A GIS Assessment of Urban Sprawl in Richmond, Virginia

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(ABSTRACT)

In the United States, the urban sprawl debate has closely paralleled urban growth trends over the past few decades. Many studies indicate that it is the pattern, density, and rate of new urban growth that create the appearance of sprawl. Population dynamics are often cited as a driving force behind urban sprawl. This thesis uses Geographic Information Systems (GIS) mapping and land cover change analysis, neighborhood statistics, community surveying, key-informant interviews with planners and developers, and planning documents to measure sprawl. The study area includes the jurisdictions that comprise the Metropolitan Statistical Area (MSA) of Richmond (The City of Richmond, Chesterfield County, Hanover County, and Henrico County). Urban land cover increased by one-fourth, from approximately 559 square kilometers to approximately 746 square kilometers from 1992 to 2001. Over the nine year time period, population within The City of Richmond decreased from 203,056 in 1990 to 197,790 in 2000, while Chesterfield, Henrico, and Hanover Counties increased in population from 1990 to 2001.

Until the early part of the 20th century, cities in the United States experienced dramatic densification as industry set up shop in the city and workers flocked there in large numbers to claim jobs. As population grew and technology became more advanced, many people left rural farming areas to settle near industrialized urban core areas. This allowed the population to earn more money and with the introduction of cheap transportation in the form of the automobile, suburbanization began to take place. With more cars came the need for more roads. With more roads came more opportunities for people and employment to move away from the city into rural areas, thereby setting up communities which some refer to as sprawling developments. GIS maps suburbanization in the form of urban land cover, transportation networks, and population densities within and outside core urban areas over any given time period in order to assess trends in urban growth.

This study analyzes urban land cover data as well as interviews with local developers and planning documentation to understand development trends in Richmond from 1992 to 2001. These dates reflect the availability of National Land Cover Data (NLCD), which I reclassified in the GIS to show only those classes that represent urbanized land. I then compared the two years to show the level of urban growth over the nine year time period. Next, I analyze patterns of urban expansion by using mapping capabilities within the GIS and neighborhood statistics in order to show the density and connectivity of patches of new growth. Based on the density and connectivity of new growth areas, I classify patterns as one of three types of sprawl: linear along highways, cluster, and leapfrog. My threshold densities are; 0 to 400 30 meter pixels per square kilometer for low density, 401 to 700 for medium density, and 701 to 1200 for high density. I also interviewed local developers and planners to gauge their opinions on the issue of urban sprawl versus urban growth. Developers do not see themselves as

contributors to sprawl while planners see their roles as buffers between unfettered growth and market forces. The results indicate that the Richmond MSA did experience an increase in urban land from 1992 to 2001 and that urban growth in the study area can be classified as urban sprawl with the use of GIS mapping, neighborhood statistics, and analysis of jurisdictional planning documentation coupled with interviews with developers, land owners, and local planners. The density of new development is greatest in Henrico and Chesterfield, but the pattern and character with which development has occurred in Hanover is synonymous with sprawl. Sprawl is also facilitated by inexpensive land with available infrastructure (water, sewer lines).

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"Have I not commanded you?
Be strong and courageous.
Do not be terrified;
do not be discouraged, for
the Lord your God will be with you
wherever you go."
Joshua 1:9

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And now these three remain:
faith, hope and love.
But the greatest of these is
Love.
1 Corinthians 13:13

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Chapter 1: Introduction

The Urban Sprawl Debate

As urban development takes place within U.S. cities and around their fringes, urban sprawl or the lack thereof will continue to be a byproduct of development practices and policies. Population increases and the consequences of unplanned urbanization are directly related to recent growth management practices that seek to influence the way in which built-up land can proliferate. The pattern, density, and rate at which built-up land develops are the basis for one contemporary debate: urban sprawl versus urban growth. As a contemporary planning issue, the debate over sprawl is framed by different disciplines and their understanding of how and why urban areas grow. Although urban sprawl is a type of urban growth, sprawl is dependent on the way in which development occurs.

Issues related to Urban Sprawl

Sprawl has been criticized for eliminating agricultural lands, spoiling water quality, and causing air pollution (Allen et al 2003). As population increases, so does the need for new housing, schools, and transportation networks. In the urban world today, industrial, commercial, and residential districts are markedly different from years past. Decentralization is a trend indicative of urban sprawl and present day industrial, commercial, and residential areas are no longer necessarily a part of the urban core (Nechyba et al 2004). Rather, these types of development are often found in low-density areas that are separated from the major urban area by large tracts of homogeneous land. Hence, the needs for larger transportation networks and in turn a greater dependency on

automobiles, which produce more air pollution. As new roads are put in place, precious farmland is often left unprotected from commercial or residential developers (Hathout 2002). The greater the imperviousness of an area the more water runoff one can expect, which is the catapult for water pollution (Wilson et al 2003). Without regulations on urban growth, consequences of urban sprawl are likely to continue.

Visualizing Urban Sprawl

Before the introduction of Geographic Information Systems, mapping any phenomenon took an extremely long time. Maps produced through manual cartography for comparison were planned well in advance of a due date. Computer aided maps without GIS were very rudimentary and were not very aesthetically pleasing to say the least. The availability of different types of spatial data allows a GIS user to map virtually any phenomena with a geographic dimension applied to it. In addition, large amounts of data are processed before the creation of a map with much less work than with manual cartographic techniques. With a GIS, maps can be compared in a fraction of the time and can be done at variable scales with ease.

The use of Geographic Information Systems modeling has become quite prevalent within the field of urban sprawl research. Some research on urban sprawl uses GIS as a tool in understanding the effects of urban sprawl on the natural environment. GIS reveals spatial patterns of urban sprawl by measuring distances of new urban growth areas from town centers and roads for example (Gar-On Yeh et al 2001). Because urban development is irreversible, GIS simulates future land development (Lee et al 1998). A Geographic Information System is a decision support system that can facilitate urban planning.

Because there is a lack of a universal definition of urban sprawl, a map of urban or built land is an adequate starting point in studying urbanization. A map provides the visual aspect from which studies on urban sprawl can begin in relation to urban growth. A Geographic Information System is useful for mapping the spatial distribution of urban areas. Unlike traditional cartographic methods, GIS allows for the manipulation of different types of data in one map frame. Mapping urban phenomena is a crucial part of quantifying urban sprawl. While many layers of data are used to create a map of urban growth, ultimately it is the map that tells the story about the level of urban sprawl over a given landscape. This type of mapping involves a temporal signature in which two or more time periods are used for comparing amounts of urbanization. One base map shows urban or built-up land in a starting year and another map shows the developed land from the end year. Therefore, mapping the extent of urbanization over a given period of time is an essential part of understanding urban sprawl.

The Distinction between Growth and Sprawl

As urban growth occurs, that growth is often confused with urban sprawl. However, there is a distinction between urban growth and urban sprawl. Cities often experience growth either physically, by population, or by a combination of both. Urban sprawl is much more complicated because it may or may not qualify as urban growth. How a city grows can create the appearance of sprawl. Such urban growth may appear as a low-density leapfrog pattern, a linear or strip development pattern along highways, or a tightly condensed pattern of new development around pre-existing built-up landscapes (Nechyba et al 2004). Without urban growth there would be no appearance of urban sprawl.

The patterns represented by sprawling landscapes are aligned with the definition of the word sprawl. If I lay out on the floor in an awkward way, I am sprawling out. This idea coupled with urban development gives a good visualization of what urban sprawl may look like. A formal entry reads this way: "**Sprawl** *v*. sit or spread out in a relaxed or awkward way - *n*. sprawling position" (Goldman, 1993, p. 279). This definition coupled with the phrase urban growth is one example of the difference between simple growth and urban sprawl. Urban growth may have more of a planned appearance while the pattern of sprawl often appears awkward, uncontrolled, and haphazard. Perhaps there is a new development very similar to an urban landscape in the middle of a seemingly rural area broken up by many other rural landscapes such as farmland or forested areas. Perhaps the timing of this development closely follows the completion of a new road network or major highway.

The debate over urban sprawl is relatively new, yet there are many definitions of urban sprawl. This is due in large part because there is no consensus on what sprawl is and what is simply urban growth. Despite vivid examples of what some may classify as sprawl over a given landscape, there is no clear definition of urban sprawl that is shared by all who study urban phenomena. There are definitions based on characteristics of urban sprawl, effects of urban sprawl, and factors leading to urban sprawl. Further, definitions of urban sprawl are also influenced by the people that create them. Many definitions of urban sprawl may include bias towards being pro or con urban development.

It is important to note a few of the definitions from different time periods. Here I will present those definitions in a chronological manner in order to show a progression in

the concept of urban sprawl. Ottensmann (1977, 389) defines urban sprawl as "the scattering of new developments on isolated tracts, separated from other areas by vacant land." Ewing (1997, 108) characterizes urban sprawl as "leapfrog land use patterns, strip commercial development along highways, and very low-density single-use developments." Zhang (2001, 221) states that "urban sprawl results from poorly planned, large scale new residential, commercial and industrial developments in areas previously not used for urban purposes."

For the purposes of my research, I will use a combination of all of the previous three definitions in my conceptualization of urban sprawl. In operationalizing sprawl, I will use many of the techniques found in the literature review section of this paper. I will begin operationalization by isolating only urban land within the GIS for 1992 and 2001. I will incorporate road data at this point. Then, I will use neighborhood statistics to measure the density and connectivity of new patches of urban growth. After quantifying how dense and connected patches of new growth are, I will classify those new growth areas as one of three types of sprawl: linear along highways, cluster, or leapfrog. I will also incorporate responses to interview questions from developers, land owners, and local planners and analysis of planning documentation to gauge opinions and perceptions of sprawl as well as planning practices.

Study Area

Four jurisdictions constitute the study area: The City of Richmond, Hanover County, Henrico County, and Chesterfield County. I selected these entities because there is a great deal of variety among these jurisdictions concerning land cover, land use type, land area, and zoning practices for example. The City of Richmond has a population of

197,790 with an approximate population density of 1241 people per square kilometer. Logically, Richmond is roughly the center of the study area (Census Bureau, 2005). The greatest difference in land area and population density is between The City of Richmond and Hanover County (Table 1.1).

Table 1.1: Population Density and Land Area in Richmond and Adjacent Counties

	2000 Population	Population Density (people / km2)	Land Area (in km2)
Richmond City	197,790	1241	159.4
Chesterfield County	259,903	236	1103.3
Hanover County	86,320	71	1225.1
Henrico County	262,300	426	616.4

Data Source: United States Bureau of the Census (http://quickfacts.census.gov/qfd/states/51000.html)

Richmond is located in central Virginia at the fall line of the James River (Figure 1.1). Hanover and Henrico counties are located to the north of the city. Chesterfield County is located to the south of the city. The City of Richmond obtained that name in 1737 when it was laid out by Major William Mayo on land donated by William Byrd II. Richmond was settled in the 1740's on the fall line of the James River, a shallow and rocky section of the river (Moeser 2000). Consequently, ships could not navigate from the Chesapeake Bay up the James River any further than Richmond, which made the city a major center of exchange because people and goods had to switch from water transport to land transport and vice versa (Moeser 2000). Richmond did not become the capital until 1780 when it replaced Williamsburg. The City of Richmond also served as the capital of the Confederacy during the American Civil War until it was burned to the ground in 1865. Then the city was returned to Northern control and became part of "Military District # 1" during the reconstruction period from 1865-1870. Richmond was

rebuilt after the American Civil War and has been the Capital of Virginia ever since (Wikipedia The Free Encyclopedia 2005).

Throughout the 20th century, Richmond functioned as a regional distribution, commercial, and finance center due in large part to a deep water port, dense highway system, and extensive railway facilities (Home In Richmond, 2005). Phillip Morris, which is owned by Altria Group, is a staple tobacco industry in the region (Wikipedia The Free Encyclopedia 2005). Tobacco processing, food products, textiles and paper and chemical manufacturing are some of the key industries that The City of Richmond has to offer (Home In Richmond, 2005). While many of these industries clustered close to the city, the locations of many new jobs in Richmond have suburbanized, and this is central to my research. Suburban jobs are exploding as is the suburban population. Between 1994 and 1998, Henrico County and Chesterfield County added 24,075 jobs and 13,575 jobs, respectively while the City of Richmond lost 4,839 jobs (Moeser 2000).

There are many factors related to the attractiveness of the City of Richmond, Virginia. It has four distinct seasons including a relatively benign winter. Richmond, Virginia has a low tax base and is surrounded by plenty of undeveloped land. The metropolitan area is fairly centrally located by interstate between Charlottesville and Washington D.C., which provides options for school, work, and play. The city boasts some of the top schools in the state with Randolph Macon College, Virginia Commonwealth University, and The University of Richmond (Wikipedia The Free Encyclopedia 2005). These are the attributes that a growing metropolis needs to attract more people.

Sprawl City rates Richmond, Virginia as the 30th most sprawling metropolis out of 100 urbanized areas. Richmond has 158.1 square miles of sprawl (approximately 409.5 square kilometers) of sprawl. This statistic was derived from the U.S. Census Bureau's 1970 and 1990 reports on urbanized land areas. In addition, they found that 47% of the sprawl in Richmond is related to population growth (Table 1.2) while 53% is due to growth in per capita land consumption. The study also concludes that Richmond grew by 109% from 1970-1990.

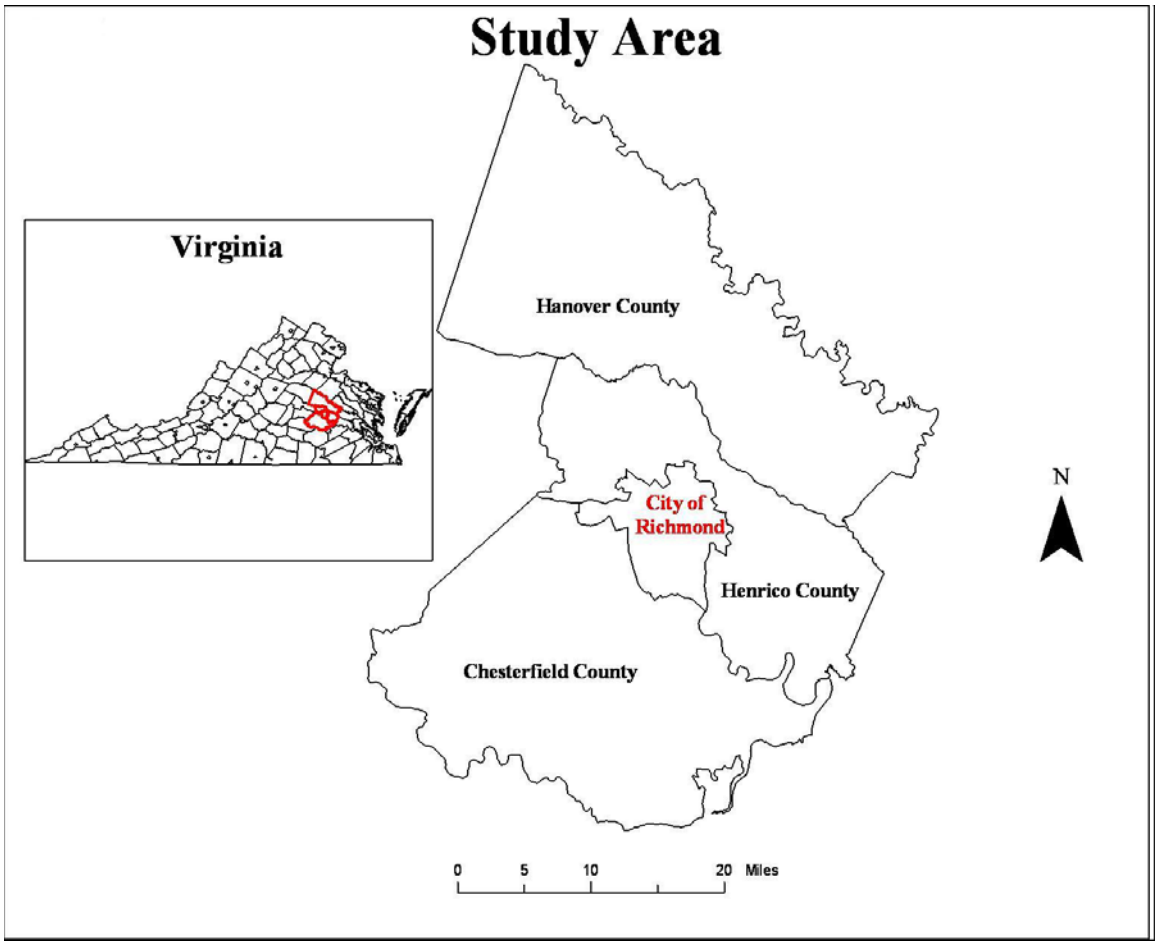

Figure 1.1: map showing study area
Data Source: U.S. Census TIGER Data

Table 1.2: Population Growth in Richmond and Adjacent Counties

	1990 Population	2000 Population	Percent change[1]
Richmond City	203,056	197,790	- 2.6 %
Chesterfield County	209,274	259,903	+ 19.5 %
Hanover County	63,306	86,320	+ 26.7 %
Henrico County	217,881	262,300	+ 16.9 %

Data Source: United States Bureau of the Census (http://quickfacts.census.gov/qfd/states/51000.html)

[1] Percent change calculated by the author

Purpose of Study

The purpose of this study is to use spatial and non-spatial approaches in measuring urban sprawl in the Richmond, Virginia area between two different time periods: 1992 and 2001. I selected the time between 1992 and 2001 because of the availability of data. A spatial modeling approach is one that employs GIS analysis techniques such as buffering and reclassification of data. Buffering refers to creating a zone wherein urbanization may occur along highways. Reclassification of the National Land Cover Data entails aggregating or eliminating the 21 classes of land cover into only those classes that represent urban or built-land. The specific land-cover categories that I use for this research are detailed in chapter three. A non-spatial modeling approach involves analysis of land use regulations, master plans, local land use policies and practices, and interviews with developers, land owners, and local planners. Four entities make up the study area: Richmond City, Chesterfield County, Hanover County, and Henrico County. These four jurisdictions constitute a contiguous "border" around Richmond and manifest a broad range of land uses and land cover as well as differences in land use policies and practices.

