Trends in Land Cover Change with City Annexation: Rock Hill & Greenville, South Carolina

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Abstract

In the United States, 63% of the population lives in cities, which makes up 3.5% of the land (United States Census Bureau). As the population continues to increase and people concentrate in cities for their economy and access to services, cities must take steps to economically and physically grow. Annexation is one option. Increased revenue and tax base, increased number of individuals participating in government, increased economy of scale in providing services, and a stronger corporate community, are some benefits of annexation (Municipal Association of South Carolina, 2012). But with growth comes increased, urbanization and natural land cover types such as forests, wetlands, and grasslands are converted to developed, impervious surfaces. In this case, ecosystem services such as terrestrial carbon storage, habitat quality, soil stability, and nutrient cycling are significantly affected (Foley et. al, 2005) and pollution, waste, and degradation increases (Bagan & Yamagata, 2014). Natural land covers not only preserve ecosystem services but maintain natural spaces and recreational areas both of which are beneficial for human health (Rakhshandehroo et al., 2015) and economic development in an urban environment.

Cities planning for future development should be aware of trends in land cover change that occur with annexation and growth in order to make informed decisions and predictions. In this study, I addressed two preliminary questions for the city of Greenville, South Carolina in an effort to uncover trends in city growth through annexation that might inform city planning:

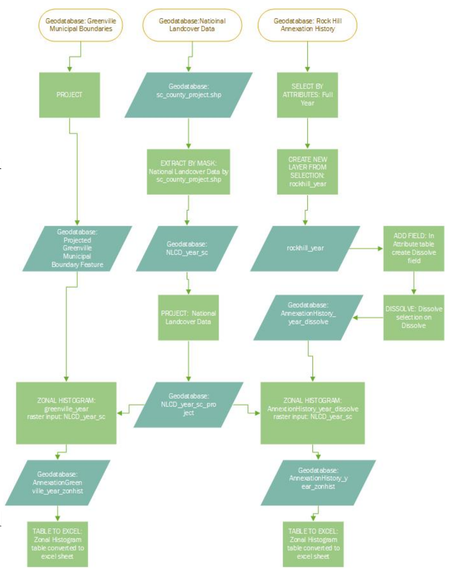
1. What land cover types are the cities annexing?
2. How does the composition of land cover within the city boundaries change over time?

Annexation in the state of South Carolina requires that the landowners petition to be annexation and receive city services. This makes it difficult for cities looking to grow through annexation to have direct control over the kind of land they are able to add to the city. Thus, understanding trends in annexation and land cover change might inform cities how the urban landscape may change in the future and what step they need to take to successfully implement city plans.

To do this, I used National Land Cover Data (NLCD) from 2001, 2006, and 2011 and municipal boundaries from Greenville, South Carolina and Rock Hill, South Carolina to analyze trends in land cover change. The analysis shows distinct differences between the type and amount of land annexed by Greenville and Rock Hill as well as changes in total land cover composition over a 16-year time span, measured in one 6 and two 5 year intervals. City planning, available land, and which property owners desire to be annexed are likely candidates for explaining differences in land cover annexation and change.

Methods

I used ArcMap 10.4.1 to perform spatial analysis and create maps of Rock Hill and Greenville, South Carolina. NLCD from 2001, 2006, and 2011, a 16 class, LANDSAT-based 30 meter resolution land cover database for the United States, was used to determine land cover within municipal boundaries from one annexation period to the next. I overlaid municipal boundaries on NLCD and used zonal histogram to get a count of the number of cells of each land cover type within the boundary of interest. This data was used to determine the hectares of each land cover type within the boundary of interest. Graphs and tables were created in Microsoft Excel to show trends in the data.



Rock Hill, South Carolina

Rock Hill, South Carolina is the fifth largest city in the state and is located in York County, the upstate of South Carolina. According to the US Census Bureau 2015 estimate, the population is 71,548 people. It is a part of the piedmont region in the foothills of the Appalachian mountain. Rolling hills, forest, and streams dominate the natural landscape.

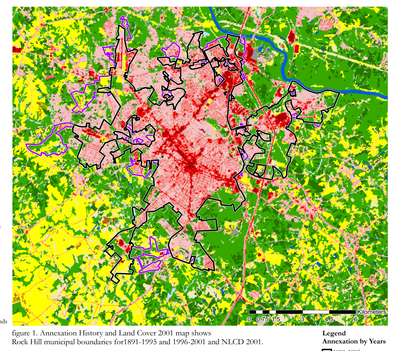


figure 1. Annexation History and Land Cover 2001 map shows Rock Hill municipal boundaries for1891-1995 and 1996-2001 and NLCD 2001.

