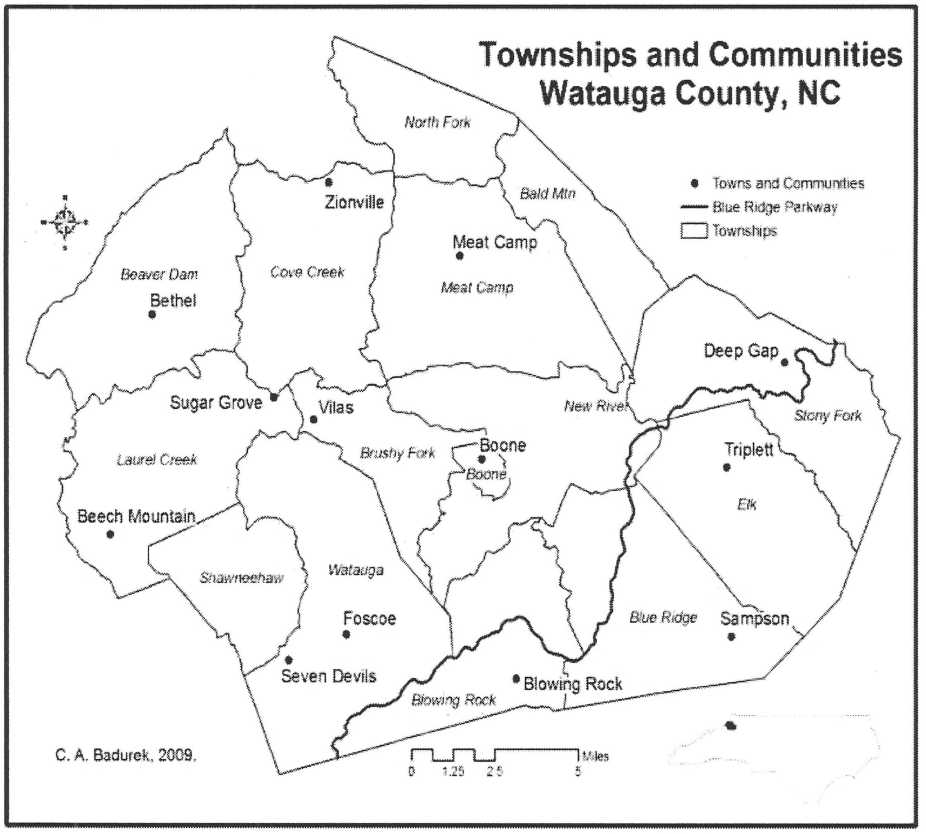


Figure 3. Townships and communities within study area of Watauga County, North Carolina.

Case Study: Watauga County

Watauga County has a year around population of 44,716 (US Census Bureau, 2007) plus a consistent number of seasonal residents not included in the census. Digital tax parcel data available from Watauga County for the year 2007 show land area, tax value, parcel use classification, and the year of building construction. These data were analyzed with ESRI's ArcGIS to demonstrate a change in housing density in Watauga County from 1940 to 2007.

The 2007 land parcel database had 45,473 records classed as: 'Agriculture',

'Commercial', 'Commercial/Residential', 'Residential', 'Condominium', 'Townhouse', 'Exempt', and non-classified. For this analysis the 'Agriculture', 'Commercial', 'Exempt' and non-classified parcels were removed from the dataset. The 23,153 remaining residential parcels were then classified by the date when construction began, starting with houses built prior to 1940 and continuing in decadal intervals to 2000, and ending with a final 2007 interval. Point files were created using the mean center of each parcel polygon and interpolated using ArcGIS Spatial Analyst extension to create eight parcel density surfaces. Parcel density surfaces were then compared with major county roads, rivers, and 'urban centers' to observe how these features affected development patterns. Each density surface was then reclassified as 'Urban', 'Suburban', 'Exurban', and 'Rural' using the methods described by Theobald (2001) (Table 1).

Land Use Class	Density Value
Rural	<0.025 buildings/acre
Exurban	0.025 – 0.1 buildings/acre
Suburban	0.10 – 0.75 buildings/acre
Urban	> 0.75 buildings/acre

Table 1. Land use and parcel density values.