Research Questions

Two research questions guide this study. These questions are guided by two research objectives.

1) Has urban sprawl taken place in the study area based on characteristics of new urban growth?

The hypothesis behind this question is that urban sprawl has taken place within the study area based on an increase in the amount of urban or built-up land from 1992 to 2001.

Further, the pattern of new growth areas can be classified as urban sprawl based on spatial distribution, density, and connectivity of development between the period of time from 1992 to 2001.

2) Why have some areas within the study area seen growth while others have not? I hypothesize that the presence or absence of new urban growth within the study area is related to master plans, zoning practices and ordinances, and the availability of relatively inexpensive land for development.

Objectives

1) To measure urban sprawl within the study area based on urban land use change between 1992 and 2001 and assess patterns and densities of new urban growth thereby classifying those patterns as urban sprawl: linear or strip along highways, expansion or cluster, and leapfrog or relocation (Figure 2.1).

2) To understand why new urban growth has occurred in some areas and has not occurred in other areas based on examinations of land use regulations, land use policies, and jurisdictional master plans. I also based the results of this objective on interviews with local developers and planners.

Chapter 2: The Literature; Urban Sprawl and GIS

Urban Sprawl Conceptualized

Urban sprawl is often difficult to gauge because it can occur slowly over time. Wilson et al (2003) argue that without a universal definition of sprawl it is extremely difficult to model. Not all urban growth is considered sprawl because what is sprawl to some may not be to others. "Creating an urban growth model instead of an urban sprawl model allows us to quantify the amount of land that has changed to urban uses, and lets the user decide what he or she considers to be urban sprawl" (Wilson et al., 2003, 276).

Urban sprawl is characterized by leapfrog land use patterns, strip commercial development along highways, and very low-density single-use developments, all of which occur over a relatively short period of time (Ewing 1997). It has also been defined in terms of associated causes: urban sprawl is generally believed to result from poorly planned, large-scale new residential, commercial and industrial developments in areas not previously used for urban purposes (Zhang 2001). However, there is one overriding theme in the recognition of urban sprawl: a spatial-temporal signature unique to the phenomenon. Over the past 50 years the process of urbanization, suburbanization, counter-urbanization, and re-urbanization, has allowed for urban expansion into rural areas taking the form of low-density development, predominantly single family residential subdivisions and strip commercial development (Lee et al 1998).

> "The result of this development process is commonly called 'urban sprawl.' In this form, urbanization spreads outward in a haphazard pattern, consuming more

land than is necessary and creating excessive public costs for community facilities and services (Lee et al., 1998, 865).

Sprawl is urbanization that takes place in either a radial direction around a well-established city or linearly along the highways over a given period of time (Sudhira et al 2004). Clearly, radial and linear are just two types of map patterns that sprawl can take. Sudhira et al. (2004) state that to understand the complexity of urban sprawl, land use change analyses and urban growth pattern recognition must be determined. Throughout the literature, there is ambiguity on the difference between urban growth and urban sprawl except to suggest that urban sprawl is a type of urban growth (Figure 2.1).

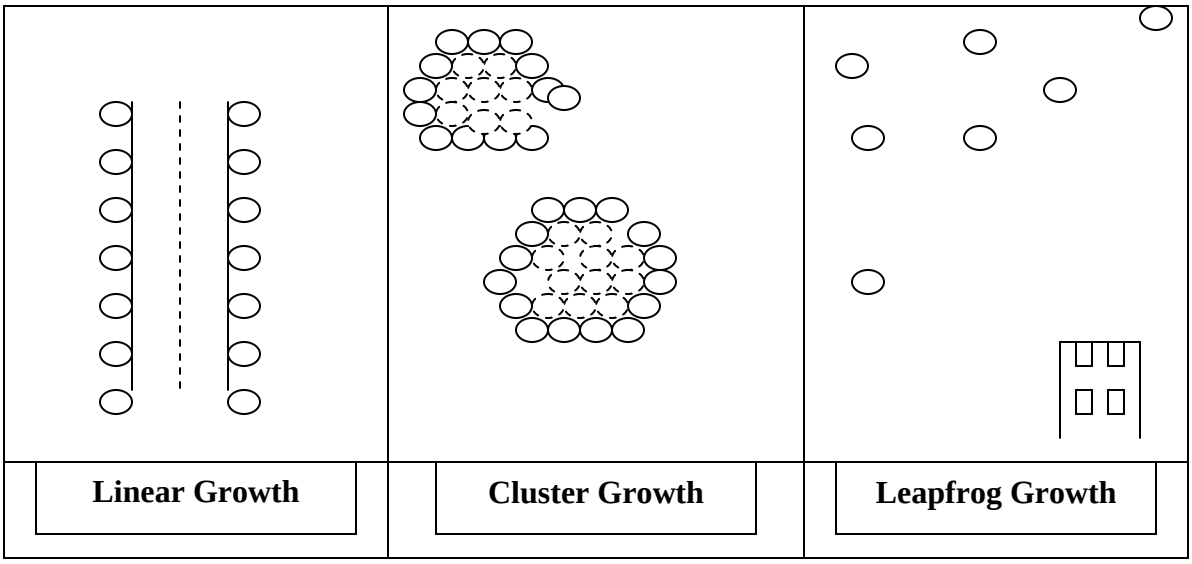

Figure 2.1: Types of Urban Growth
= Proposed New Urban Growth / Urban Sprawl

It is much more feasible to define sprawl after the formulation of necessary data into useable results. Examples of those results include spatial data such as National Land Cover Data along with a determination of the density and connectivity of new patches of growth.

The Justification for studying Urban Sprawl

Sudhira et al. (2004) state that understanding the patterns of urban sprawl can help with natural resource planning, natural resource utilization, and the provision of infrastructure facilities. Urban sprawl creates inefficient use of land, land resources, and large-scale encroachment on agricultural land (Gar-On Yeh et al 2001). The most pressing problem is the substantial loss of fertile agricultural land in many coastal cities because of short-term economic considerations (Gar-On Yeh et al 1998). Ewing (1997) argues that suburbanization as we know it is not the issue, but rather the wasteful form of development known as sprawl with which many critics have a problem. Nechyba et al (2004, 186) list a plethora of ills related to sprawl: the loss of open space, urban decay, unsightly strip mall developments, the loss of a sense of community, patchwork housing developments in the midst of agricultural land, increasing reliance on the automobile, the separation of residential and work locations, and the spreading of urbanized developments across the landscape.

> "Sprawl has become the metaphor of choice for the shortcomings of the suburbs and the frustrations of central cities (Galster et al., 2001, 681)."

Urban sprawl Operationalized

Urban sprawl is initially detected by gauging urban growth in many ways. Masek measures urban growth by using remote sensing and GIS to measure rates of urbanization (Masek et al 2000). Other studies have measured sprawl in terms of data layers within a GIS to detect patterns of urban sprawl (Clarke et al 1998). Wilson et al. (2003) not only measure change of an individual pixel, but also changes within a framework of a neighborhood of pixels. This technique is known as neighborhood statistics and is extremely useful in visualizing densities of new growth areas.

In modeling the complex nature of urbanization, it is often necessary to apply more than one technique to understand how to measure an increase in urban growth or urban sprawl. In South Carolina, Allen et al (2003) used an integrated approach to model urban sprawl in which aspects of three different techniques were employed to model urbanization. The first enlisted a logistic regression model to predict urban transition probabilities. Next, a relative probability model was used to test different growth scenarios. Later, they organized focus groups to help set growth scenarios.

While quantification of urban growth often involves a direct measurement of new built-up or urban land, it is also important to include qualitative information. A study done in the Chicago metropolitan region by Zhang (2001) found that social-economic factors were most important in attracting residents to a new development, potentially leading to urban sprawl. The discernment of qualitative data does not come from any single computer program because of the complexities of urbanization.

Clearly, there have been many ways to measure urban dynamics indicating that there are numerous avenues to reach a similar destination. Population growth can be a driving force behind urban sprawl.

> "If population growth is substantial enough to produce the required consumer market, "big box" commercial development often takes place. Seeking larger lots for stores, ample parking, easy access for multiple communities, and heavy commuting traffic, big-box developments locate on the outskirts rather than in the existing town commercial centers (Lindstrom et al., 2003, 11)."

A study done by Sprawl City, a non-profit organization that researches urbanization issues shows that there is a correlation between the amount of population growth and the consumption of land in what the United States Bureau of the Census calls urbanized areas (Sprawl City, 2005). Urbanized areas are comprised of the contiguous developed land of the central city and its suburbs (Sprawl City, 2005). In order to understand urban sprawl it is important to contemplate many different urban growth dynamics including population growth, land conversion practices, and market forces.

Methodological approaches to Sprawl

As the previous discussion shows, urban sprawl is difficult to measure because it is difficult to define. Further, definitions and ideas about urban sprawl abound and are largely shaped by contributions of many different disciplines and their ideas about urbanization. A starting point for much of the research on urban sprawl is measurement and understanding urban growth processes. Assuming that all urban sprawl comes from urban growth, there is an obvious connection between the two.

Much of the quantitative research on urban sprawl begins with measurements of urban growth over a given time period. Gar-OnYeh et al. (2001) measure the urban form of an area to examine a change in shape, size, and configuration of the built-up environment. They use Shannon's entropy, which measures the degree of spatial concentration or dispersion of a geographic variable, coupled with a GIS and remote sensing technology to calculate sprawl. This type of research keys in on aspects of sprawl such as density, connectivity, and location of new urbanization.

There is also an inherent variable of time that must be incorporated into these studies to account for rates of growth, which is a key component of sprawl. Allen et al. (2003) calibrated their model of urban growth with data from 1973, 1975, 1981, 1985, 1989, and 1994 in order to predict growth scenarios up to the year 2030. The researchers used a logistic regression technique to generate probabilities that parcels of land would be converted to urban land use based on land suitability (Allen et al 2003). By using remote sensing and GIS to examine different urbanization scenarios for different years, Allen et al. (2003) predicted the degree of urbanization over the next 20 to 30 years.

These approaches although useful do not consider the underlying social processes that generate urban sprawl. Zhang (2001) examined local and regional factors related to urban sprawl such as federal policy on mortgage interest taxation and public spending, community location, transportation accessibility, and community features of a neighborhood. A great deal of Zhang's (2001) data came from local zoning ordinances and interviews with local government planners, which provided information on land use regulations. Zhang (2001) also examined transportation conditions and educational quality indicators to further gauge the attraction of a community to new development.

The Use of GIS in Urban Sprawl Research

The complexity of urban systems makes it difficult to adequately address their changes using a model based on a single approach (Allen et al., 2003, 1). Therefore, it is ideal to use a tool such as a GIS as part of research on urban sprawl because of its capacity to handle many different types of spatial data. In South Carolina, a GIS-based integrated approach to modeling and prediction of urban growth in terms of land use change was employed to meet the challenge of studying urban sprawl (Allen et al 2003). The researchers used satellite imagery incorporated into a GIS to map predictions of urban growth in the study area. The predictions were based on variables such as road density, forest, slope of the land, and population density. Each variable was entered into the system as a data layer and multiplied by a coefficient to determine how likely it was that a given parcel of land would be converted to urban land use (Allen et al 2003).

In East and West St. Paul, Winnipeg, Manitoba, Canada, most urban sprawl was occurring on prime agricultural land (Hathout 2002). In that study, a GIS was used to predict future growth patterns and the impacts that such growth would have on

agricultural land (Hathout 2002). Hathout (2002) used the data base analysis capabilities found in a GIS to analyze aerial photographs of the study area from 1960 and 1989 to determine impacts on agricultural land. For that study, land use derived from the aerial photographs in the GIS was placed in one of three main categories: urban, agricultural, and other (Hathout 2002).

A study conducted on the Washington-Baltimore CMSA used a cellular automata model combined with historical maps in a GIS to determine where future development may occur (Clarke et al 1998). The cellular automata model assumes an action within a given space, viewed in this case through a GIS grid, a set of initial conditions, and a set of behavior rules (Clarke et al 1998). GIS grid data layers were incorporated into IDRISI, GIS software, and iterations were performed to show different growth scenarios given different behavior rules (Clarke et al 1998). The same study was also able to use the GIS to produce maps of different growth scenarios, which allowed visualization of the results. A GIS will not only allow for powerful visualization of urban sprawl within the study area by providing maps, but it will also allow for an in depth analysis of the data by providing the capability to examine all of the data in one system therefore facilitating the measurement of urban sprawl.

A GIS is also an extremely powerful tool for creating new data from existing data and is often referred to as a decision support system (Burrough et al 1998). In China, A GIS was used as a decision support system to test different development scenarios and land consumption parameters for use by planners and local government officials (Gar-On Yeh et al 1998). Using the neighborhood function in the GIS, Gar-On Yeh et al. (1998) were able to test development scenarios that would reduce the fragmentation of new

growth, a component of urban sprawl (Gar-On Yeh et al 1998). In another study by the same authors, it was concluded that Landsat TM images coupled with an entropy integrated GIS was successful in measuring and monitoring urban sprawl patterns when the area is large and land use changes quickly (Gar-On Yeh et al 2001). Gar-On Yeh et al. (1998) employed a Shannon's entropy technique with the integration of remote sensing and GIS. Shannon's entropy is another landscape metric calculation technique whereby the authors measured urban sprawl patterns statistically based on the spatial variation and temporal changes of growth areas (Gar-On Yeh et al 1998). A numeric value was given to the new growth areas to quantitatively describe how dense and connected growth areas were (Gar-On Yeh et al 1998).

The methods used to quantify urban sprawl throughout the literature are dependent on the intended purpose and the individual aim of each piece of research. The objective of the research conducted on the Washington-Baltimore CMSA was to relate observed changes in land cover to economic and demographic drivers of that change (Masek et al., 2000, 3474). They used historic and present-day satellite imagery to measure land use change, but it was unclear how the researchers were going to link those changes to economic and demographic data. The purpose of the study was to quantify and map urban growth thereby determining the geographic extent, pattern, and class of such growth over time. The researchers categorized satellite-derived imagery into three classes: developed, non-developed, and water. Then, a window technique was used within a GIS to analyze each pixel according to its neighboring pixels. The value of each pixel was added up and attributed to the center cell of the window each time it passed

over the study area. This is an extremely effect method to measure urban growth patterns over time and therefore classify that growth as urban sprawl.

> "The model can be used to describe the urbanization processes in a way that offers insight into changing and emerging landscape patterns, without applying subjective labels (Wilson et al., 2003, 284)."

As Wilson et al. (2003, 275) show, urban sprawl has been cited for its negative impacts on the environment, but with no clear definition of urban sprawl, it is difficult to measure.

Global trends in Urban Sprawl

As population increases, urban sprawl on a global scale is becoming more apparent than ever. Increases in population often lead to increases in development, which has a direct influence on agricultural land conversion. Masser (2000) states that urban growth is inevitable over the next two decades and that most of this growth will take place in less developed countries. In China, rapid land use change has occurred since economic reform (Gar-On Yeh et al 1998). A study done there measures urban sprawl in terms of land suitability and the favorability that land has for being converted to an urban use (Gar-On Yeh et al 1998). The authors were interested in developing a model that could be used for sustainability purposes in an attempt to control urban sprawl under rapid rural urbanization (Gar-On Yeh et al 1998).

> "This is most severe in southern China and the coastal areas where the economy is developing very rapidly and the conflict between the environment and economic development is most severe (Gar-On Yeh et al., 1998, 169-170)."

In Dongguan, a fast growing city in southern China, the conversion of agricultural land into urban land has removed the possibility for food production forever (Gar-On Yeh et al 1998).

Southern China is not the only place where patterns of urban sprawl are materializing due to sharp increases in population and the creation of new infrastructure. In other developing countries like India, where the population is over one billion, one-sixth of the world's population, urban sprawl is taking its toll on natural resources (Sudhira et al 2004). The study area of Mangalore, India is a national leader in banking, private entrepreneurship, insurance and other financial institutions (Sudhira et al 2004). Mangalore, India has also seen an increase in the amount of industrialization in the form of Iron Ore Pelletization Units, Fertilizer, Refinery, and Petro-chemicals with the economy also fortified by agricultural processing and port related activities (Sudhira et al 2004). Over 25% of India's population lives in urban centers and it is projected that about 33% of the population will be living in urban centers in the next 15 years (Sudhira et al 2004).

> "This indicates the alarming rate of urbanization and the extent of sprawl that could take place. In order to understand this increasing rate of urban sprawl, an attempt is made to understand the sprawl dynamics and evolve appropriate management strategies that could aid in the region's sustainable development (Sudhira et al., 2004, 29)."

The approach to the Sudhira (2004) study is to use change at the landscape level within a Geographic Information System to calculate the fragmentation and patch density of new

growth areas and classify those areas as sprawl. While many models seek to achieve this goal, they do not relate urban sprawl to anything more than urban growth.

> "The inadequacy in some of these is that the models fail to interact with the causal factors driving the sprawl such as population growth, availability of land and proximity to city centres and highways (Sudhira et al., 2004, 30)."

Sudhira et al (2004) use GIS, remote sensing, and landscape metric techniques to quantify urban sprawl by measuring densities and spatial distributions of built-up land. Using landscape metrics that show densities of urban land and connectivity of that land, the authors are able to justifiably classify different types of urban sprawl: cluster, leapfrog, and linear (Sudhira et al 2004). More dense and compact areas of built-up land are classified as cluster, while medium density areas with low connectivity areas are indicative of leapfrog patterns. The linear pattern of sprawl is classified as high and medium density built-up areas of development located along the highways (Sudhira et al 2004). This technique for quantifying urban sprawl is extremely adequate based on the assumption that it is the pattern and spatial distribution of urbanization that is the key component to urban sprawl.