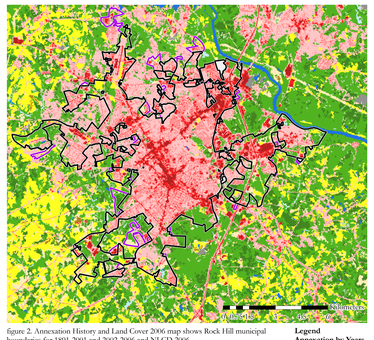


figure 2. Annexation History and Land Cover 2006 map shows Rock Hill municipal boundaries for 1891-2001 and 2002-2006 and NLCD 2006.

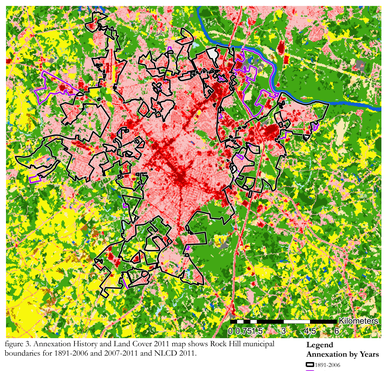


figure 3. Annexation History and Land Cover 2011 map shows Rock Hill municipal boundaries for 1891-2006 and 2007-2011 and NLCD 2011.

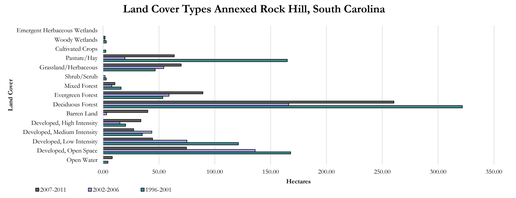


figure 4. Land Cover Types Annexed Rock Hill, South Carolina graph shows the total number of hectares of each land cover type annexed during each of the three annexation periods studied. Pasture/Hay, Grassland/Herbaceous, Evergreen Forest, Deciduous Forest, and Developed land dominated the annexation landscape.

Total Land Cover Change Rock Hill, South Carolina 1996-2011

Land Cover	1891-1995 (ha)	2001 (ha)	1996-2001 Change (ha)	2006 (ha)	2002-2006 Change (ha)	2011 (ha)	2007-2011 Change (ha)
Open Water	11.25	13.66	4.41	10.71	-4.95	18.54	7.83
Developed, Open Space	2280.69	2448.63	167.94	2650.23	210.60	2715.84	56.61
Developed, Low Intensity	2055.15	2176.58	121.23	2386.35	209.77	2446.56	60.21
Developed, Medium Intensity	731.59	786.78	55.19	970.38	183.60	1052.10	81.72
Developed, High Intensity	380.79	401.04	20.25	439.18	38.14	508.55	69.37
Barren Land	1.08	1.08	0.00	9.81	8.73	53.46	43.65
Deciduous Forest	1005.66	1327.41	321.75	1535.80	208.39	1535.13	0.67
Evergreen Forest	283.56	295.82	53.46	295.20	-1.62	360.00	64.80
Mixed Forest	58.14	74.34	16.20	65.34	-9.00	73.17	7.83
Shrub/Scrub	9.00	11.97	2.97	17.82	5.85	46.89	29.07
Grassland/Herbaceous	161.19	207.90	46.71	253.26	45.36	297.18	43.92
Pasture/Hay	241.11	406.17	165.06	369.60	-105.57	358.74	58.14
Cultivated Crops	2.16	4.68	2.52	0.00	-4.68	0.00	0.00
Woody Wetlands	26.19	28.98	2.79	29.16	0.18	30.87	1.71
Emergent Herbaceous Wetlands	0.45	0.45	0.00	0.54	0.09	0.54	0.00

table 1.Total Land Cover Change Rock Hill 1996-2011 table shows total hectares of each land cover type at the end of each annexation interval studied. Land cover change is the difference between hectares of land cover from two adjacent time intervals.

Greenville, South Carolina

Greenville, South Carolina is the sixth largest city in the state and is located in Greenville County, the upstate of South Carolina. According to the US Census Bureau 2015 estimate, the population is 64,579 people. It is a part of the piedmont region in the foothills of the Appalachian mountain. Rolling hills, forest, and streams dominate the natural landscape.

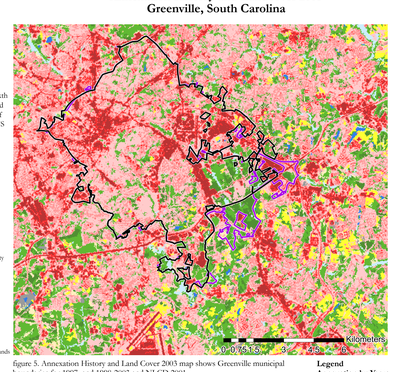


figure 5. Annexation History and Land Cover 2003 map shows Greenville municipal boundaries for 1997 and 1998-2003 and NLCD 2001.

