Land Cover Change Impact Studies in the Enoree River Basin: The Effect of Scale

Catherine Anderson, Fall 2007

Earth and Environmental Sciences Department, Furman University, 3300 Poinsett Hwy, Greenville, SC 29613

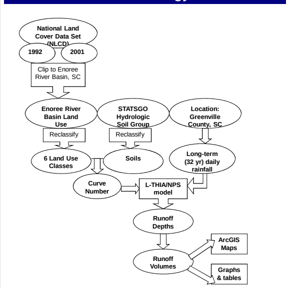
Abstract

Land use change profoundly affects ecosystem health, particularly in increasingly urbanizing watersheds. While the amount of incurred change is an important factor, the spatial distribution of changes in land use, which greatly impacts runoff volume, should be considered. This project examines the impact of land use change different scales in the Enoree River Basin, SC. Impacts caused by changes on the river basin scale may seem relatively insignificant, but can become more dramatic and significant at increasingly smaller scales, such as subwatersheds. National Land Cover Data for year 1992 and 2001 were used to study the changes in urban area and runoff production at different scales. Results show major trends towards urbanization: decreases in forested land, moderate increases in high-density residential land, and large increases in low-density residential land. The more recent the urbanization these watersheds have experienced and the smaller the scale, the more dramatic are the impacts of land use changes on runoff volume.

Background

Land use changes affect the geomorphic, ecologic, and hydrologic health and function of streams. Urbanized streams characteristically experience collapsed or heavily incised banks, extensive soil erosion, flashy hydrographs, higher nutrient concentrations, and depletion of the riparian zone, all contributing to changes in stream dynamics at the local scale. Riparian zone loss contributes to runoff volume increases and habitat fragmentation. The Enoree River Basin, located in Greenville County, Upstate South Carolina, has experienced considerable land use changes over the past 15 years. Mountain, Brushy, Rocky, and Gilder Creeks are of interest because of their varying states of development for the duration of the study (1992-2001). This study will aid the River Basins Research Initiative (RBRI) program at Furman by providing insight on the effects of land use change in our areas of study. Furthermore, this study compliments our developing knowledge of storm water chemistry by demonstrating changes in runoff volume associated with land use change on both small and large scales. Runoff volumes and land use data from 1992 and 2001 were analyzed at 3 different spatial scales: (1) The Enoree River Basin; (2) The watersheds of Mountain Creek, Brushy Creek, Rocky Creek, and Gilder Creek; and (3) land within a 100m buffer zone on both sides of the stream within each of the four watersheds.

Methodology



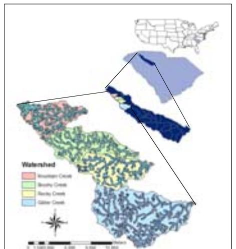
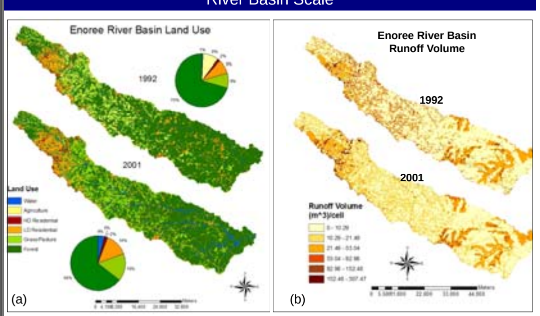


Figure 1. Three scales of study: Enoree River Basin, four selected watershed boundaries in the Upper Enoree, and 100m buffer zone surrounding streams within each watershed.

River Basin Scale



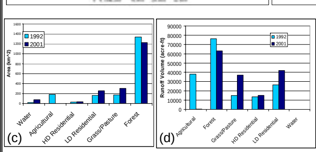
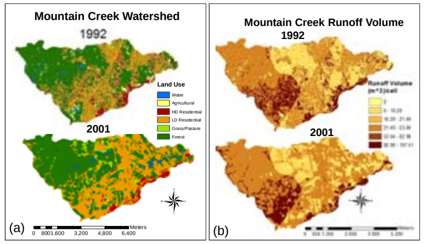


Figure 2. Enoree River Basin land use change (fig. a and c) and runoff volume (fig. b and d), 1992-2001.