National Trends in Urban Sprawl

Urban sprawl is an issue that many cities across the United States face as urban areas continue to grow. A case in point is the Washington-Baltimore Consolidated Metropolitan Statistical Area (CMSA), which has seen tremendous population increases over the past two or three decades. From 1970 to 1994, the Washington-Baltimore CMSA grew in population from 3 million to 4.5 million (Masek et al 2000). They found

it critically important to link observed changes in land cover to driving socio-economic or environmental changes (Masek et al 2000). They used remote sensing techniques to observe changes in land cover and integrated that data with data from the United States Bureau of the Census in a GIS. Masek et al. (2000) found that in Northern Virginia, development followed road networks and allowed for diffuse development brought on by liberal zoning and lower taxes, which are key drivers behind urban sprawl.

Since the 1930's urban areas in the United States have expanded into the suburban fringe (Lee et al 1998). In the New York-New Jersey-Connecticut tri-state region, two generations of decentralized growth have dramatically expanded the amount of urban land by 60% despite only a 13% increase in population over the last 30 years (Esnard et al 2002). While Richmond, Virginia is ranked 30 out of 100 cities in terms of urban sprawl, Atlanta, Georgia is ranked number one out of 100 cities with 701.7 square miles of sprawl and both cities have experienced population growth in the surrounding counties (Sprawl City 2004). Lee et al. (1998) argue that as urbanization proliferates, the issue is not really sprawl versus compact development forms, but whether urban growth should be planned more efficiently by way of growth management policies.

In Michigan, green space is being converted at a rate seven times greater than was formerly the case and potentially contaminated land is being redeveloped as rapid growth regions form around large metropolitan areas. This growth pattern has lead to the phenomenon of urban sprawl over the past several years (Thomas 2002). The value of redeveloping brownfields has become an undependable deterrent to urban sprawl (Thomas 2002). Brownfields are defined as abandoned, idle, or under-used industrial and commercial properties where expansion or redevelopment is complicated by real or

perceived environmental contamination (US Environmental Protection Agency 1997). However, in Michigan, local governments are recognizing brownfields as important assets in realizing the goal of urban revitalization (Thomas 2002). There is now legislation in Michigan that provides economic and legal incentives for local governments and prospective developers who are willing to redevelop brownfields instead of farmland and open space. Thomas concedes that brownfield redevelopment is now seen as a sustainable land use strategy (2002).

In his book *The Limitless City*, Gillham states that metropolitan regions like Los Angeles-Riverside-Orange County do not have a single dominant city center but are polycentric (Gillham 2002). “Just as Manhattan is vertical, the new metropolitan region is flattened out beyond the horizon (Gillham., 2002, 19).” For Gillham, this pattern of urbanization is an indication of sprawl and is reflected in the book's opening statement about a view from a jet plane window:

> "Huge expressways snake out over the land, generating a wide, loosely formed network across the world below. The system is punctuated at predetermined intervals by interchanges in cloverleaf, diamond, and other geometric forms that connect to a secondary network of arterial roadways lined with glittering commercial buildings. These, in turn, lead to a winding labyrinth of neighborhood roads, a web of caterpillars connecting to the individual housing cells that make up most of the landscape below-a landscape stretching beyond the horizon (2002, xiii)."

As Gillham sees it, zoning or lack there of cannot be blamed too much for sprawling development. Rather, Gillham (2002) notes places like Nantucket or

Beacon Hill in Massachusetts have zoning bylaws and other regulations that work to protect their historic character and require that new development fit into an existing pattern. Gillham also notes that a sprawling city such as Houston, Texas without zoning could have been built like Manhattan, Colonial Williamsburg, or even a medieval Italian hill town, but it did not turn out that way (2002). "Even without zoning, Houston exhibits many of the sprawl characteristics of other metropolitan areas (Gillham., 2002, 17)." Further, Gillham says that regulations, standards, and practices largely determine the shape, size, and configuration of the land subdivisions, houses, cul-de-sacs, parking lots, and strip commercial buildings that make up our sprawling suburbs (2002, 23). Attitudes that Americans have about their right to land ownership combined with market forces and a large industry in real estate and construction are preconditions to sprawl and these conditions have been the same for much of America's urbanization (Gillham., 2002, 23). It is therefore important to acknowledge the ubiquity of influences on the debate over urban sprawl in the United States.

Summing up, the various definitions of sprawl indicate that the term is most often used as a noun (Galster et al 2001). Sprawl describes conditions and patterns of development characteristic of an urban area or part of that urban area over a period of time (Galster et al 2001). The given definitions suggest that there can be different levels and types of sprawl and that sprawl can be viewed as a process because of the inclusion of time (Galster et al 2001). The advantage that GIS offers to sprawl research is the capability to visually assess and quantify defined sprawl patterns. The research discussed thus far used techniques such as landscape metrics and neighborhood statistics, both of

which are extremely affective in measuring the density and connectivity of new patches of urban growth over a given time period. I have shown that while these approaches are extremely adequate in understanding sprawl, they are often more complex than they need to be. In my methodology I will show how the use of neighborhood statistics within the GIS can be an extremely effective way to visually assess and quantify sprawl.

Chapter 3: Methodology

Quantitative and Qualitative Techniques

I used two basic research methods to carry out this study: quantitative and qualitative. The quantitative methods involved the usage of Geographic Information Systems data to produce maps of urbanization within the study area. Neighborhood statistic measurements were also used to quantify and display the density and connectivity of patches of new built-up land. The Geographic Information System allowed for reclassification of land cover data into categories appropriate for the purposes of this study: urban and non-urban. The GIS also allowed for the usage of different types of data such as jurisdictional boundaries and roads that lie within those boundaries. The neighborhood statistic calculations were important in justifying the classification of new growth areas as one of three types of sprawl: linear, cluster, and leapfrog.

The qualitative aspects of this study consisted of interviews with local land developers, planners, and analysis of jurisdictional comprehensive plans. With a qualitative approach, I hoped to gain a better understanding of multivariate phenomenon such as urban sprawl and further be able to account for development based on land value and zoning ordinances. It is not practical to assume that a strictly quantitative or qualitative approach alone would be adequate enough to make any conclusions about sprawl trends in a given area. While my maps will provide visualization of the spatial distribution of built-up land, they cannot explain why one parcel is more attractive to a developer or investor than another parcel of land. Conversely, my interviews with developers and audits of comprehensive plans alone will not allow for quantification and classification of growth areas into meaningful classes of urban sprawl. Therefore, it was

vital to incorporate aspects of both qualitative and quantitative analysis techniques in order to be able to reasonably describe and understand whether and to what extent urban sprawl trends exist in Richmond, Virginia.

Sampling Strategy

Because of the ubiquity of possible sample areas, I had to merge quantitative and qualitative data sampling strategies into one approach. I created the quantitative data by reclassifying the National Land Cover Data in the GIS to only those classes that represent built-up land (Table 3.1) and then calculating neighborhood statistics on built-up areas. For the purposes of my research, I defined built-up land as any land cover that is synonymous with urban land cover, which includes paved, industrial, commercial and residential areas. Therefore, I used the terms "built-up" and "urban land" cover interchangeably. I took one sample of each kind of assumed sprawl based on the neighborhood statistic calculations to use in interviewing developers and to analyze jurisdictional master plans. In order to gauge sprawl trends, I only took samples from the Counties of Chesterfield, Henrico, and Hanover. I did this because I wanted to examine the extent to which growth had taken place around the city and not within Richmond. By this approach, I used the reclassified National Land Cover Data, neighborhood statistics, and final maps of growth characterized as sprawl to sample areas that I would qualitatively assess through interviews and analysis of planning documentation.

In order to obtain my sample sites, I used a combination of the map of new urban growth, urban areas in 1992, and the map of new urban growth density. Using the guidelines for the three types of sprawl of interest as stated in the method for objective one section, I pinpointed one of each type of sprawl within each county. Then, I reported

the coordinates of the selected sprawl sites to each GIS department for each county. From those coordinates, the GIS office of each county gave me information regarding the developer or land owner of each site. After I obtained contact information for each developer, I interviewed and tape recorded those encounters for transcription at a later date.

Objectives

1) To measure urban sprawl within the study area based on urban land use change between 1992 and 2001 and assess patterns and densities of new urban growth thereby classifying those patterns as urban sprawl: linear or strip along highways, expansion or cluster, and leapfrog or relocation (Figure 2.1).

2) To understand why new urban growth has occurred in some areas and has not occurred in other areas based on examinations of land use regulations, land use policies, and jurisdictional master plans. I also based the results of this objective on interviews with local developers and planners.

Data Manipulation and Analysis Methods

Method for Objective 1

I began data analysis by georeferencing the coordinate system for each GIS data layer thereby ensuring spatial consistency with regards to the extent of the study area and "clipping" the land cover and roads data to the boundary layer. Georeferencing entailed making sure that all spatial data layers used the same map projection. I used the tools found in ArcGIS to register the spatial data layers to a common map projection. The map

projection I used for the study is the Universal Transverse Mercator (UTM) North American Datum (NAD) 83 Zone 18 North.

Following georeferencing of all GIS data layers, I incorporated each National Land Cover Data set into the GIS to determine urbanization from 1992 to 2001. After "clipping" the NLCD data for each year to the study area, I "reclassified" the 21 classes of land cover into only those classes that represent built-up or urban land (Table 3.1).

Table 3.1: 1992 and 2001 National Land Cover Data (NLCD) classes used

1992 NLCD Classes	2001 NLCD Classes
21 Low Intensity Residential	21 Developed, Open Space
22 High Intensity Residential	22 Developed, Low Intensity
23 Commercial / Industrial / Transportation	23 Developed, Medium Intensity
85 Urban / Recreational Grasses	24 Developed, High Intensity

Data Source: United States Geological Survey

I then compared the two data sets to determine the amount of urban growth based on land use change from non-urban to urban land use from 1992 (Figure 3.1) to 2001 (Figure 3.2). After the reclassification, I calculated neighborhood statistics on new growth areas in order to calculate density and display connectivity of new growth areas thereby classifying those new patterns of development as one of three types of sprawl: linear, expansion or cluster, and leapfrog or relocation. I also incorporated road data with buffers around those roads to assist in determining the extent of the linear nature that sprawl can take along highways and other major roads.

Based on the density of new growth areas as well as a visual assessment of the spatial distribution of built-up land in 2001, I classified those new areas of growth as one of three types of potential sprawl: linear, expansion or cluster, and leapfrog or relocation. I classified a new growth area as linear sprawl if it occurred along a highway and exhibited high to medium density. I set the threshold for low to high density (Table 3.2)

Table 3.2: Density threshold

Low Density	Medium Density	High Density
0 - 400	401 - 700	701 - 1200

If an area of new growth occurred around existing areas of urban land and exhibited high density, then I classified that area as expansion or cluster sprawl. Those areas of new growth that were medium to low density and were sparsely distributed throughout the study area, I classified as leapfrog or relocation sprawl. The threshold was represented by the total number of 30 meter pixels added up within the one square kilometer window. The windowing technique added up all of the pixels within the analysis window and attributed that value to the center cell of the neighborhood. The techniques I used to classify areas of new growth are based on research done by Sudhira et al. (2004) and Wilson et al. (2003).

It was important to isolate areas of new growth in 2001 from areas of existing growth in 1992. I created the layer of new growth pixels by adding the urban 1992 layer to the urban 2001 layer. The urban 2001 layer was initially classified in twos and zeros. The urban 1992 layer was initially classified in ones and zeros. I performed the addition operation in the raster calculator in ArcGIS. The resulting layer was represented by pixels numbered zero, one, two, and three (Table 3.3).

Table 3.3: Resulting raster calculator categories

Stayed Non-Urban	Urban to Non-Urban	Non-Urban to Urban	Stayed Urban
0	1	2	3

In order to calculate neighborhood statistics, I incorporated a filtering technique used by Wilson et al. (2003), in which a window of pixels approximately one kilometer by one kilometer was passed over the entire study area in order to calculate the density of urban pixels within that window (Wilson et al 2003). The terms "window" and "neighborhood" are used interchangeably with regards to this technique. I then produced maps of relative density within the given window of pixels to show the sum of the density within the window as well as sprawl patterns over the study area (Wilson et al 2003). The result of this technique is that all of the pixels within the window are added up and the new value is attributed to the center of the neighborhood. Within the GIS one kilometer by one kilometer equated to approximately 36 by 36 cells given that each cell was 30 meters by 30 meters. I created urban density maps for urban land in 1992, 2001, and new development over the nine year time period based on the given window in order to compare densities for each classification of urban land use.

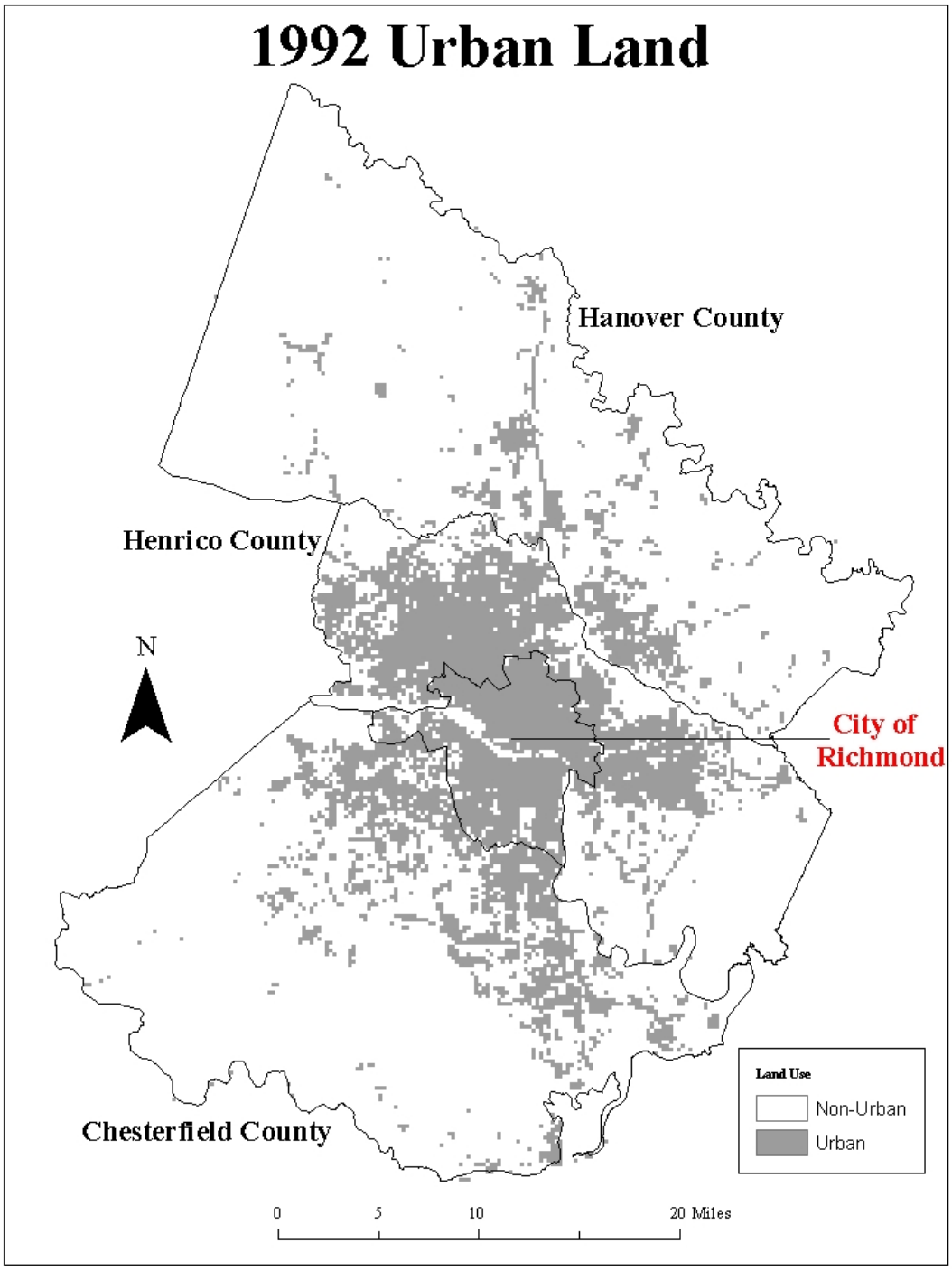

Figure 3.1: map showing urban areas in 1992
Data Source: U.S. Geological Survey
http://seamless.usgs.gov/, 2004