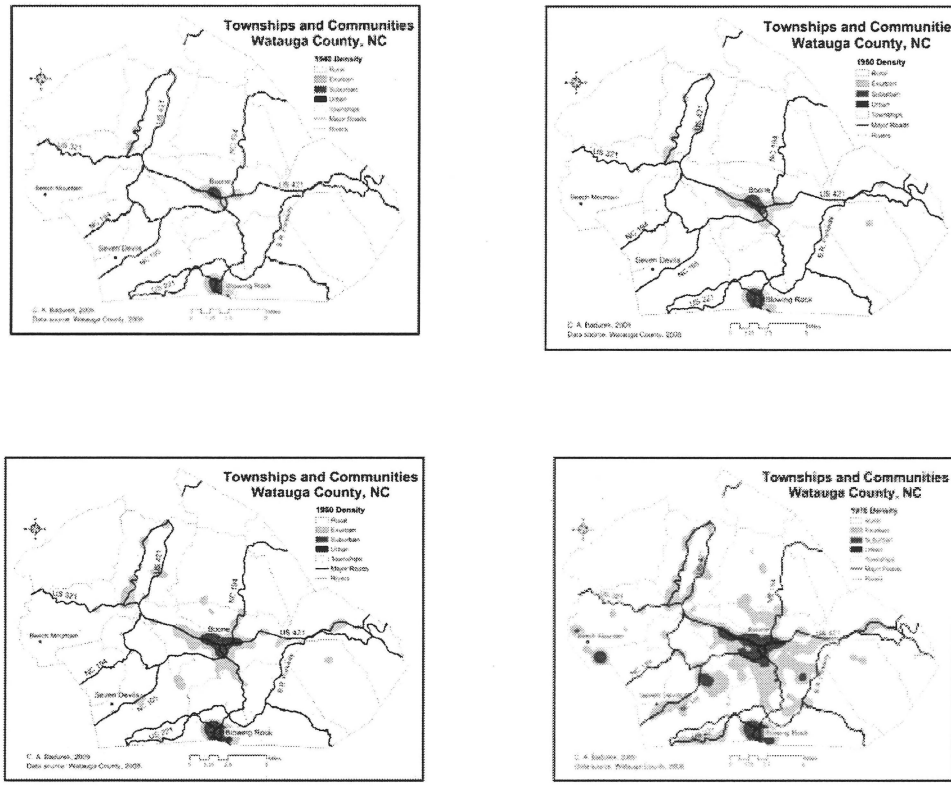


Figure 4. Housing density diffusion, 1940 - 1970 in Watauga County, North Carolina.