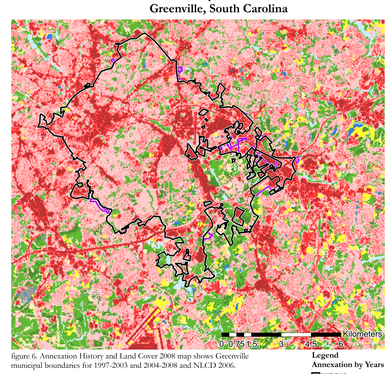


figure 6. Annexation History and Land Cover 2008 map shows Greenville municipal boundaries for 1997-2003 and 2004-2008 and NLCD 2006.

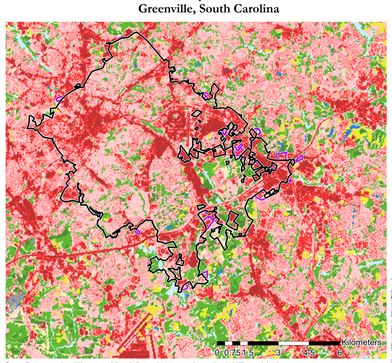


figure 7. Annexation History and Land Cover 2001 map shows Rock Hill municipal boundaries for 1997-2008 and 2009-2013 and NLCD 2011.

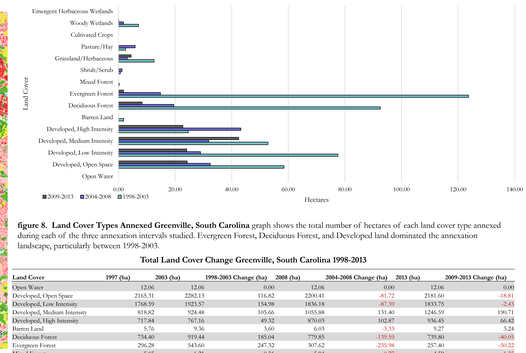


figure 8. Land Cover Types Annexed Greenville, South Carolina graph shows the total number of hectares of each land cover type annexed during each of the three annexation intervals studied. Evergreen Forest, Deciduous Forest, and Developed land dominated the annexation landscape, particularly between 1998-2003.

Total Land Cover Change Greenville, South Carolina 1998-2013

Land Cover	1997 (ha)	2003 (ha)	1998-2003 Change (ha)	2008 (ha)	2004-2008 Change (ha)	2013 (ha)	2009-2013 Change (ha)
Open Water	12.06	12.06	0.00	12.06	0.00	12.06	0.00
Developed, Open Space	2163.51	2282.13	116.62	2289.41	-81.72	2381.60	-18.81
Developed, Low Intensity	1768.59	1923.57	154.98	1856.18	-87.39	1833.75	-2.43
Developed, Medium Intensity	818.82	924.48	105.66	1055.88	131.40	1246.59	190.71
Developed, High Intensity	717.84	767.16	49.32	870.03	102.87	936.45	66.42
Barren Land	5.76	9.36	3.60	6.03	-3.33	9.27	3.24
Deciduous Forest	734.40	919.44	185.04	779.85	-139.59	750.80	-40.05
Evergreen Forest	296.28	543.60	247.32	307.62	-235.98	257.40	-50.22
Mixed Forest	5.85	6.21	0.36	5.94	-0.27	4.59	-1.35
Shrub/Scrub	4.68	5.94	1.26	40.68	34.74	33.03	-7.65
Grassland/Herbaceous	28.08	53.10	25.02	74.61	21.51	77.40	2.79
Pasture/Hay	63.36	66.69	3.04	56.79	-9.81	44.10	-12.69
Cultivated Crops	0.00	0.00	0.00	0	0.00	0.00	0.00
Woody Wetlands	62.55	76.59	14.04	72.54	-4.05	70.20	-2.34
Emergent Herbaceous Wetlands	0.00	0.00	0.00	0	0.00	0.45	0.45

table 2.Total Land Cover Change Greenville, South Carolina 1998-2013 table shows total hectares of each land cover type at the end of each annexation time interval studied. Land cover change is the difference between hectares of land cover from two adjacent time intervals.

Discussion

Between 1996-2011, Rock Hill annexed 1365.93 ha of land. Forested land was the most annexed, accounting for 45.89%. Deciduous Forest accounted for 33.64%, Evergreen Forest 10.9%, and Mixed Forest 1.35%. Developed land accounted for 34.35% of total land annexed. There was a small loss of 11.61 ha and 1.62 ha of deciduous and evergreen forest respectively between 2001-2006, which was rectified between 2007-2011, with the addition of 219.33 ha and 64.80 ha. Grassland/Herbaceous and Pasture/Hay land cover came in next, accounting for 9.46% and 6.14% respectively.