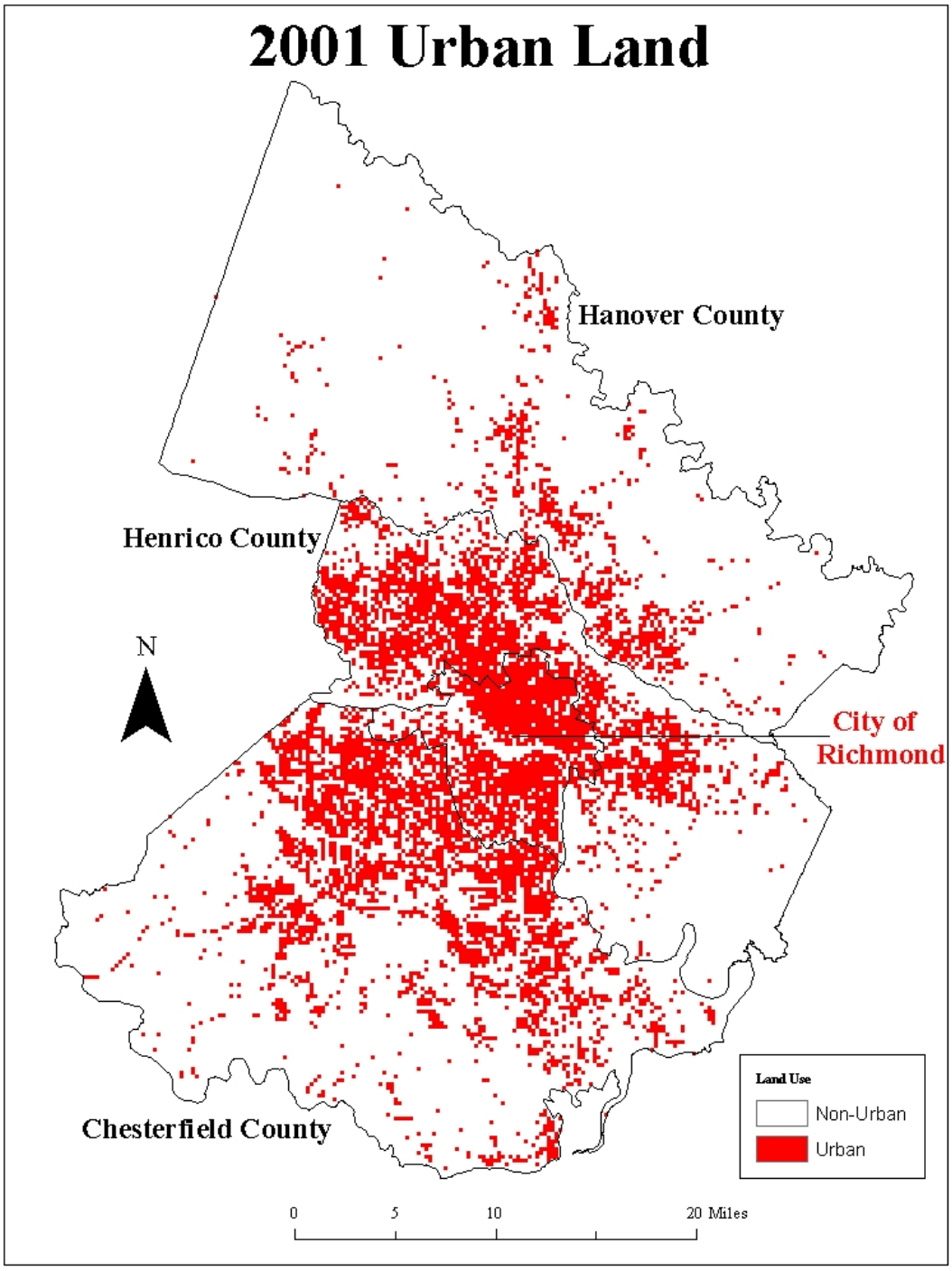

Figure 3.2: map showing urban areas in 2001
Data Source: U.S. Geological Survey
http://seamless.usgs.gov/, 2004

Method for Objective 2

For the second objective, I took a stratified sample of each type of sprawl within each of the three counties to begin data analysis. I looked at one example of each type of sprawl within each of the three counties to try to understand why new growth occurred there as opposed to another area within the given jurisdiction. Then, by identifying the developer or land owner responsible for the conversion of that land to urban or built-up land, I was able to interview the respective developer or land owner to assess the reasoning behind purchasing the land. I identified sample sites by creating point shapefiles of each type of sprawl within each county. I contacted the planning department for each county with coordinates for each sample site. From the given coordinates, each planning department was able to tell me what the particular plot of land was as well as the developer or land owner of the site.

Contact with local developers was done by phone and appointments for personal interviews were scheduled during the spring of 2005. A series of semi-structured and open-ended questions allowed me to gauge personal and professional opinions on issues such as zoning practices, variances, land use regulations, and land value. I formulated the questions for each interview to gain an understanding of the perception of urban sprawl by developers. I tape recorded all of the personal interviews so that I would not disrupt the conversation by trying to write everything down. All questions and interviews with human subjects were approved by the Virginia Tech Office of Research Compliance prior their administration.

I also examined comprehensive master plans to gain further understanding of trends in planning practices in each jurisdiction. This allowed me to conclude that certain

tracts of land were not developed by intent of that jurisdiction. In cases such as these, I was able to ascertain that within each jurisdiction, certain areas of land were purposely not planned for development. Examination of master comprehensive plans also allowed me to understand limitations for developers and land owners. This technique coupled with interviews, questionnaires, and GIS and neighborhood statistics were a comprehensive way to clarify trends, practices, and patterns of development within the Richmond metropolitan area.

Data Collection

Objective 1

GIS data layers were readily available for the study area, which is part of the Richmond-Petersburg Metropolitan Statistical Area. Necessary data sets included National Land Cover Data (NLCD) for 1992 and 2001, county boundary files showing the border of each jurisdiction within the study area (County 1990 and County 2000), and road data for each jurisdiction, master plans, and responses to questions from interviews with developers and land owners.

I worked with the county 1990 and county 2000 boundary files to display the extent of the study area. I obtained these files from the United States Bureau of the Census web site. County boundary files are available under the Topologically Integrated Geographically Encoded Reference system (TIGER) project undertaken by the census bureau. In addition, I worked with road data from the United States Bureau of the Census, which is also available under the (TIGER) project. TIGER data contains information about line features such as roads and waterways, boundary features, and

landmark features. I used road data files in the GIS for use as one basis for showing the extent and linear pattern of urban sprawl.

I obtained the NLCD from the United States Geological Survey. NLCD are derived from early to mid 1990's Landsat Thematic Mapper satellite data and is a 21-class land cover classification scheme applied consistently over the United States. The NLCD for 2001 are still in the development process, but was available for my study area. In order to carry out a comparison of the 1992 and 2001 urban land, I obtained NLCD data for both years. I downloaded the NLCD data that applied to the study area from the United States Geological Survey, which I then "clipped" to the border of the study area. It is important to note that the classification scheme is different for 1992 and 2001. In 1992 the land cover classification was based on actual land use / land cover type. In 2001 the land cover classification was based on the impervious cover of the land, which indicated built-up or urban land. For 1992 those classes were low intensity residential, high intensity residential, commercial / industrial / transportation, and urban / recreational grasses. For 2001 those classes were developed open space, developed low intensity, developed medium intensity, and developed high intensity (Table 3.1).

Objective 2

For the second objective, I collected data from comprehensive master plans and interviews with developers and local planners. I decided to use the most recent comprehensive planning documentation so that I could gauge planning practices and the degree to which each jurisdiction promoted development, smart growth, and conservation. I received comprehensive planning documentation from each of the respective jurisdictions; Chesterfield County, Henrico County, and Hanover County. After I collected the planning documentation and interviews with developers and local planners, I began analysis of the data. Appendix I includes a semi-structured instrument for developers and land owners. Appendix II, III, and IV includes a semi-structured instrument for Chesterfield, Hanover, and Henrico Counties.

Chapter 4: Results and Interpretation

My results and interpretation section is divided into many different sections and sub-sections for organizational purposes. The largest sections are broken up by the type of data that I collected: quantitative and qualitative. In the quantitative results section, sub-sections include a restatement of the first research question, GIS mapping of growth distribution, and neighborhood statistics. The qualitative section is broken up by a restatement of the second research question, analysis of comprehensive plans, interviews with planners and developers, Hanover County planners interview, Henrico County planners interview, Chesterfield County planners interview, Hanover County developer interviews, Henrico County developer interviews, and Chesterfield County developer interviews. The last section of this chapter is the interpretation section, which gives an explanation for all of the data that I collected and analyzed as stated in the methodology chapter.

Quantitative Results

I obtained quantitative results for the study area by collecting all necessary spatial data layers and analyzing them accordingly. The data layers include boundary files for the entire study area, transportation data, and land use / land cover data.

Research Question 1: Has urban sprawl taken place in the study area based urban land use change and the patterns and densities of new growth between 1992 and 2001?

GIS Mapping of Growth Distribution

Manipulation of GIS data revealed basic spatial patterns of urbanization over the time period between 1992 and 2001. I collected the necessary NLCD, which had to be clipped to the study area. After this was done, I was able to reclassify the data into applicable classes that represented built-up or urban land cover. Next, I created a one mile buffer (Figure 4.1) around major roads in order to isolate linear patterns of sprawl. Major roads included Interstates and U.S. Highways. Interstates such as I 95, I 295, and I 64 were the largest of the major roads to be included in the analysis process.

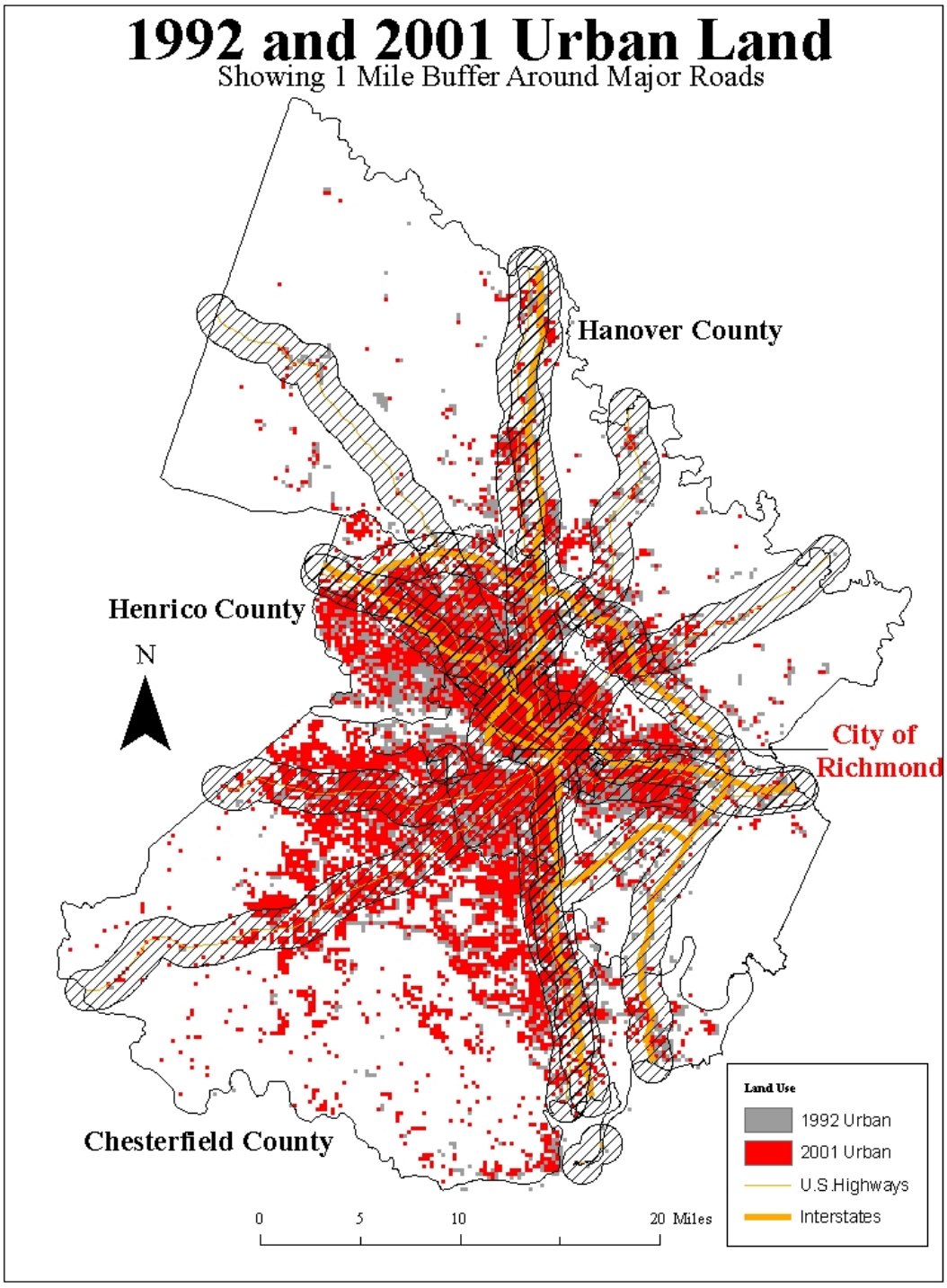

Figure 4.1: One mile road buffers
Data Source: U.S. Census TIGER Data

With the analysis capabilities in the GIS, I calculated approximate square kilometers of urban or built-up land for each year; 1992 and 2001. This allowed me to conclude initially that there was a clear increase in the amount of urbanization over the given time period (Figure 4.2). In 1992 there was approximately 559 square kilometers of urban or built-up land within the study area. In 2001 that number increased by 25% to 746 square kilometers of urban or built-up land indicating a large increase in the extent to which urban sprawl occurred between 1992 and 2001. To assess urban sprawl, I had to be able to recognize urban growth patterns by performing a land use change analysis from non-urban to urban as stated by Sudhira et al. (2004). Then based on techniques to measure density, view connectivity and the spatial distribution of new growth areas with the GIS, I calculated patch density of new growth areas in order to classify some of those areas as sprawl. For the purposes of my research I used neighborhood statistics within ArcGIS to calculate the density of patches of new growth and create maps of that density. Then based on the spatial distribution and pattern of that density, I classified new growth areas as one of three types of sprawl: cluster, leapfrog, and linear. This approach is consistent with techniques employed by Wilson et al. (2003). Sudhira et al. (2004) used landscape metric calculations, which measure the density and connectivity of patches of growth, to classify new growth areas as one of three types of sprawl: cluster, leapfrog, and linear.

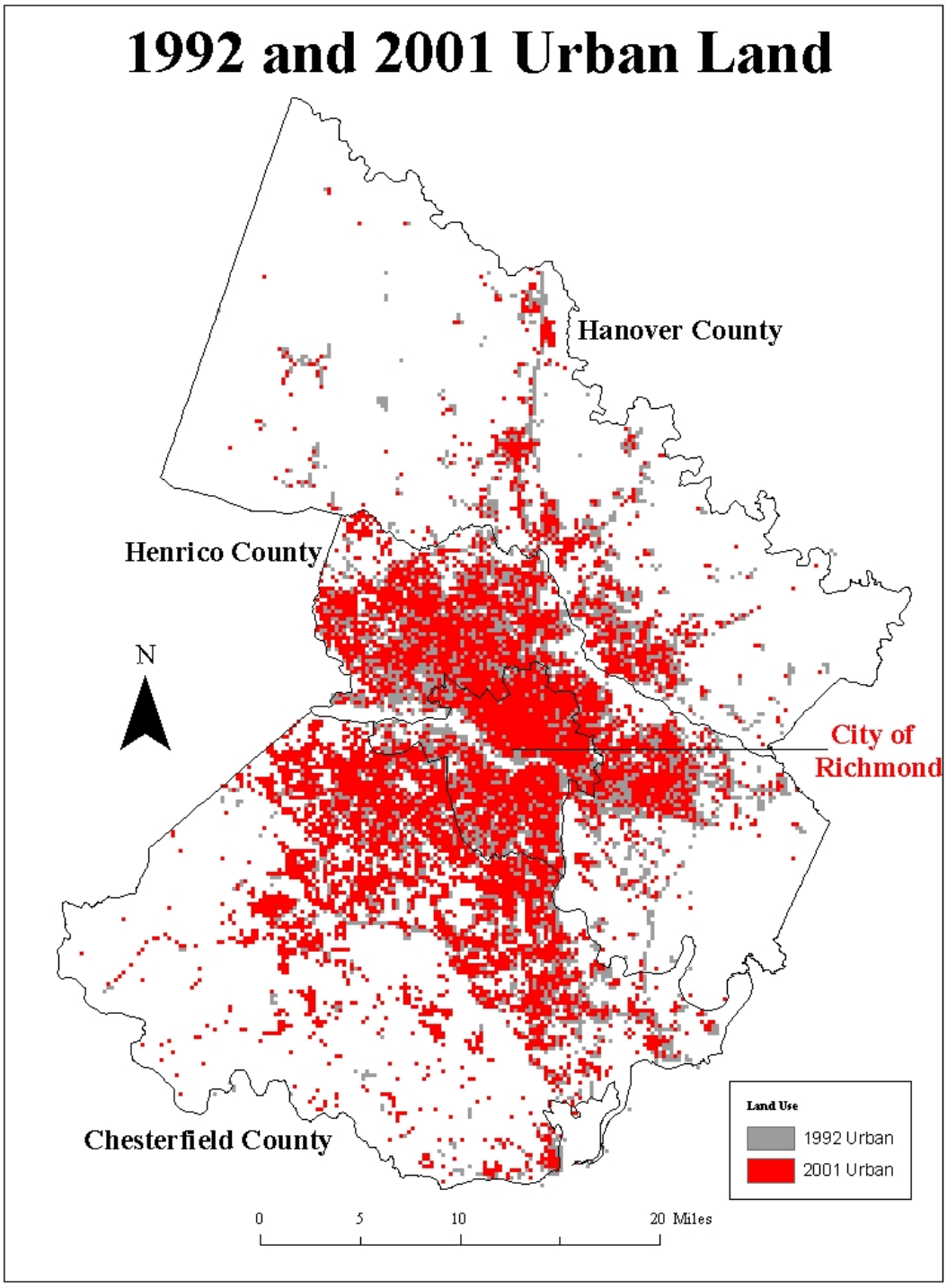

Figure 4.2: Extent of urbanization: 1992-2001
Data Source: U.S. Geological Survey

In order to determine sprawl areas, I visually assessed the three main patterns of development that were of interest in the study: linear or strip along highways (Figure 4.3), expansion or cluster (Figure 4.4), and leapfrog or relocation (Figure 4.5). This was the first step in quantifying sprawl within the study area. The second step was to calculate the density of new growth areas and create relevant maps thereby allowing me to view the connectivity of areas of new urban growth based on neighborhood statistics. However, at this stage in the research I only visually assessed possible patterns of sprawl because I wanted to see whether or not the NLCD was sufficient to use for the purposes of my research. Whether or not those areas could be classified as sprawl was based not only on the spatial distribution of the new growth areas, but also on the neighborhood statistics, which provided density of new growth areas within the one kilometer by one kilometer window. Visually, it did appear that the NLCD was appropriate for my research at this stage because it allowed me to pinpoint where areas of new growth were located.