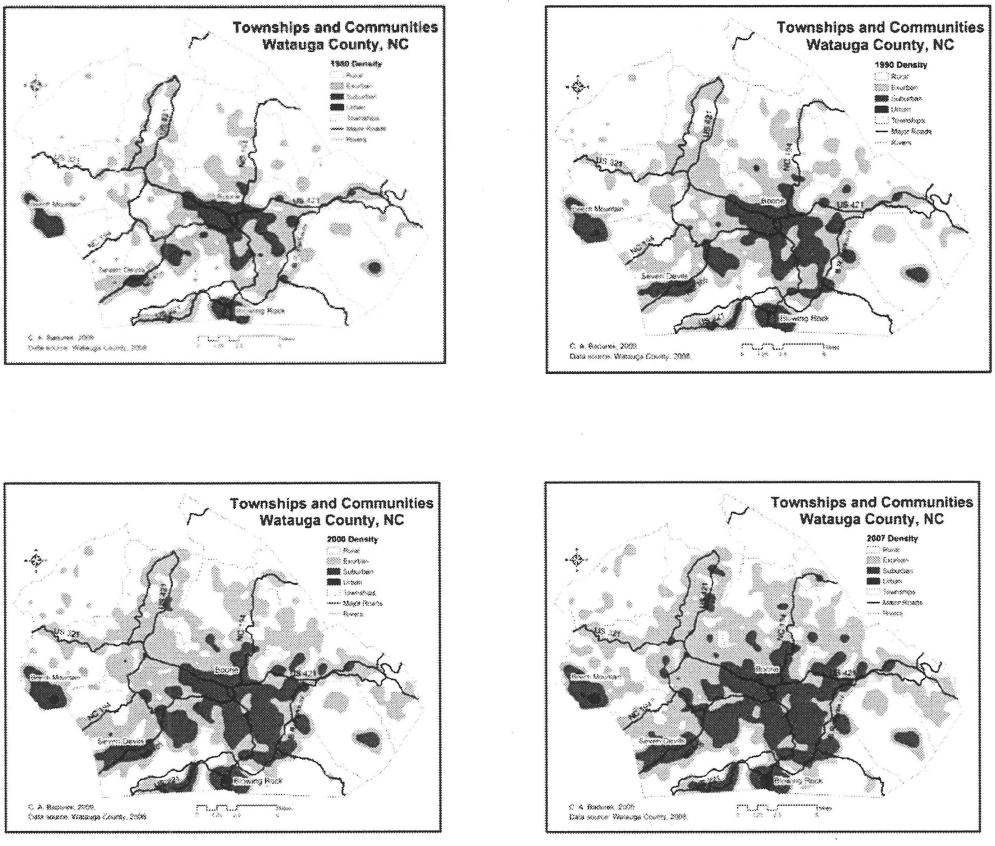


Figure 5. Housing density diffusion, 1980 - 2007 in Watauga County, North Carolina.

Figures 4 and 5 show the progression through time. A striking feature is the growth of hotspots in proximity to significant natural landscape features and existing infrastructure. For example, the southeastern limits of high density are located exactly at the crest of a ridge offering vistas of the Blue Ridge Parkway. Growth also follows along major roadways, such as the recent Laurelmor development by the Ginn Company in the southeastern part of the county. Further visual comparison of the patterns of growth in the north and northwest parts of the county suggests development occurs first along existing roadways. There is a consistent increase in density along Highway 421 east of Boone and along Highway 194 to the north before 1960, as well as density increases along Highway 105 near Seven Devils in 1970. Increasing density is also evident along the Blue Ridge Parkway after 1980. Significant infill is evident between these lines of growth. In summary, the trends indicate three major drivers of residential development in Watauga County: the location of natural boundaries and landscape features; towns with a significant number of seasonal residents; and existing transportation and utility infrastructure.

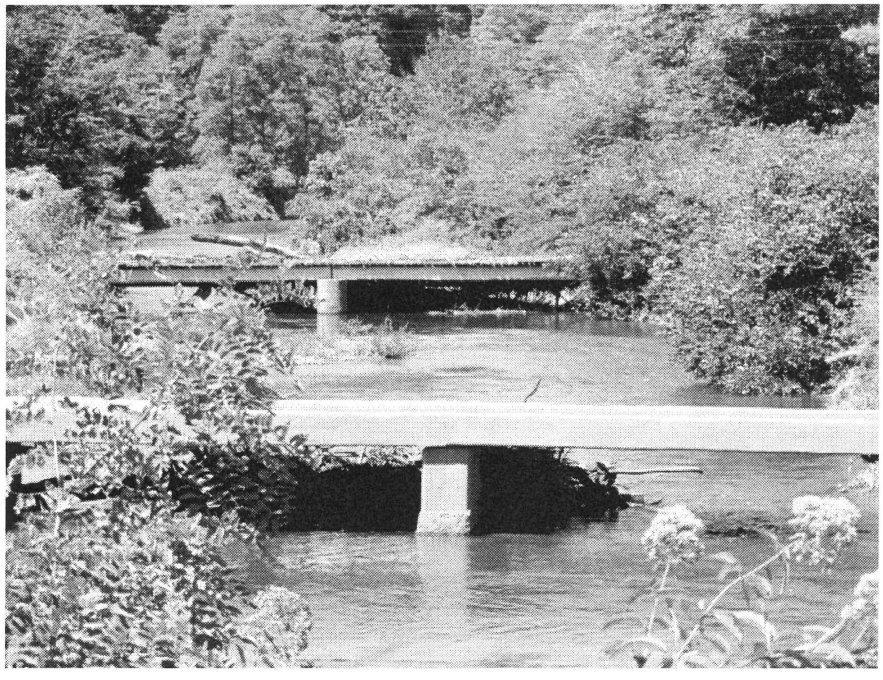


Figure 6. Flooding and debris along the South Fork New River, Watauga County.

Figure 7. Agricultural land use within proximity to the S. Fork New River, Watauga County.

Decade	Population Growth Rate	Built Parcel Growth Rate
1940-1949	1.3	19.9
1950-1959	-4.4	24.6
1960-1969	33.5	37.0
1970-1979	33.2	40.2
1980-1989	18.6	25.8
1990-1999	15.6	22.3
2000-2007	4.7	19.5

Table 2. Relationship between population and built parcel growth rates (1940-2007).