Between 1998-2013, the city of Greenville annexed 764.73 ha of land. Developed land was the most annexed, accounting for 60.56%. Developed, Open Space accounted for 15.04% Developed, Low Intensity 17.06%, Developed, Medium Intensity 16.62%, and Developed, High Intensity 11.84%. Contrast to Rock Hill for which developed land accounted for 34.35% of annexed land. Between 1998-2003, the addition of 123.66 ha of Evergreen Forest and 92.52 ha of Deciduous Forest dominated the land cover annexed for that interval. However, forested land made up only 34.08% of land cover annexed. Between 2009-2013, Greenville lost 18.81 ha and 2.43 ha of Developed, Open Space, and Developed, Low Intensity land cover respectively, but made gains in Medium and High intensity development. During the 2004-2008 and 2009-2013 annexation intervals, Greenville saw a the most reduction of natural land covers. Overall, there was a greater reduction in natural land cover within the municipal boundary of Greenville (5.97%) than Rock Hill (0.18%).

Several factors may explain the differences between Greenville and Rock Hill. First, different planning strategies and expected types of growth (i.e., commercial, residential, agriculture) could influence the types land cover the city approves or targets to annex. Secondly, the types of land cover annexed may be a reflection of the land cover surrounding the two cities. Rock Hill is surrounded by a larger amount of natural land cover than Greenville, which is urbanized well outside of the municipal boundary. Third, property owners of certain types of land may use their own judgement to determine that annexation would benefit them.

Because so much of the land surrounding Greenville proper is already developed, further annexation will likely continue to add a greater proportion of developed land cover to natural land cover to the city. This is an important consideration in city planning and making the city somewhere were people and businesses want to be. Without having jurisdiction over surrounding land and with the depletion of undeveloped land cover surrounding a municipal area, municipalities tend to create more urban open spaces and recreational areas within municipal boundaries (Kim et. Al, 2016). This may be the case for Greenville, but the current scope of the study shows that there was still a large loss of natural land cover, suggesting that existing natural land cover is being developed without being replaced. Additionally, the city actually lost 100.53 ha of Developed, Open Space that includes areas such as parks, golf courses, aesthetic and recreational plantings, and residential plantings. Rock Hill on the other hand saw a gain of 267.21 ha. It was also the largest category within developed land to be annexed, at 224.91 ha. Over time, the creation of parks and greenspaces could alter the balance of developed versus natural land cover types depending on the long term plans of the cities and annexation strategies.

As Rock Hill continues to annex, it will likely continue to decrease the amount of natural land cover *surrounding* it with future annexation. However, with a greater amount of undeveloped, natural land cover, Rock Hill may be in a better position to work natural land cover preservation into the city development plan.

Implications Further Research

Implications

- Land cover change in cities may vary from region to region due to the ease of annexation, types of land cover available outside the city limits, political, cultural, and historical factors.
- Areas surrounding Greenville proper have experienced significant urbanization.
- Annexation may be a useful strategy to preserve natural land cover where available.
- Cities with limited undeveloped land may need to create natural open spaces for recreational use, habitat, or pollution mitigation.

Greenville and Rock Hill Annexation Comparison

Data	Greenville 1998-2013	Rock Hill 1996-2011
Total Land After All Annexation Periods	7446.69 ha	26461.26 ha
Total Land Annexed	764.73 ha	1365.93 ha
Most Annexed Landcover	Developed (Open, Low, Medium, and High Intensity)	Forest (Deciduous, Evergreen, Mixed)
Net Loss of Natural Land Cover through Conversion	(-) 444.60 ha	(-) 48.60 ha
Net Gain of Developed Land Cover through Annexation and Conversion	301.05 ha	1306.53 ha

Questions for further research:

- Do cities that are able to grow more with annexation have a different pattern of total land cover change?
- Investigate trends in Charleston and Columbia, South Carolina.
- Do cities that annex more annex different types of land cover?
- Does the development of new parks and greenspaces within cities increase overtime, slowing down land cover change from natural to developed within municipal boundaries?
- Is there a relationship between amount of annexation and creation of greenspaces?
- How does land cover change differ with different annexation types (owner petition, elector, ordinance etc)?
- Do cities in different geographical regions with different surrounding land cover show different patterns of land cover change?

References and Data Sources

Data

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United States Counties Tiger Line shapefile: United States Census Bureau, https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2016&layergroup=Counties+%28and+equivalent%29

Historical Annexation History of Rock Hill shapefile, SC: Shawn Carson, IT/GIS Manager Information Technology Services City of Rock Hill, shawn.carson@cityofrockhill.com

Municipal Boundaries Greenville, SC shapefile: Greenville County

Maps

Projected coordinate system: NAD_1983_StatePlane_South_Carolina_FIPS_3900

Projection: Lambert Conformal Conic

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Acknowledgments

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