In order to calculate neighborhood statistics, new growth was isolated as described in the methodology section (Figure 4.6). Isolating new growth areas allowed me to quantify sprawl based on density of new growth areas (Figure 4.7). I was also able to determine pixels that remained the same (Figure 4.8) and pixels that changed from urban to non-urban from 1992 to 2001 (Figure 4.9). This was helpful in visually assessing those areas that did not have an effect on the results of the study.

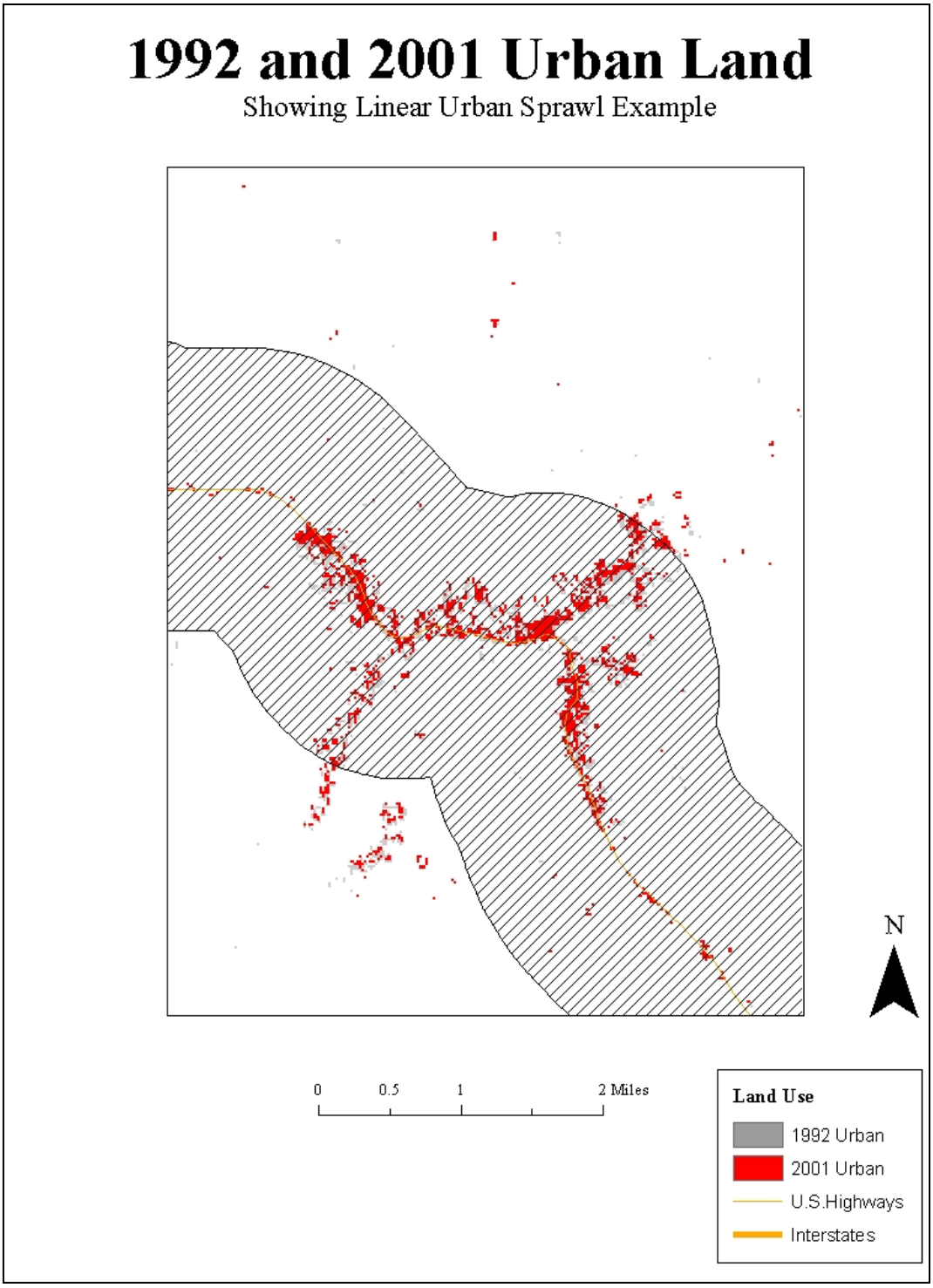

Figure 4.3: Possible sites of linear sprawl
Data Source: U.S. Geological Survey and U.S. Census TIGER Data

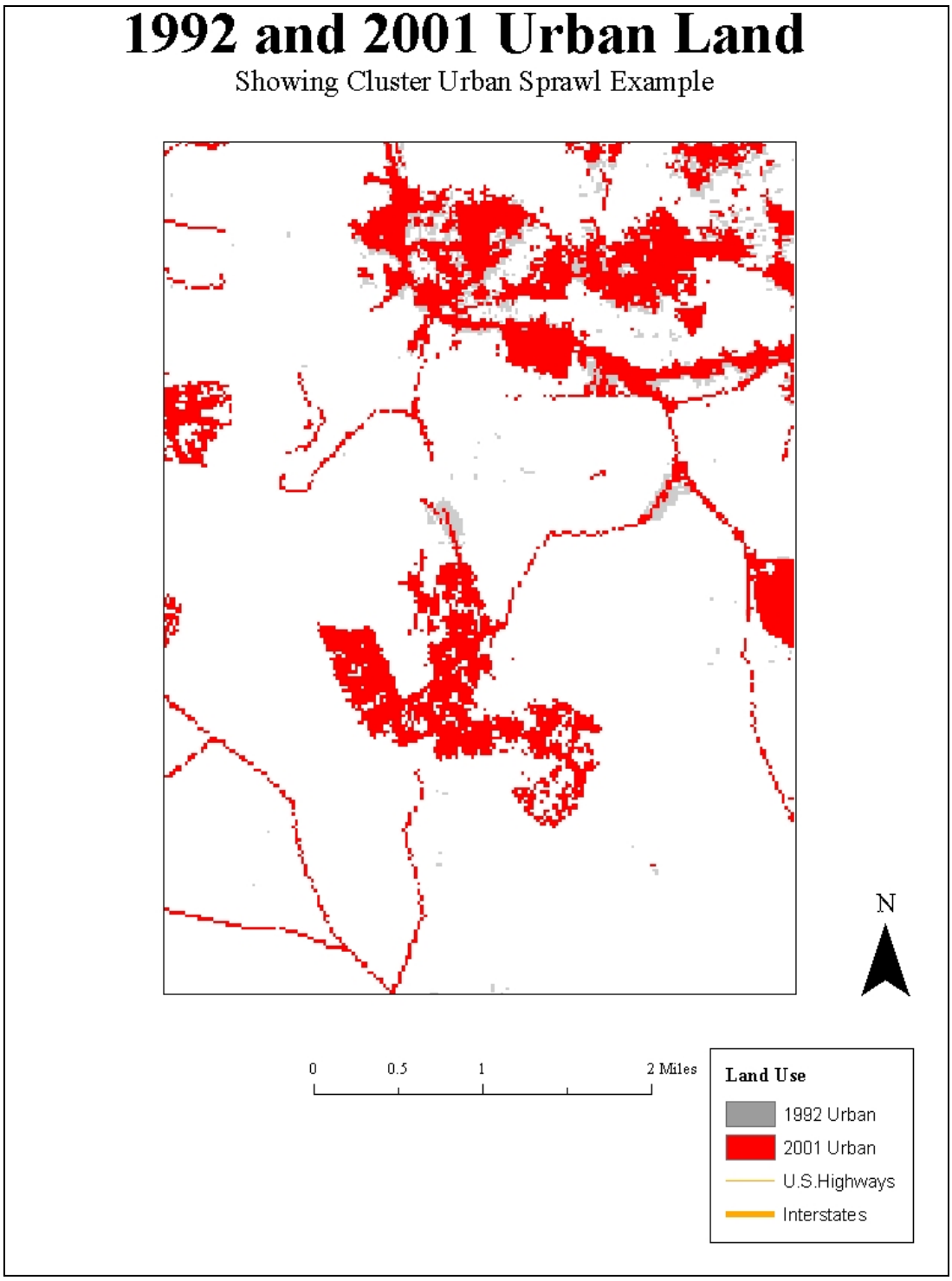

Figure 4.4: Possible site of cluster sprawl
Data Source: U.S. Geological Survey

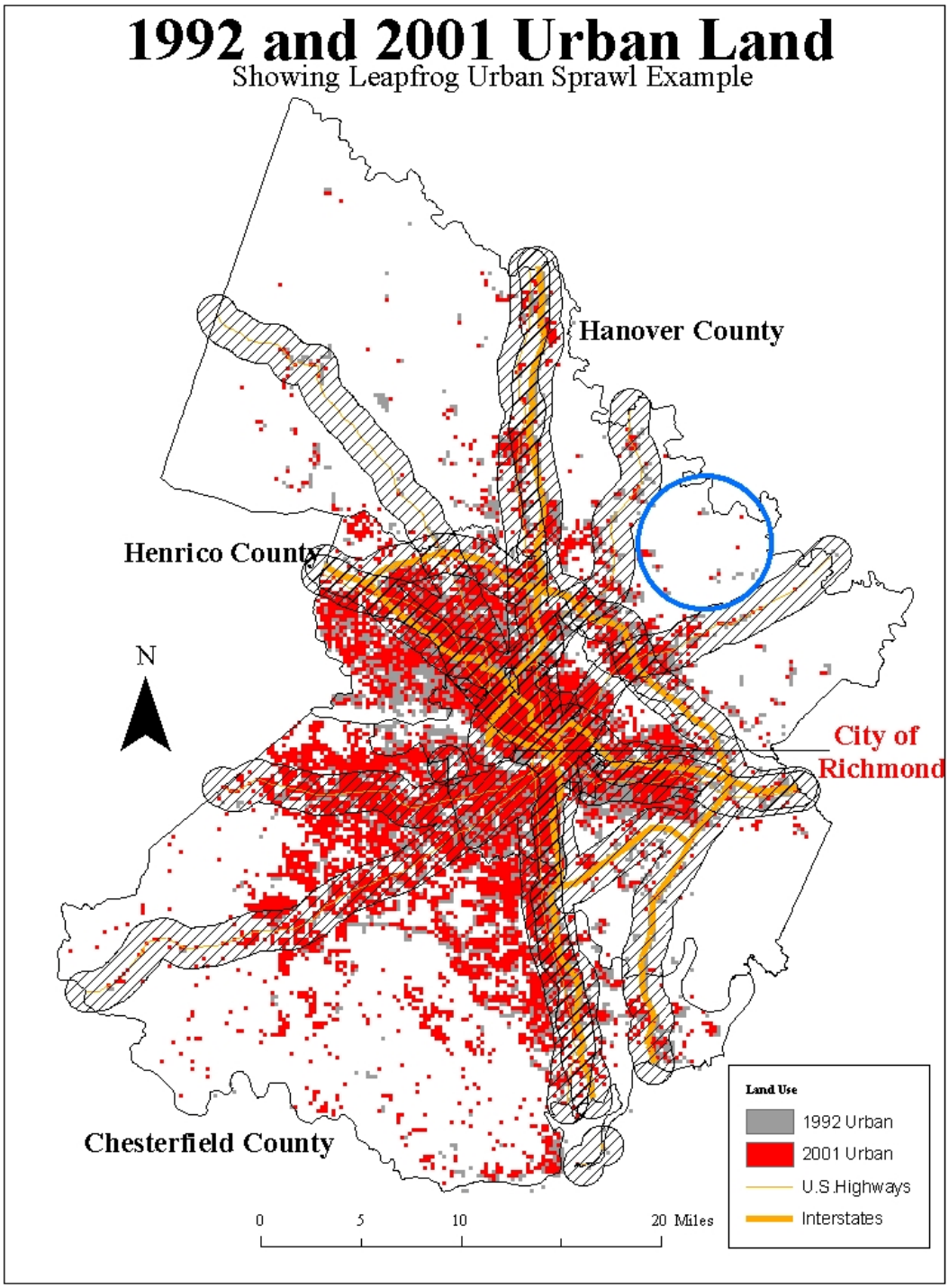

Figure 4.5: Possible site of leapfrog sprawl
Data Source: U.S. Geological Survey

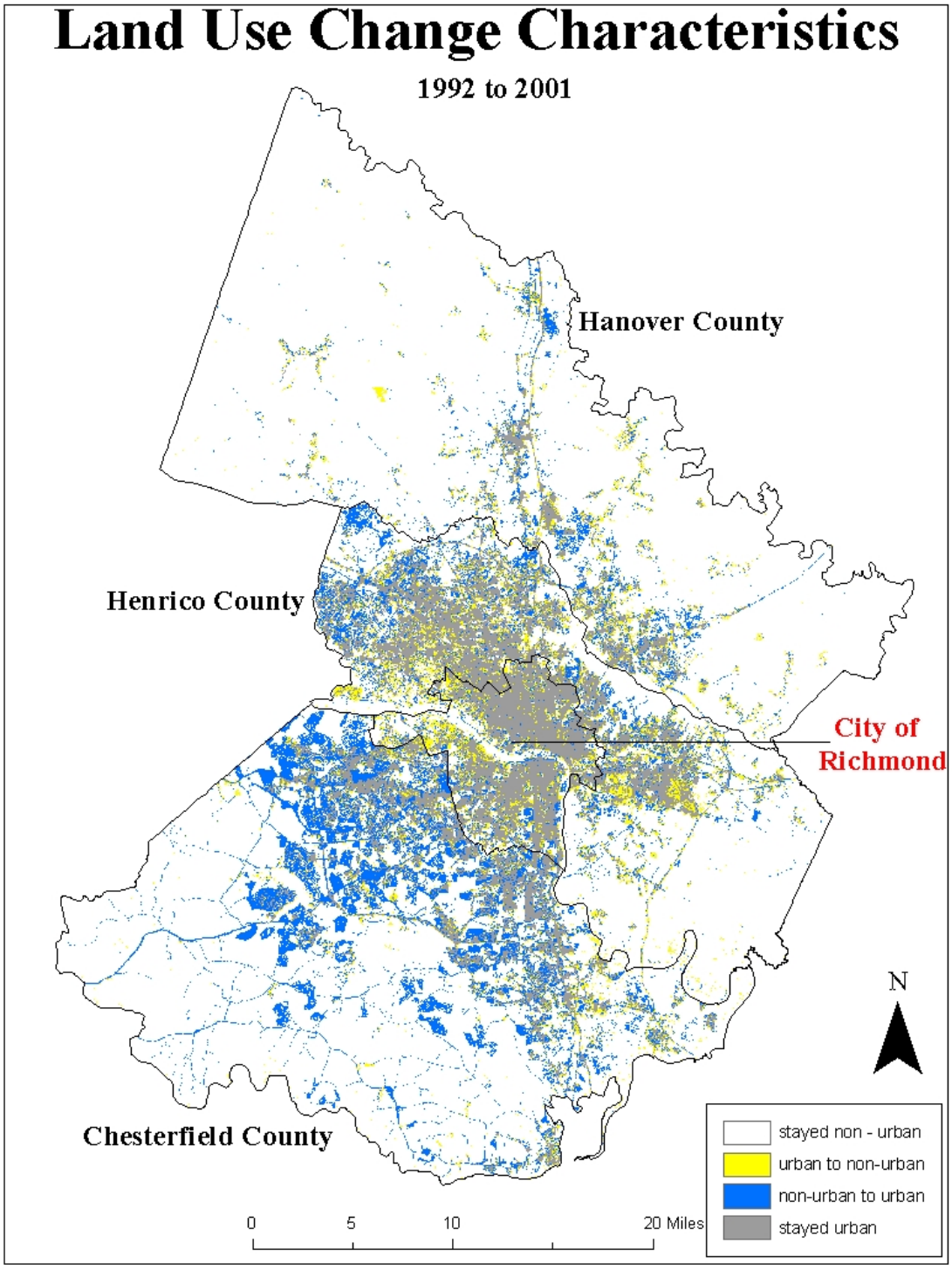

Figure 4.6: Study Area Land Characteristics 1992 to 2001
Data Source: U.S. Geological Survey