Water Quality Implications

Regulations are of increasing relevance to citizens of Watauga County. Previous work has shown significant changes in water quality in relation to land use change in western North Carolina (Bolstad 1995). These finding are also of relevance to recent concerns and anecdotal evidence of sedimentation effects on recreational fishing as well as flooding hazards in the Appalachian region, particularly with residential housing built within the floodplain or within immediate proximity to the river (see Figures 6-7). These concerns may be justified when considering the relationship between the population growth rate and built parcel growth rates, where the rate of parcels being built far exceeds population in the most recent decade (Table 2). Protection of the South Fork of the New River is particularly concerned with water quality in headwaters of the New River that flows through several states as well its rural nature which appeals to regional tourists (NCNR 2009). The majority of Watauga County adjacent to the South Fork is unincorporated, with minimal land development regulations. Watauga County's ordinances along the South Fork are limited to those outlined by the North Carolina's Division of Water Quality (NCDWQ), the agency responsible for Clean Water Act regulations. Although some county (Watauga County 1996) and state (NCDENR 2005) protections are in place, they are not particularly effective.

Conclusions

This paper has focused on examining methods for analyzing exurban patterns using land parcel data density surface analysis. Analysis of the nature of growth in Watauga County indicates that residential land use is rapidly overtaking agricultural and that environmental planning regulations may be the best approach to slow growth in the study region. Water quality, rural gentrification, and loss of agricultural land are all concerns of county residents. The effective use of GIS and land use histories may enable governmental or non-governmental organizations to maintain the environmental quality necessary for the continued economic development of the county.

Figure 8. Housing density classes, South Fork New River, Watauga County, North Carolina.