Results and Discussion

Enoree River Basin: Between 1992 and 2003, the Enoree River Basin (ERB) experienced a decrease in forested land by 6%, a 9% decrease - nearly a complete loss - in agricultural land, a 7%, increase in grass/pasture, a 5% increase in low-density (LD) residential, an increase in high-density (HD) residential by less than 1%, and an increase in water by 3% (Fig. 2). Correspondingly, total runoff volume from forested land decreased, while the volumes of runoff from grass/pasture, HD residential, and LD residential all increased. Although runoff potential is greatest for HD residential, followed by agricultural, LD residential, grass/pasture, and forested areas, the total runoff volume for each land use is a factor of both the curve number and land area. The revealing trend is the loss of forested, agricultural, and grass/pasture land to high- and especially low-density residential land.

Watershed Scale



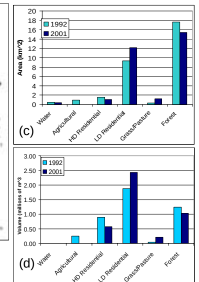
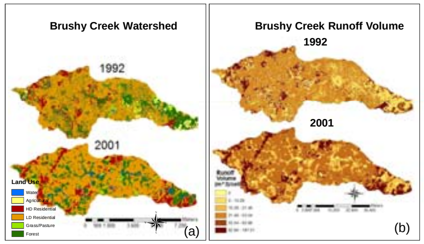


Figure 3. Changes in land use (a,c) and runoff volume (b,d) in Mountain Creek Watershed, 1992-2001.



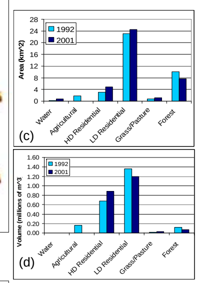
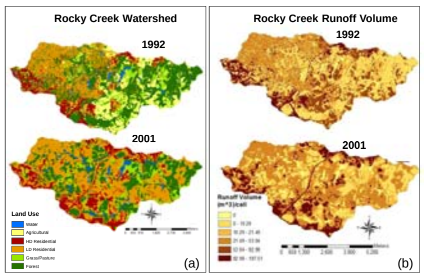


Figure 4. Changes in land use (a,c) and runoff volume (b,d) in Brushy Creek Watershed, 1992-2001.



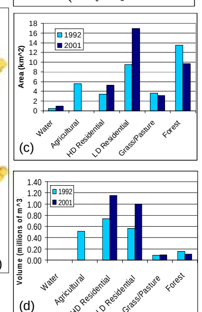
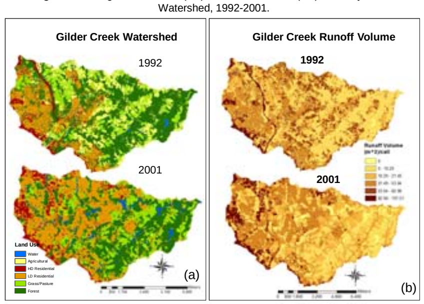


Figure 5. Changes in land use (a,c) and runoff volume (b,d) in Rocky Creek Watershed, 1992-2001.



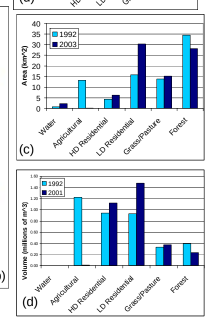
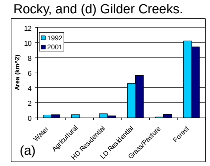
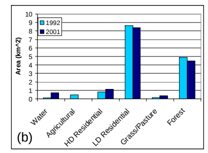


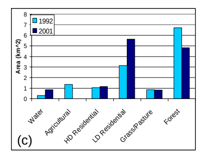
Figure 6. Changes in land use (a,c) and runoff volume (b,d) in Gilder Creek Watershed, 1992-2001

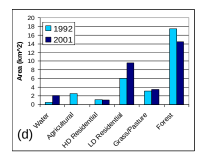
Buffer Zone Scale

The graphs in this column show the land use change within the 100m buffer zone surrounding (a) Mountain, (b) Brushy, (c) Rocky, and (d) Gilder Creeks.