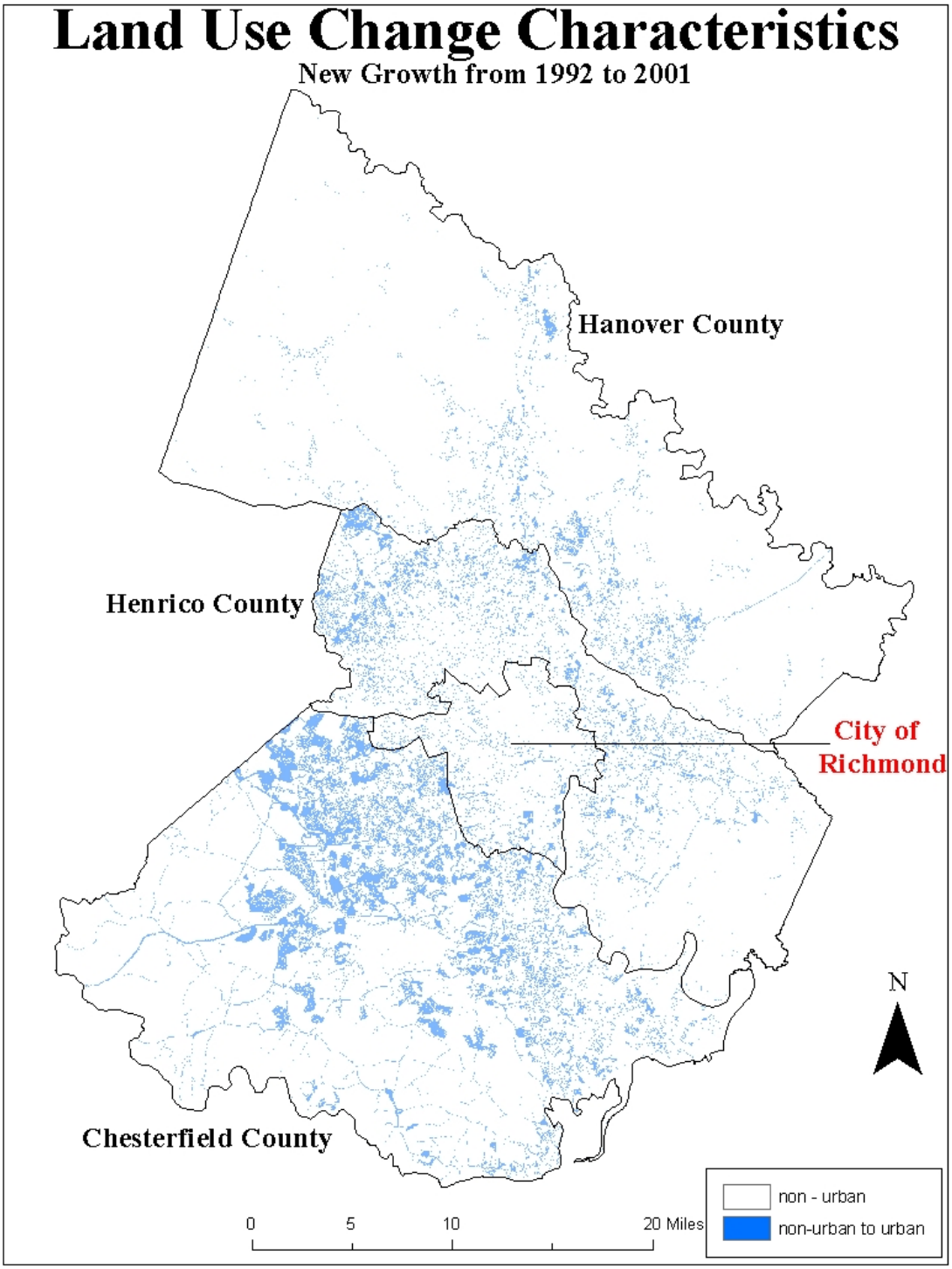

Figure 4.7: New Urban Growth 1992 to 2001
Data Source: U.S. Geological Survey

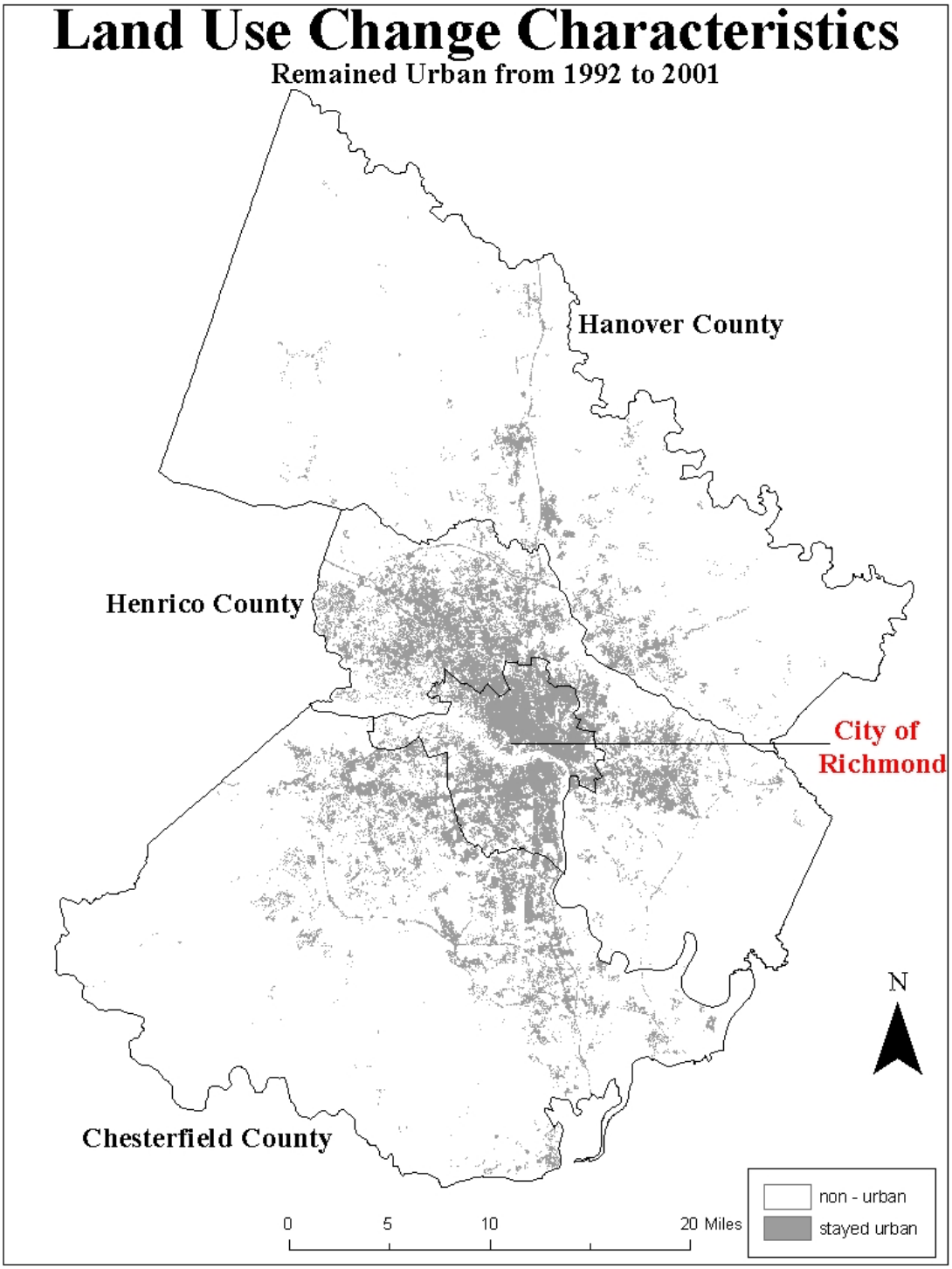

Figure 4.8: Land Remaining Urban from 1992 to 2001
Data Source: U.S. Geological Survey

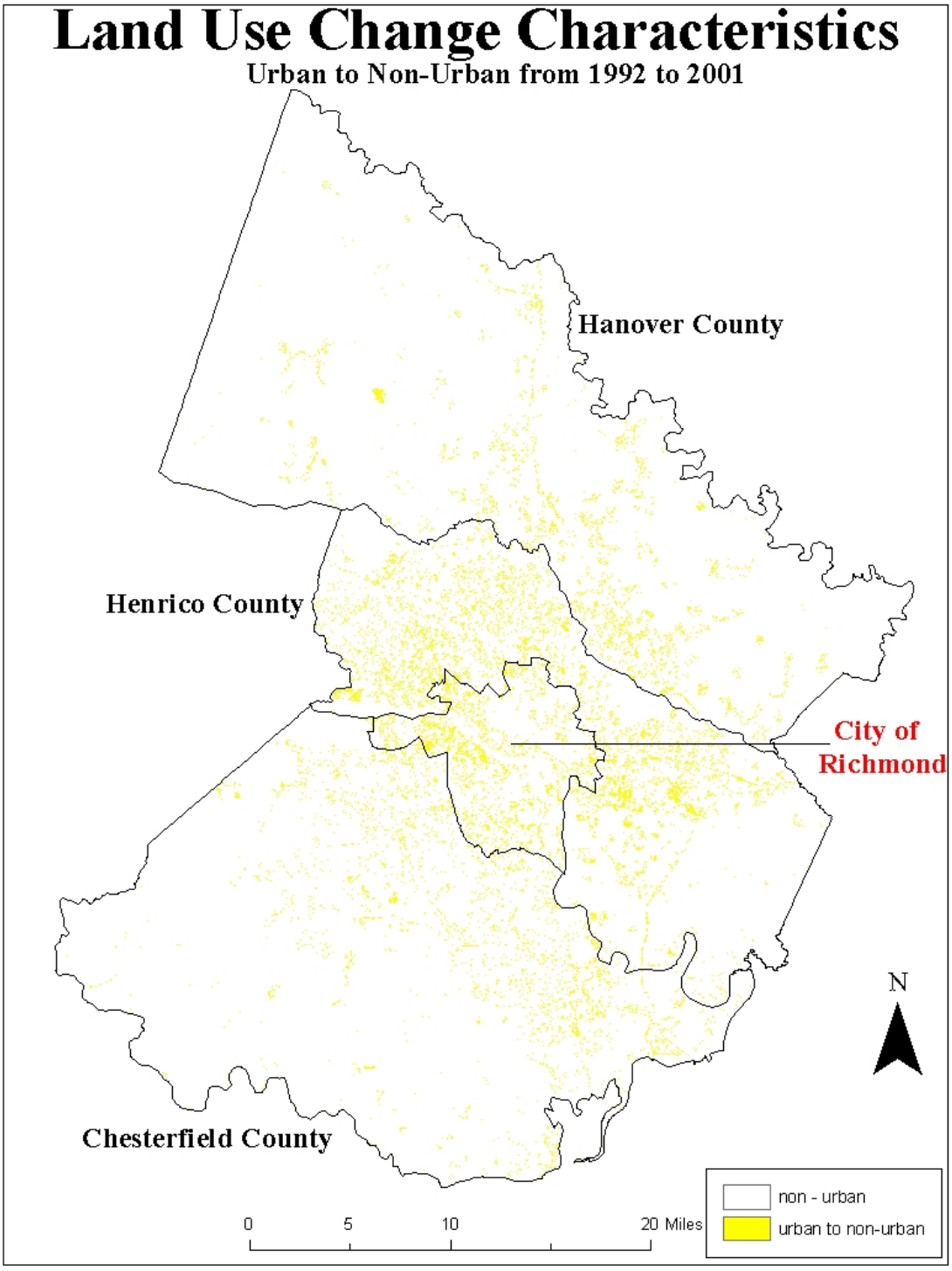

Figure 4.9: Land Changing from Urban 1992 to Non-Urban 2001
Data Source: U.S. Geological Survey

Neighborhood Statistics Calculations

Through neighborhood statistic calculations, I was able to describe why something would be called linear, cluster, or leapfrog urban sprawl. This is because it is not only the pattern of development that creates the appearance of sprawl, but also the density and connectivity of that development to existing areas of built-up land. More dense and compact areas of built-up land were classified as cluster, while medium density areas with low connectivity indicated leapfrog patterns. I classified areas of new growth that exhibited high to medium density built-up land found along highways within road buffers as linear urban sprawl (Figure 4.10). I also calculated densities of urban land in 1992 (Figure 4.11) and urban land in 2001 (Figure 4.12) for comparison with new growth areas. For my research, thresholds for low to high density can be seen in (Table 3.2).