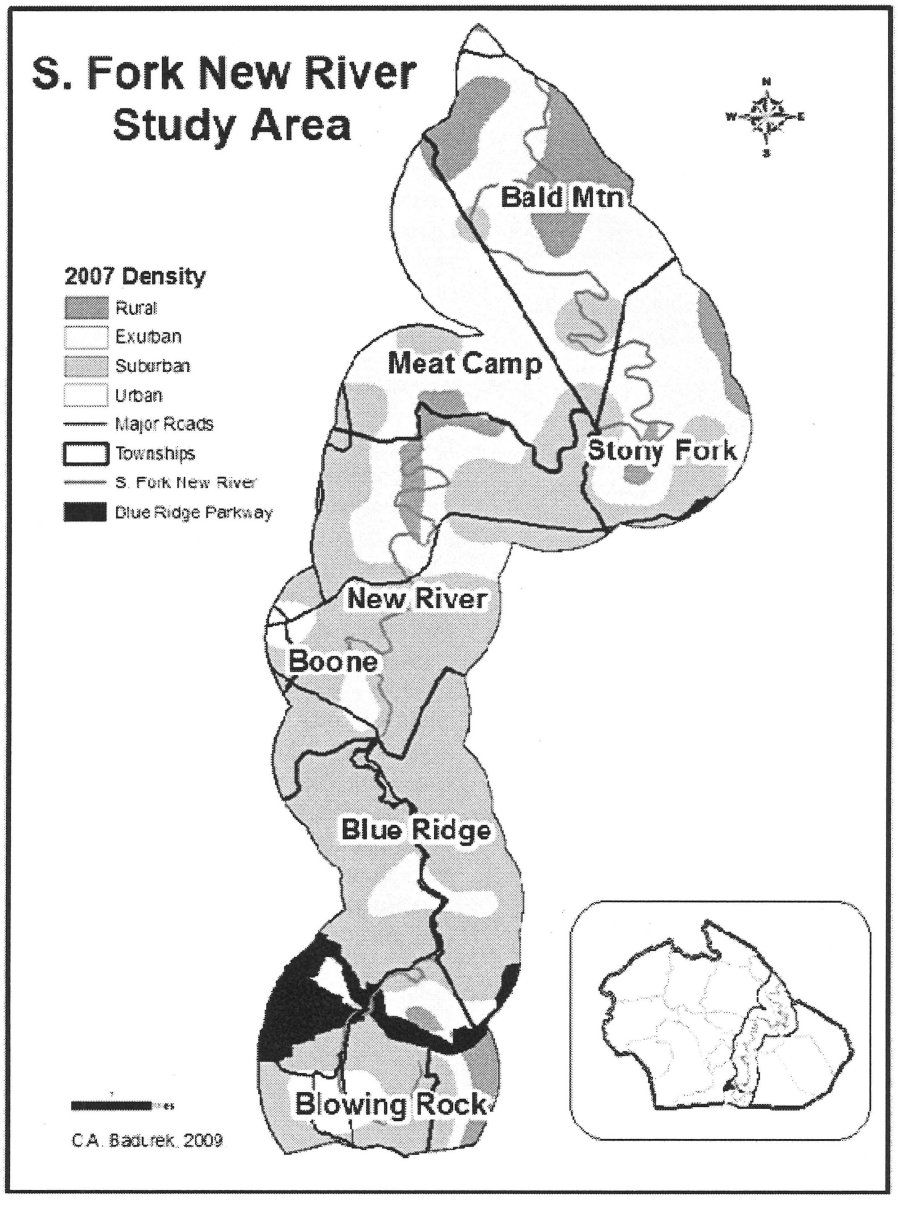
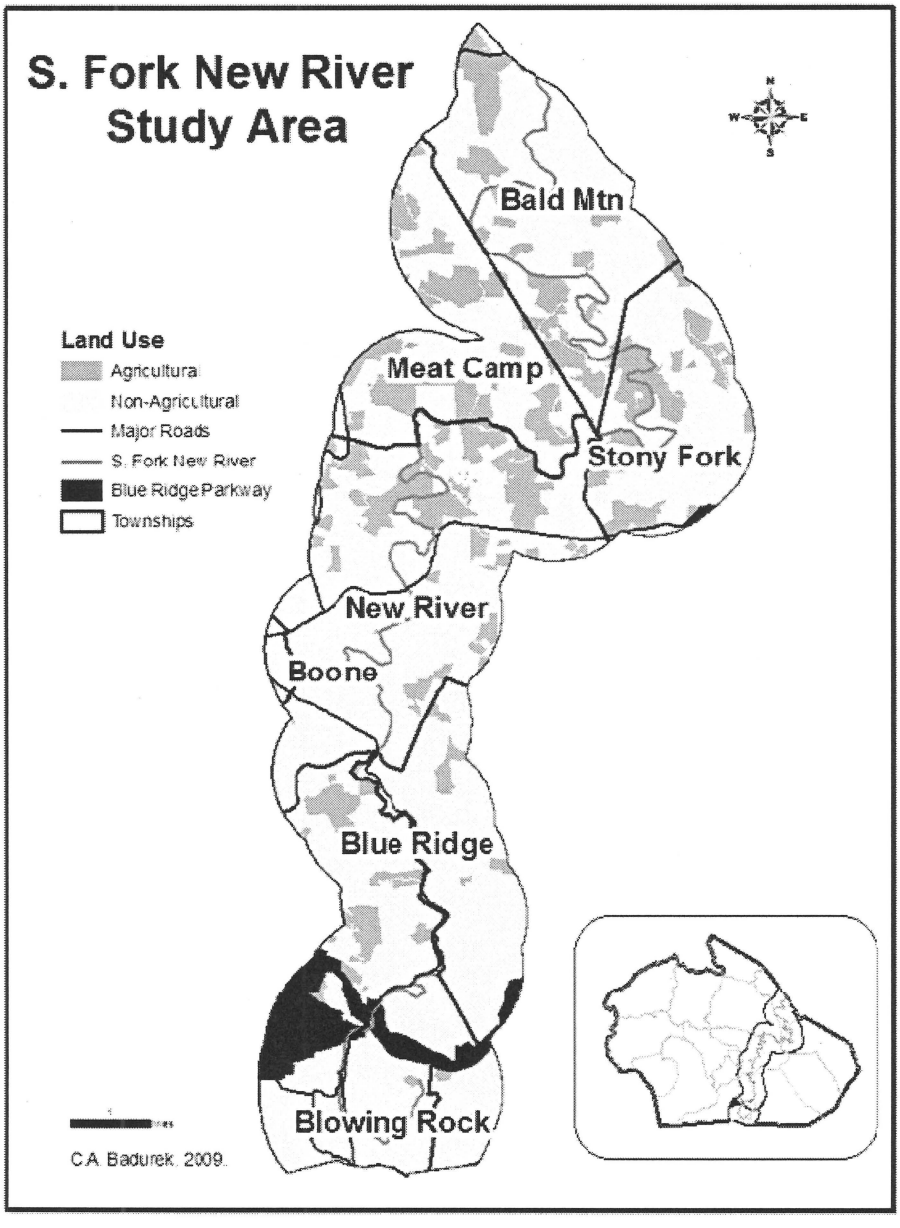


Figure 9. Land use, South Fork New River, Watauga County, North Carolina.