Results and Discussion (cont'd)

The reduction in agricultural land in the ERB from 1992-2001 to less than 1% of the total area can be partially attributed to differences in classification schemes between the two data sets (some grass/pasture may have originally been classified as agricultural), but much of the loss can be accounted for by the considerable rise in LD residential land. These trends become increasingly apparent on smaller scales. Some watersheds and buffer zone areas have changed more drastically than others since 1992. The effects of increases in urbanized land and decreases in forested, agricultural, and grass/pasture lands, can partially be seen in the corresponding increases or decreases in the runoff volumes for each area.

Mountain Creek: The northernmost of the watersheds studied, the Mountain Creek (MC) Watershed (Fig. 3) experienced a decrease in forested land by 7% , an increase in LD residential land by 9%, an increase in grass/pasture by 3%, and a complete loss of agricultural land. The runoff volumes for each land use showed corresponding changes. The MC Watershed experienced changes in the same land use categories as the larger ERB, but the effects are more dramatic: a larger decrease in forested land with respect to the total land area, and a larger increase in LD residential land. Within the 100m buffer zone surrounding MC, forested land decreased by 6%, agricultural land virtually disappeared, grass/pasture increased by 2%, and LD residential increased by 7%. Thus forested lands underwent the largest loss and LD residential land, the largest gain.

Brushy Creek: The Brushy Creek (BC) Watershed (Fig. 4) experienced similar trends, but the changes were not as dramatic since the BC area had already been extensively developed by 1992. Still, from 1992 to 2001 there was a decrease in forest by 6%, an increase in LD residential by 4%, an increase in HD residential by 4%, and again a complete loss of agricultural land (5% decrease). The loss of forest matches that of the entire ERB (based on percentage of total land area), but the percent increase in HD residential land in the BC watershed is notably higher than that in the ERB as a whole. Changes in runoff volume did not as closely parallel the land use changes as they did in other watersheds. Total runoff from HD residential land increased, and runoff from forested decreased, but total runoff volume from LD residential actually decreased in spite of the small increase in the area classified as LD residential. Contrary to all other trends, this may be due to data classification errors. On the buffer zone scale, BC experienced only slight increases or decreases in land uses, the most significant being a 3% loss of forest and a 3% increase in HD residential land.

Rocky Creek: The Rocky Creek Watershed (Fig. 5) experienced dramatic changes in several land use categories. Forested land experienced an 11% decrease, LD residential increased by 19%, HD residential increased by 6%, and agricultural land decreased completely by 15%.There were correspondingly large increases in runoff volume from HD and LD residential land, but relatively little change in runoff volume from other land uses. On the buffer zone scale, Rocky experienced the most extensive land use change, with a 15% decrease in forest, a 20% increase in LD residential, a 1% increase in HD residential, and a 10% loss in agricultural land. These figures show that much of the land use change occurring on the watershed scale occurred within the buffer zone.

Gilder Creek: The southernmost of the four watersheds, the Gilder Creek Watershed (Fig. 6) also experienced profound land use changes from 1992 to 2001. Forested land decreased by 8%, agricultural land decreased by almost 16% but, significantly, did not completely disappear, unlike the three other watersheds. LD residential land increased by 17%, HD residential land increased by 3%. Runoff volume correspondingly increased for HD and especially LD residential land, and decreased for forest. On the buffer zone scale, Gilder experienced a 10% loss of forest, an 8% loss of agricultural, and a 12% increase in LD residential land.

Conclusions and Future Plans

The watersheds and buffer zones with the most recent changes in land use with a trend towards urbanization show the most drastic changes in runoff volume. This project therefore illuminates the impact of scale when studying land use change. This method can be applied to many other variables as well, particularly water chemistry. While the L-THIA model also predicts non-point source pollution chemistry, the data is based on national averages and therefore does not achieve the desired detail for this study. Therefore, this project will continue in the future to incorporate water chemistry data for particular sample sites within Brushy, Rocky, Mountain, and other creeks of interest. Incorporation of chemistry data will allow analysis of the relationship of changes in nutrient concentrations to runoff volume and land use changes (especially urbanization). Furthermore, incorporation of field data will allow analysis on a smaller, more ecologically relevant scale.

Metadata

Projection System: Albers Conical Equal Area, UTM Zone 17N; Datum: North American Datum (NAD) of 1983; Ellipsoid : Geodetic Reference System 80; NLCD 1992 and 2001 are based on 30m resolution satellite imagery from Landsats 5 and 7, respectively.

Acknowledgements

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