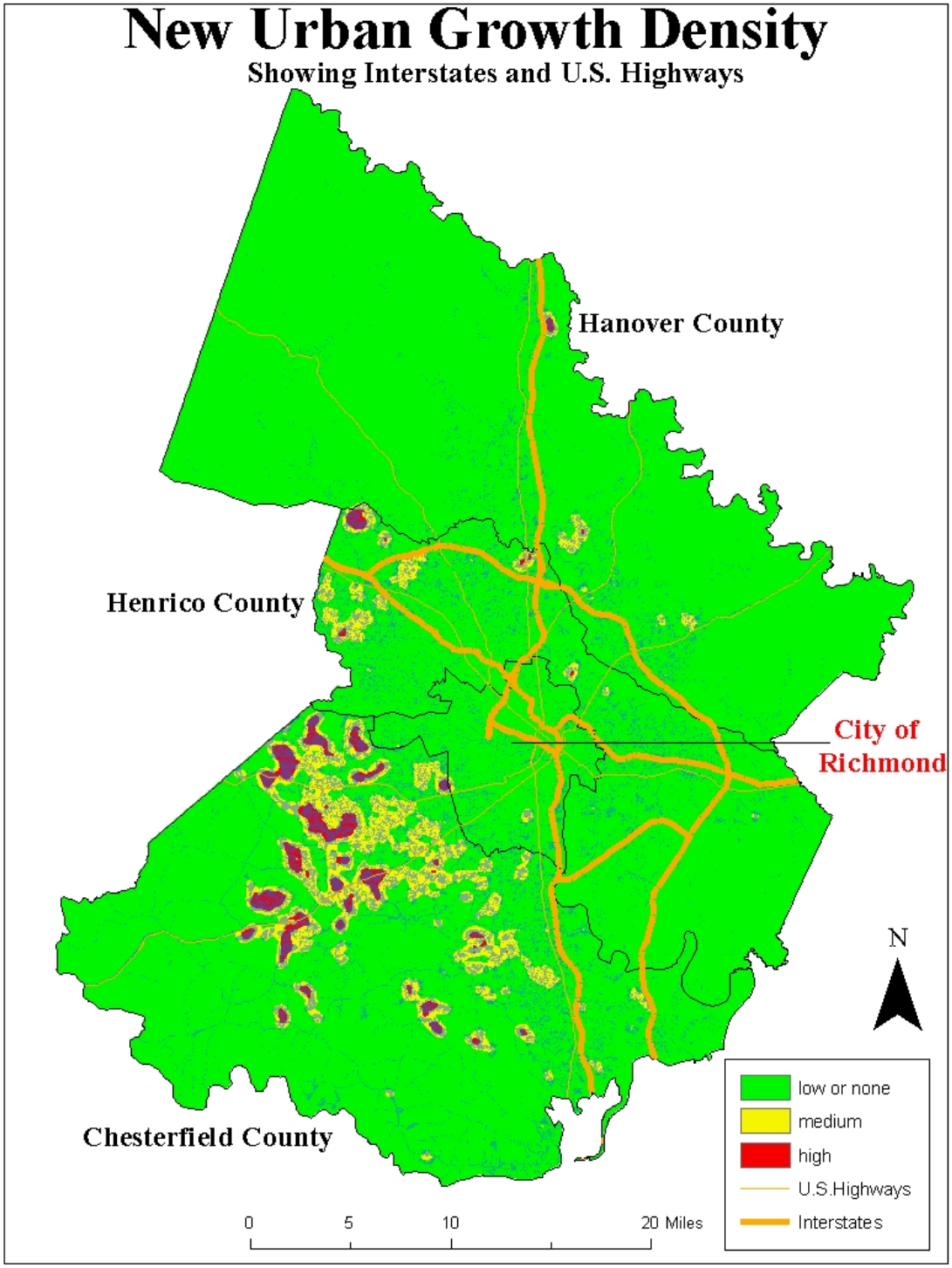

Figure 4.10: Density of New Urban Growth
Data Source: U.S. Geological Survey

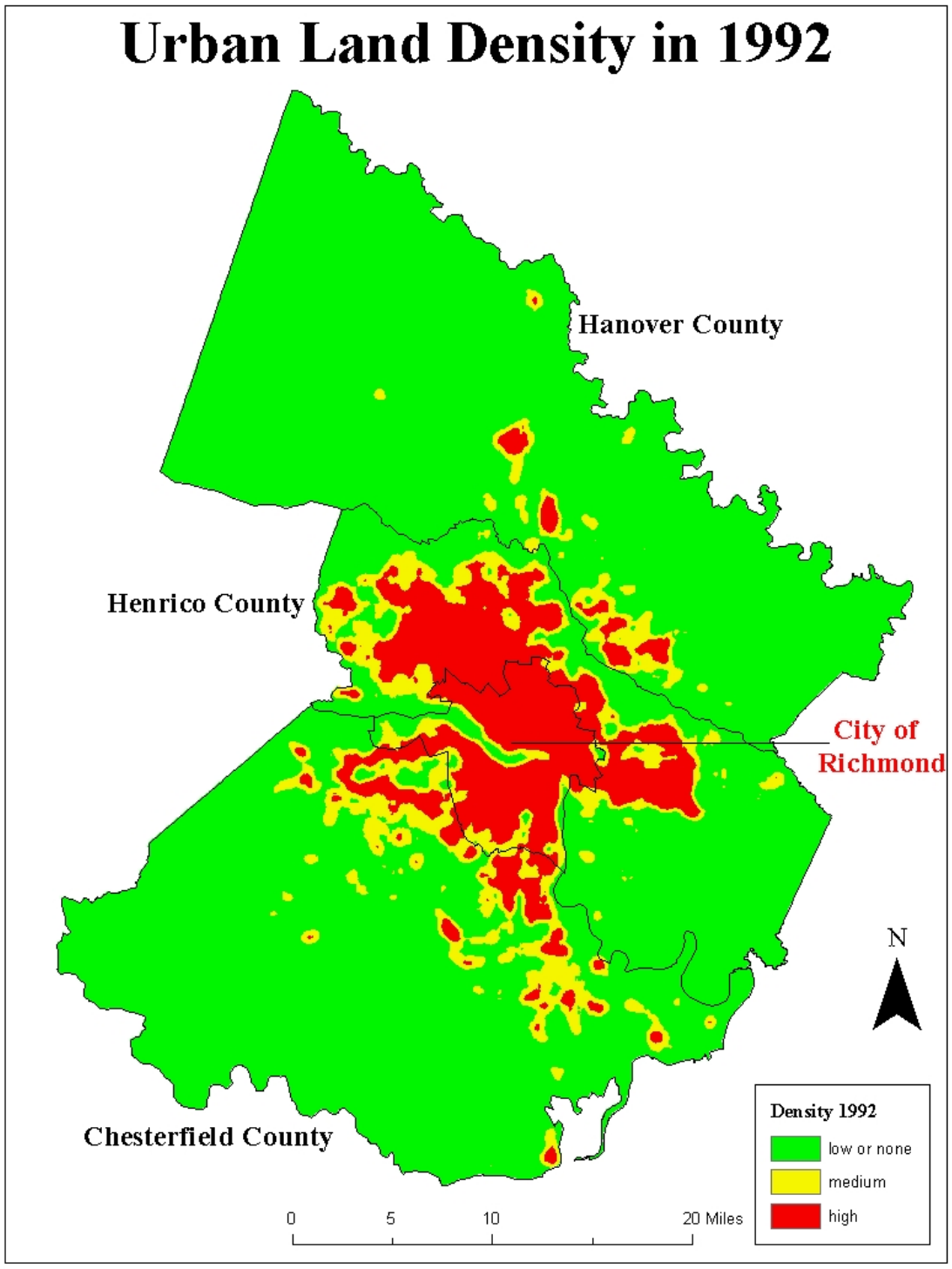

Figure 4.11: Density of Urban Land in 1992
Data Source: U.S. Geological Survey

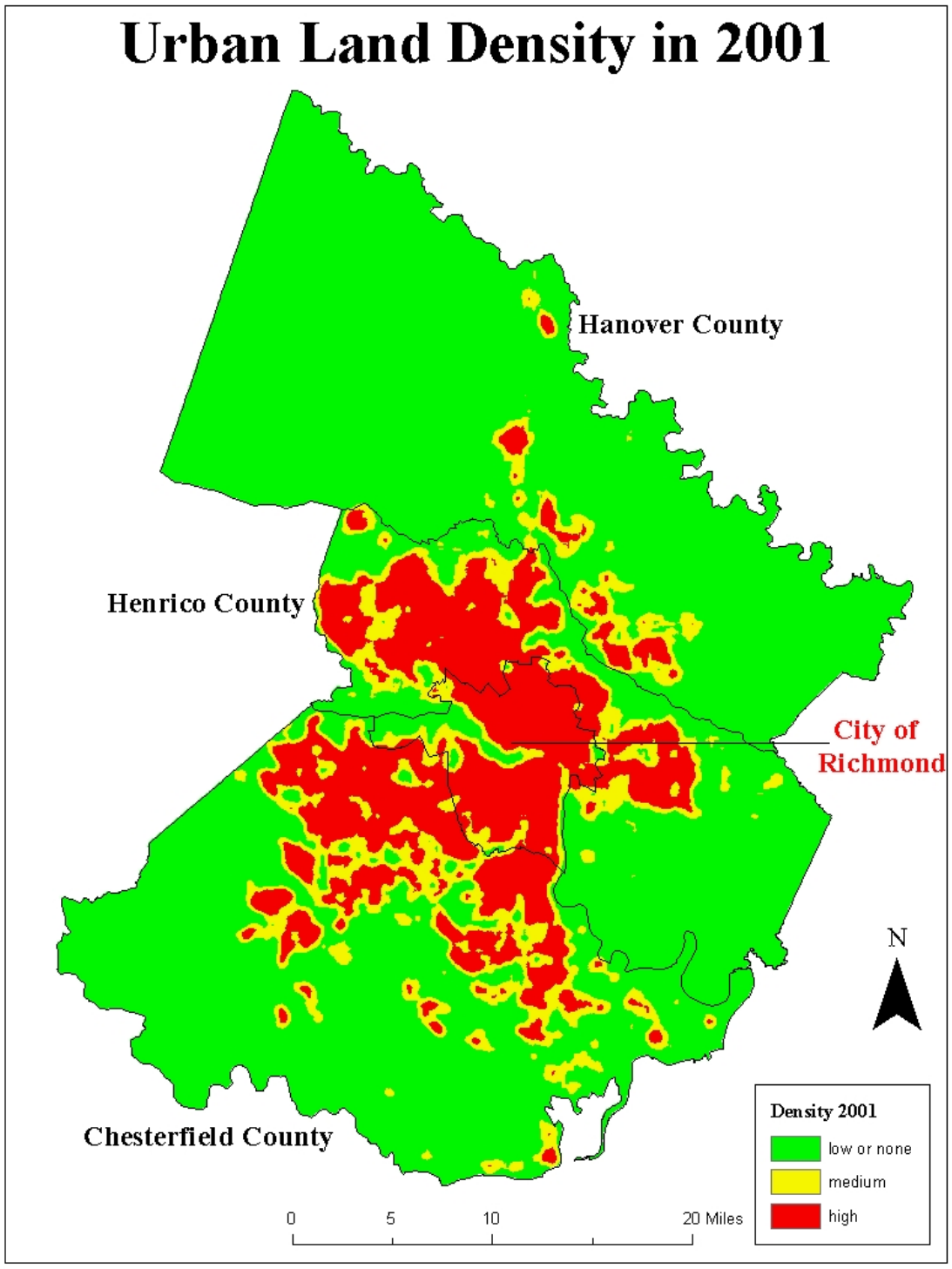

Figure 4.12: Density of Urban Land in 2001
Data Source: U.S. Geological Survey

After I calculated densities for new growth areas, I was able to pinpoint each type of sprawl within each county. I used these sites for identification of developers and land owners to interview as stated in the second objective of the study (Figure 4.13). In Chesterfield County, the sample sites were all residential developments. The example of cluster sprawl that I sampled is Gates Mill, part of a larger subdivision called Woodlake. The example of linear sprawl that I sampled is the Salisbury Michaux Section D, part of a larger residential development called Salisbury. I selected this sample site because it fell within a one mile buffer of Midlothian Turnpike, a major road in my research. The leapfrog development that I sampled is Sidlaw Hills at the Highlands. Sidlaw Hills at the Highlands is also part of a larger development; The Highlands, however the entire development is leapfrogged away from other developed areas. My sample sites in Henrico County were also all residential developments. I sampled Wellesley as my example of cluster sprawl, Wyndham as my example of leapfrog sprawl, and Twin Hickory as my example of linear sprawl. I sampled all residential developments in Hanover County also. My cluster sample site in Hanover County is Ash Creek. The leapfrog sample site I used for Hanover County is Laurel Meadows. The linear sample site that I used is Pole Green Station.

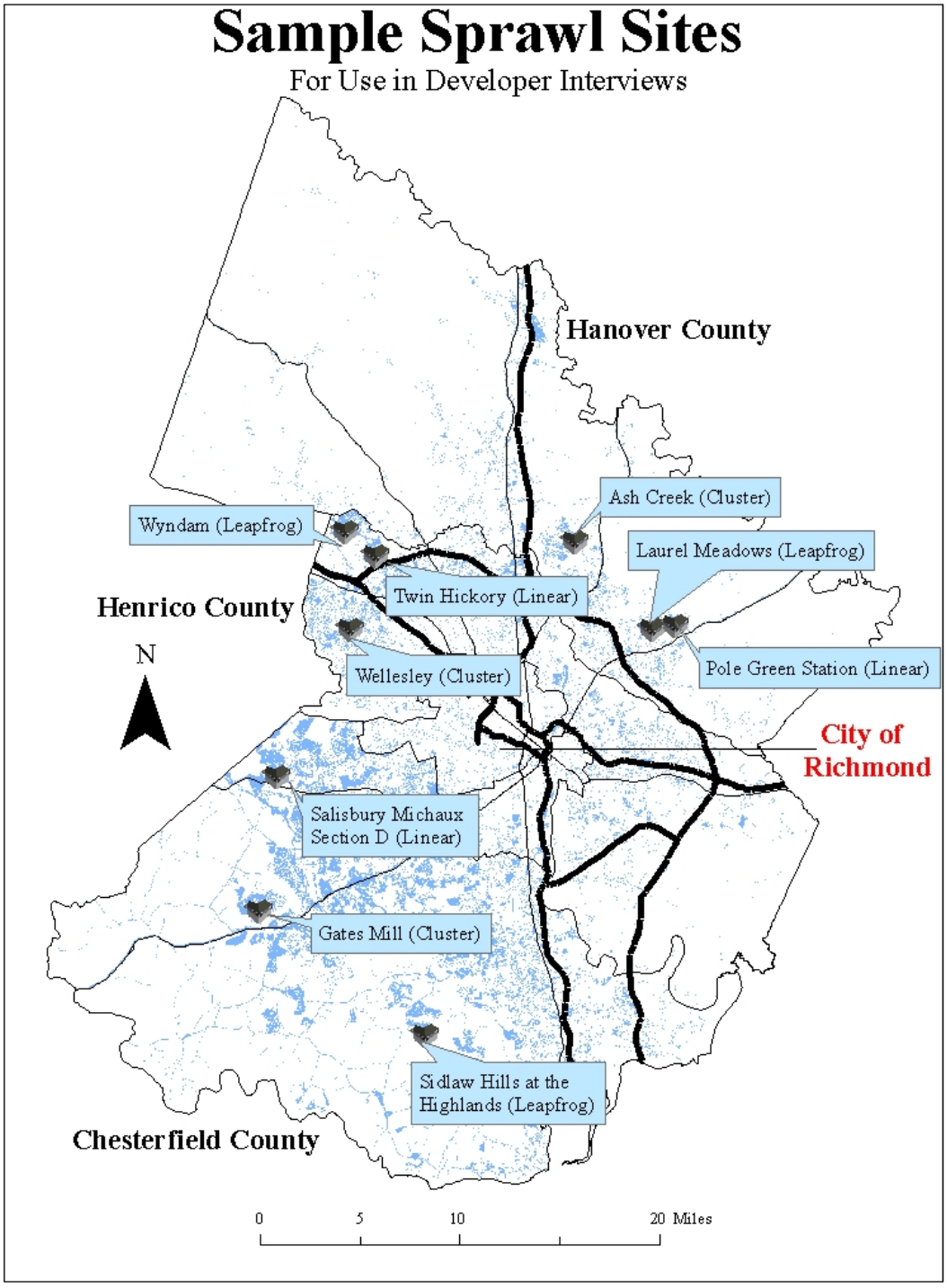

Figure 4.13: Map of Sprawl Sample Sites
Data Source: Author

Sample Site Profiles

In Chesterfield, Hanover, and Henrico Counties, my sample sites were all residential developments. Each of these developments had somewhat different characteristics as far as density, sense of place, and community features. In Chesterfield County, I sampled Sidlaw Hills at the Highlands (Figure 4.14)

Figure 4.14: Entrance to Sidlaw Hills at the Highlands
Source: Author

as a leapfrog example of sprawl, Gates Mill in Woodlake (Figure 4.15)

Figure 4.15: Entrance to Gates Mill in Woodlake
Source: Author

as a cluster example of sprawl, and the Salisbury-Michaux Section D (Figure 4.16)

Figure 4.16: Salisbury-Michaux Section D
Source: Author

as a linear example of sprawl. In Hanover County, I sampled Laurel Meadows (Figure 4.17)

Figure 4.17: Entrance to Laurel Meadows
Source: Author

as a leapfrog example of sprawl, Ash Creek (Figure 4.18)

Figure 4.18: Entrance to Ash Creek
Source: Author

as a cluster example of sprawl, and Pole Green Station (Figure 4.19)

Figure 4.19: Entrance to Pole Green Station
Source: Author

as a linear example of sprawl. In Henrico County, I sampled Wyndham (Figure 4.20)

Figure 4.20: Entrance to Wyndham
Source: Author

as a leapfrog example of sprawl, Wellesley (Figure 4.21)

Figure 4.21: Entrance to Wellesley
Source: Author

as a cluster example of sprawl, and Twin Hickory (Figure 4.22)

Figure 4.22: Entrance to Twin Hickory
Source: Author

as a linear example of sprawl.

All of the sample sites helped me to understand and assess a level of coordination between county planning departments and developers. In Chesterfield and Henrico County, one of the goals as stated by the subjects that I interviewed was to encourage large tract mix land use developments. Chesterfield and Henrico County also realized that market forces drive development in their jurisdictions and that population must be accommodated in a responsible fashion to avoid haphazard urban development and to increase an economic base. In Chesterfield County, two of the developments that I sampled exhibited mixed use characteristics: Gates Mill in Woodlake and Sidlaw Hills at

the Highlands. Gates Mill in Woodlake offers different housing options, many lake front properties (Figure 4.23)

Figure 4.23: Gates Mill in Woodlake lake front homes
Source: Author

, and walking trails throughout (Figure 4.24).

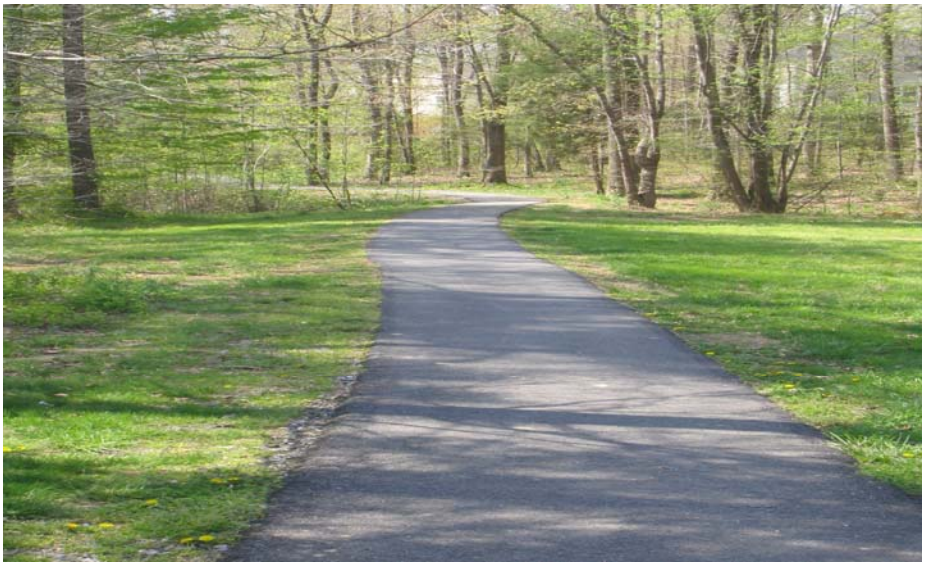

Figure 4.24: Gates Mill in Woodlake walking trail
Source: Author

Sidlaw Hills at the Highlands does not offer different housing options but does offer some large lot sizes, a golf course, a community center (Figure 4.25)

Figure 4.25: Sidlaw Hills at the Highlands Community Center
Source: Author

, and walking trails throughout (Figure 4.26).

Figure 4.26: Sidlaw Hills at the Highlands walking trails
Source: Author

The Salisbury Michaux Section D was the only development in Chesterfield County that did not exhibit many mixed land use characteristics (Figure 4.16). However, the Salisbury Michaux Section D just as Sidlaw Hills at the Highlands and Gates Mill in Woodlake is part of a larger development: Salisbury, which does have different housing options and commercial activities. The point of mixed land use characteristics in a development is to avoid excessive driving by keeping office space, shopping, and industrial centers in close proximity to residential areas that offer different housing options for different income levels.

In Henrico County, all of my sample sites were large tract mixed land use developments. Even Wyndham, which was my leapfrog example (Figure 4.27)

Figure 4.27: Just beyond Wyndham, rural land characteristics
Source: Author

, offered amenities such as housing options, a lake, a golf course (Figure 4.28)

Figure 4.28: Wyndham housing options and lake in the background
Source: Author

, and walking trails throughout. In Wellesley, my cluster example, amenities such as different housing options (Figure 4.29)

Figure 4.29: Wellesley mixed housing types: townhouse, apartment, and single family detached
Source: Author

, commercial centers (Figure 4.30)

Figure 4.30: Wellesley shopping center
Source: Author

, community centers, and walking trails throughout were common. In fact, Wellesley is located just across Nuckols road from Short Pump Town Center, a new shopping center. Twin Hickory in Henrico County exhibited many of the same characteristics that Wyndham and Wellesley did in the form of large tract mixed land use developments. All of these developments were also very close to a very large industrial and office space center: Innsbrooke. After completing field work in Chesterfield and Henrico County, I found that most of the new development in these counties exhibit characteristics of non-sprawling communities because of mixed land uses such as shopping, office space, and commercial facilities.

Hanover County was readily different in terms of the character of new development. All of the developments that I sampled in that county were highly disconnected from commercial centers and one another (Figure 4.31).

Figure 4.31: Ash Creek single family detached housing
Source: Author

The housing in all three of these developments was single family detached (Figure 4.32).

Figure 4.32: Laurel Meadows single family detached housing
Source: Author

Although Hanover County has met the goal of keeping the rural character of the county, it has facilitated the haphazard spread of development by allowing low density disconnected new development that does not exhibit any characteristics of what non-sprawling communities look like. Rather, the development in Hanover County could be considered as bedroom communities with no sense of community or place (Figure 4.33).

Figure 4.33: Pole Green Station bedroom community showing rural character
Source: Author

Qualitative Results

I obtained qualitative results for the study by collecting data from comprehensive master plans for each jurisdiction and interviews with developers and land owners from one of each type of sprawl within each county jurisdiction.

Research Question 2: Why have some areas within the study area seen growth while others have not?

Analysis of Comprehensive Plans

I reviewed the comprehensive plans for Chesterfield County, Hanover County, and Henrico County. I wanted to understand why development was occurring in specific areas within each county and throughout the study area as a whole. I also wanted to gauge basic jurisdictional planning practices and procedures. After reviewing jurisdictional plans, I determined that much of the growth was planned for, which explains the occurrence of some new growth areas within the study area. I also determined that there are important differences between each county with regards to planning practices that facilitate responsible growth management.

The comprehensive plan for Chesterfield County was initially adopted in 1986 and is loosely constituted by plans at the village, community, and corridor levels (Chesterfield County Planning Department [CCPD], 2004). There have been a number of different amendments since that date for different villages and areas within the county. The major parts of the Chesterfield County comprehensive plan include; an approach to reasonable growth management, economic development, shaping the character of the county, important resources, and neighborhoods (CCPD, 2004). It was unclear in the rest

of the plan what reasonable growth management entailed. However, there are some areas within the county set aside for development and some areas set aside for deferred growth (CCPD, 2004). An interesting aspect of the economic development section of the plan is the recognition of providing industrial, commercial, and employment areas around existing infrastructure (CCPD, 2004). The overall goal of the Chesterfield County comprehensive plan is "orderly development," yet this goal does not negate the presence of urban sprawl within the county (CCPD, 2004).