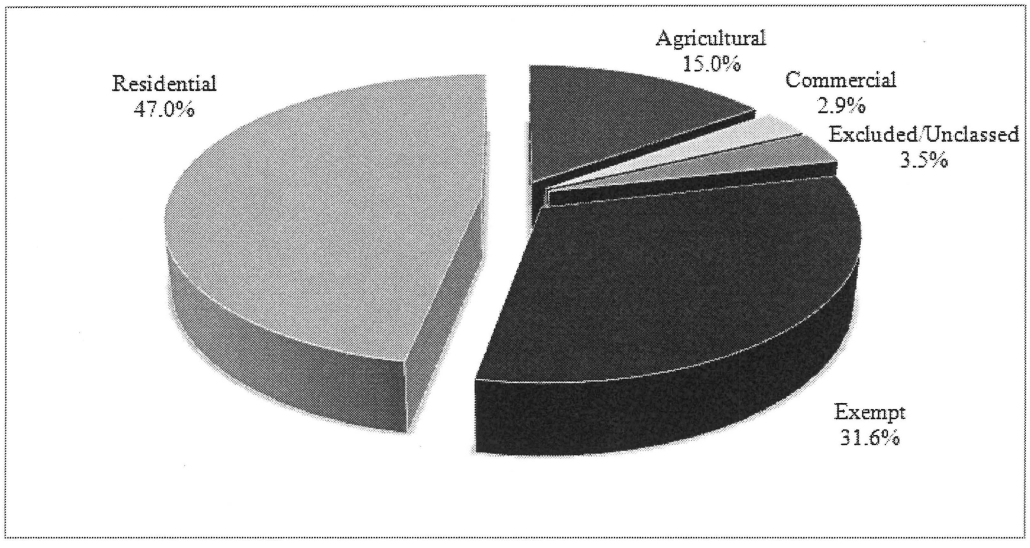


Figure 10. Percent of acres by land use in South Fork New River study area.

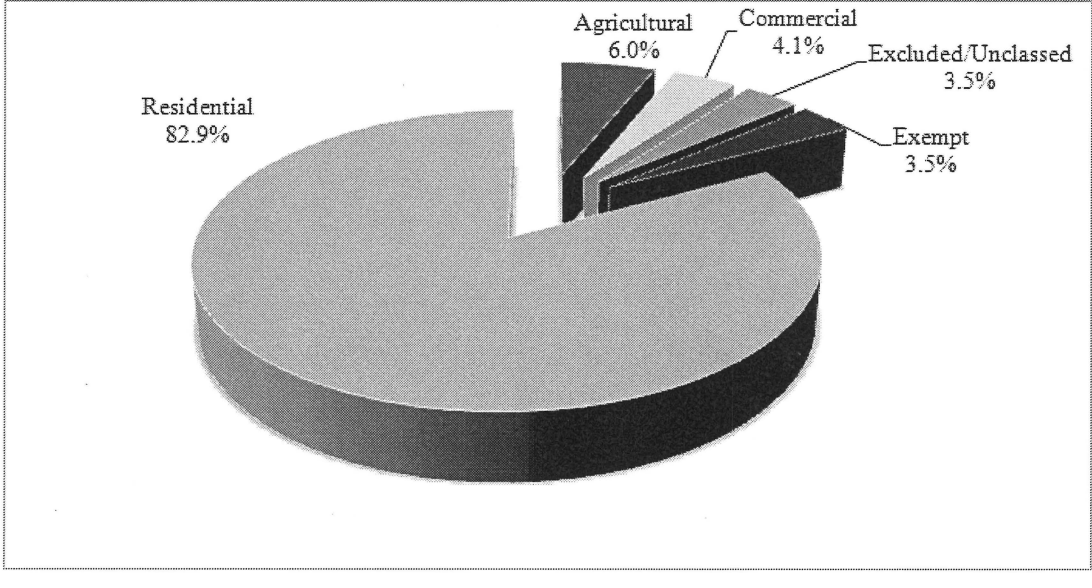


Figure 11. Percent of parcels by land use in South Fork New River study area.

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