The Hanover County comprehensive plan was adopted in 1982 and is separated into sections dedicated to land use, public utilities, transportation, public works, community facilities, historic resources, economic development, finance, communication facilities, planning for age groups, and housing (Hanover County Planning Department [HCPD], 2003). Under the land use section of the plan it is stated that Hanover County relies on a phased suburban development element plan, which partially includes zoning districts such as the agricultural-residential district and the rural conservation district (HCPD, 2003). Both the agricultural-residential and the rural conservation districts allow for decreased density of lot sizes in order to preserve the rural character of the county (HCPD, 2003). However, a goal related to suburban development for Hanover County is to encourage development of neighborhood patterns that permit a full range of public services to be provided efficiently, economically, and conveniently (HCPD, 2003). It is unclear how these two goals can co-exist because of the inherent lack of connectivity between rural neighborhoods and other neighborhoods within the county that may be closer to shopping and other public services. It is interesting to note that between rural and more densely urbanized areas within the county that are connected by large expanses

of roadways, there is the possibility for a great deal of infill marked with unsightly industrial and commercial centers along a given roadway with the materialization of the previous goal. This idea is contradicted by yet another goal in the land use plan that states that Hanover County seeks to discourage the linear spread of commercial activities along thoroughfares in favor of planned commercial facilities at selected places (HCPD, 2003). This type of development is highly characteristic of linear urban sprawl for the purposes of my research. The review of the comprehensive plan for Hanover County allowed me to understand and gauge specific and general planning practices within the county. Based on analysis of the goals within the comprehensive plan for Hanover County it is apparent that haphazard urban development is likely to continue there. With low density communities, minimum lot size requirements that are relatively high, and a planned lack of connectivity between rural and suburban areas within the county, Hanover County is not seeking promote orderly development.

The current comprehensive plan for Henrico County was adopted in December of 1995 (Henrico County Planning Department [HCPD], 1995). It is made up of a 2010 land use plan and 2010 major thoroughfare plan (HCPD, 1995). The land use section of the plan deals with proposed distribution of development (HCPD, 1995). The major thoroughfare section of the plan deals with proposed residential setbacks, mixed land use types, and transportation networks (HCPD, 1995). There is also an open space plan incorporated into the overall plan that aims to guide park and open space development and acquisition (HCPD, 1995). One of the general goals for Henrico County is to encourage large tract planned mixed use developments that promote economies of sale, energy conservation, and efficient use of infrastructure (HCPD, 1995). Henrico County

does account for areas of targeted development such as the short pump area which is located in the west central portion of the county. However, this does not deal with the density or pattern at which actual development takes place. An economic goal for Henrico County is to attract new and expanding commercial and industrial activities that will increase the economic base of the community (HCPD, 1995). However, the expected location of such development and how major thoroughfares would accommodate that growth is unclear. Further, Henrico County does not appear to take into account practices of redevelopment of existing commercial and industrial areas. After reviewing the comprehensive plan for Henrico County, it is clear that there are areas within the plan that need reinforcement in order to avoid haphazard growth patterns that are synonymous with urban sprawl.

Interviews with Planners and Developers

I interviewed planners and developers within each of the three jurisdictions of interest in order to understand how developers related to and were guided by comprehensive plans set forth by the respective planning departments. It was important for me to understand how much of an effect comprehensive plans had on the ability of a developer to acquire land within the study area. I also wanted to understand the perception that planning departments had of development in their jurisdiction as well as perceptions of developers.

Hanover County Planners Interview

The interview of the Hanover County Planning Department began with a description of development over the past 10 to 15 years. The subject described Hanover County by stating that:

> "We are a suburban locality with the majority of new development being single family detached housing. Our economic focus is on commercial, industrial, and office types of development that lead to employment."

An interesting statement that the subject made was that development in Hanover County seemed to "follow the roof-top." I would later find out while interviewing subjects from Henrico and Chesterfield County that to "follow the roof-top" means that new residential areas are often followed by retail, commercial, and industrial centers.

When asked about targeted areas within the county for preservation and development, the subject discussed two areas that were set up in Hanover County in 1982.

> "We use our suburban service area and the rural planning area to guide targeted areas of development and preservation. Hanover County uses a growth management approach to concentrate development into 20 percent of the county thereby preserving the rural character of the county. By this approach, our overall goal is to avoid leapfrog development patterns."

The planning official went on to state that through the suburban service area:

> "The county has been successful in preserving the rural character of the county by requiring minimum lot sizes and concentrated development, preserving

approximately 2500 acres of land through conservation easements and minimizing development."

However, when asked about the goal of providing public services efficiently, economically, and conveniently, I was told that:

"That only applied to suburban service areas within the county and not to the residential developed areas in more rural parts of the county."

As a follow up, I asked whether the lack of services provided for rural development could lead to development pressures in between rural and suburban areas along major roads, which is indicative of linear sprawl for the purposes of my research, the subject stated that:

"We do not anticipate any of that type of development in Hanover County because of they way we have planned things."

I followed with a question regarding the County's objective of discouraging the linear spread of commercial activities along thoroughfares in favor of planned commercial facilities at selected places.

"Along U.S. Highway 360, the goal has not been met in some places because of the tremendous development pressure, but that is an issue that the board is presently dealing with."

In closing, the subject offered an overall assessment of the department’s efficacy:

"Hanover County has been very successful in implementing its plan and all of the sections of the plan have seen great coordination, which accommodates an approximate growth rate of 2.5 percent in population per year over the last 10 or 15 years."

The final question of the interview dealt with the perception of sprawl.

> "It depends on how you define sprawl but there are areas within Hanover County that are disconnected and where adequate public facilities have not been provided efficiently, but counties don't have the ability to adopt an adequate public facilities ordinance. There are legal issues involved with that. Overall, we feel that our plan has been effective in limiting sprawl because most of it has been envisioned and planned."

The idea of the dependence of sprawl on a definition would be a common point among all three of the planning departments that I interviewed.

Henrico County Planners Interview

My second interview was with the Henrico County Planning Department. As with the Hanover County Planning Department, I will only refer to the individuals as employees of the Henrico County Planning Department because anonymity was requested. I conducted this interview with two members of the Henrico County Planning Department, while Hanover County was done with one subject. This was helpful because I was able to get more than one opinion for the questions that I was asking.

The interview began with a description of development in Henrico County over the past 10 to 15 years.

> "We have seen steady growth of about 2% in population annually and over time that compiles quickly. As you keep growing with 2% it also depends on what your population is in the first place. I used to work in Hanover and with a 2% increase there, residents were very concerned, but their population is only about 80,000 where Henrico is about 260,000. We have started to see a lot of office

development, which used to be considered sprawl because it pulled away from the city core, but over the last 5 years development has been predominantly residential and commercial areas like 'short pump' town center, which is a huge tax base because it pays for itself and offsets some of the residential growth. Hanover is very residential. Henrico is probably the most mixed of land uses of the three counties that you will find. We have balanced growth and Chesterfield is somewhere in the middle. Wyndham could be called 'leapfrog' sprawl, but it was planned out as a community and there were so many pluses like water and other infrastructure that the county decided to approve it. With Wyndham, HHHunt put in about $10 million in infrastructure and utility improvements, but at the same time that opened up that entire northwest quadrant of the county to development. HHHunt benefited in the long run. Now, we are facing areas in the far eastern part of the county where farmers want to sell their land and subdivide it and there is nothing legally that we can do about their lot sizes, but that is where I would look at sprawl next."

Coincidentally, Wyndham is the exact location of a leapfrog sample site within Henrico County that I had determined prior to these interviews. The subjects went on to state that:

"In Henrico County, if the developer goes in and puts in sewer, they get paid back by the county as the county gets paid connection fees to that sewer."

The introductory question was wrapped up with the statement that:

"Our goal is to keep development at 70% residential and 30% non-residential because they don’t require as many services like schools. However, we have

maintained a 65% to 35% ratio of residential to non-residential so we have beaten our goal."

The implication of the previous statement is that Henrico County did not have to provide as many public services as they initially anticipated.

After discussing development trends over the past decade, I asked the planners about areas of targeted development and areas of targeted preservation within the county.

"We have tried to focus most of the development in northwest part of the county because it was a logical continuation of where we were with neighborhoods like Wyndham and office spaces such as Innsbrooke. Currently, it is the West Broad Street corridor out to the border of Goochland where we are looking at intense mixed uses. The county recognizes now that we are not just a suburban locality, but that we have urban, rural, and suburban development trends as well. We try to focus our preservation where there is a floodplain in the eastern part of the county; typically, but by law you can't develop there anyway. For the most part the agricultural areas have been preserved, but more and more mixed uses are being approved and we are analyzing what that could evolve into."

In talking about mixed uses and the goal of the county to encourage planned large tract development, the subjects spoke of many instances where some development has been rejected in favor of the highest mixed use for the land.

"We are starting to see results of planning for mixed uses and we do discourage certain types of land uses. For example, a developer may get different pieces of disconnected property and want to develop them separately, but we wait until they have all of the contiguous land to encourage more mixed uses."

As a follow up, I asked about minimum lot size requirements within the county. One of the subjects explained:

> "We have not had to worry about that because there is a mixture of housing types within the county already including apartments, town homes, and large single family homes where people can stay in the same community and still move to different types of housing as their income increases."

This question was followed by a question regarding the goal of attracting new and expanding commercial and industrial activities that will increase the county's economic base. The subjects agreed that:

> "Most of that type of development is also occurring in the northwest part of the county with industrial areas such as the White Oak facility, commercial areas such as Virginia Center Commons and Short Pump Town Center, and office space such as Innsbrooke."

As new commercial and industrial areas were being developed, I was interested in redevelopment efforts within Henrico County. It was stated that:

> "We are just starting to get into redevelopment with the creation of the enterprise zone in 2002 along the Nine Mile Road Corridor and Staples Mill Road. Also, the planning department has recently been split into the planning department and the department of community revitalization. Officials here are really starting to take it seriously. We want to capture certain areas before they need redevelopment by rezoning into the urban mixed uses areas"

The last part of the interview with Henrico County dealt with a departmental assessment of growth accommodation as well as a perception of possible sprawl with the

county. In discussing how effective the county has been in accommodating new growth, I was told that:

> "As long as it is a steady increase and we are planning for it, it is good because it brings in the tax base. We feel that we have been very effective and we have been able to accommodate continuous growth without sacrificing services such as schools. For example, our schools have hardly any trailers except for very high growth areas where it is temporary. We have had good management, but as the word got out about our minimum lot size requirements, people started buying a lot of land to get more lots."

It was clear that an increase in the county tax base was a priority for Henrico County. When asked about the level of sprawl over the past 10 to 15 years within Henrico County, just as Hanover County stated, it depended on how sprawl was defined. However, the subjects stated that:

> "Some people would say there has been a great deal of sprawl and some people would say there has not been any sprawl, but you have to grow somewhere. Henrico is opposed to bad growth, but, I think Henrico County is banking on building-out. If there is a choice to build-out then they will and the preservation area in the east could almost be considered a holding area for future development."

Chesterfield County Planners Interview

My third interview was with the Chesterfield County Planning Department. As with the Hanover County Planning Department and the Henrico County Planning Department, I will only refer to the individuals as employees of the Chesterfield County Planning Department. I conducted this interview with four members of the Chesterfield County Planning Department, all of whom had different levels of service with the county and therefore different opinions of development trends in the county.

This interview started just as the other two: with a discussion of development trends over the past 10 to 15 years in Chesterfield County. The subjects agreed that:

> "We are a fairly rapidly developing suburban county with our biggest development being land use for single family residential on the order of about 1.5 to 3 units per acre. We have seen an overall growth rate of 2.5% in population and residential growth. In the 1980's the county was labeled as one of the fastest growing communities in the country, but this was not true then and it is not true now. A problem is that growth has not been uniform within the county. In some areas, growth has been extremely rapid and in some areas the county has seen no growth at all. I would say that there are hot spots of development that are mostly in the western part of the county."

In discussing areas of targeted development and targeted preservation, all four of the subjects agreed that:

> "The southern and western parts of the county are targeted as a rural conservation area in 1991, but this can be confusing because they are really areas of deferred growth until utilities are appropriate for development there. This entails 20% of the

county where it is zoned agricultural and development is not allowed, but at some point in the future when utilities and other infrastructure end up out there, we may lift that limit on development in those areas for preservation. We try to use infrastructure availability as a tool for development allowances. We see the northwest part of the county as where most of the development is occurring and will continue to occur."

This view of preservation areas is somewhat synonymous with the way that Henrico County views the eastern part of that county.

An interesting aspect of the comprehensive plan for Chesterfield County is its organization, which entails sections devoted to specific villages, corridors, and areas. I asked if this was intentional and if so how effective that strategy had been in preparing for growth. Two of the senior members of the planning department stated that:

"In the past, there used to only be five areas that we called geographies and they weren't related in any way. So one of the problems was that with the way Chesterfield built out as a suburban county, people didn't relate to the idea of a community or a neighborhood, but people related to their own subdivision. So over time we started to do plans that were unique to a community. These were not necessarily thoughtful, but we did geographically determine 25 communities. So, we have been successful in creating community based organizations to help people see outside of their subdivision and the health of their community. The village plans have been more successful than the corridor plans."

The next part of the interview dealt with the level of success for the goal of "orderly development" for the county. With this question, the most senior member of the planning department replied:

> "Depends on who you talk to whether or not we are doing a good job at managing development, because we feel that our plan encourages orderly development, around the city we show higher density development radiating out into lower density development out to the rural conservation areas. Around our major transportation nodes we show mixed use types of development that take advantage of the regional transportation systems and along our corridors we show higher density development. We do try to discourage leapfrog development. Roads are another issue because roads in Virginia are up to the DOT. In Virginia, there are only two counties that manage their own transportation systems: Henrico and Arlington. They opted out of the VDOT maintenance. But, from a purely planning perspective, we feel that we do a good job at managing growth through our plan in as much as the community follows the plan."

It is interesting to note that all three planning departments mentioned leapfrog growth as a negative type of development.

In discussing zoning variances that had an affect on the comprehensive plan for the county, the most senior staff member noted that:

> "It goes back to the plan, which suggests what is appropriate and where. The system in place calls for meetings and decision on whether we can support that re-zoning from the plan. Typically our commission board is pretty adamant about sticking to the plan. Sometimes though, with the plan being a guide they may

allow a variance to the plan under certain circumstances. However, around 80% of the time development conforms to the plan. About 20% of the time development does not conform to the plan. Under those cases where development does not conform to the plan we find that there are extenuating circumstances where the plan did not anticipate the development, the plan is out of date, or the developer offers something that makes it more appropriate to the plan such as office to commercial, which is the same type of land use. In Chesterfield, a zoning ordinance implements the plan and an ordinance implements the zoning. The plan is not updated by amendments. Rather amendments are guided by the plan."

After discussing zoning variances I proposed a question of how effective the subjects felt the county had been in accommodating the 20 percent population growth from 1990 to 2000. The subjects agreed that:

"From a utilities stand point; we have an excellent system where the utilities pay for themselves called an enterprise system. It is proactive but the older neighborhoods don't have to worry. Police coverage is good, and the fire stations are somewhat catching up. Schools are their own entity with their own staff, and their philosophy is not based on geography but on programs. Other than that, for a county that has grown like Chesterfield the only problems we can report are roads and schools and they are not part of the planning department. As far as retail goes, it follows the roof-top. We are trying to prepare where we think development will occur so we can accommodate that growth. Market forces are left free to roam as long as they meet up with the plan."

It was interesting to hear one of the senior members of the department state that development often follows the roof top. This was a similar statement made about development from all three planning departments that I interviewed.

The next part of the interview dealt with the goal of promoting economic growth within the county by responsibly using existing and proposed infrastructure. The subjects stated that,

> "We have not really seen areas in the county where we have not been able to use existing infrastructure for new development, but there have been places where the county has invested heavily to encourage economic development, but I can't think of any place where we had to go back and retro-fit infrastructure to accommodate existing industry or development. There is redevelopment however along Jeff-Davis Highway in an enterprise zone. Most of the time developers take care of that and build in the capacity for the growth."

The final part of this interview was similar to the interviews with Hanover and Henrico County. I asked the subjects to evaluate any level of sprawl occurrence within the county based on the density and pattern of new development. Just as the planners from Hanover and Henrico stated:

> "Whether the patterns of development are too low, or leapfrog, or disorderly, there are some places in Chesterfield County where more efficient use of land and facilities could have taken place, but we think it is important to remember that development is dependent on the market too. We think we do a good job of managing the development patterns given the market forces that we also have to deal with. We try to offer housing choice. We have areas where you can have very

large lots with a single house all the way up to very dense areas with apartments and we think that is healthy for the community. We also try to encourage a mixed use development pattern and where that has not happened it may have developed that way. If you define sprawl as inefficient use of land and inefficient delivery of infrastructure then you have to look at what the community wants. Sprawl is based on a value system and the value in Virginia follows what the market wants. What people want is where and how the developers will build."

These statements make sense in describing the pressures of the market on development within all three of the counties I am interested in. The statement about leapfrog or disorderly development where more efficient use of land and facilities could have taken place corroborates my definitions of leapfrog and cluster patterns of sprawl.

These interviews provide important implications for my research. As stated by Zhang (2001), urban sprawl is generally believed to result from poorly planned, large-scale new residential, commercial, and industrial developments in areas not previously used for urban purposes. By interviewing planners in these jurisdictions, I was able to understand how planners could avoid 'poorly planned' new development through targeted development and conservation areas, provision of infrastructure facilities as mentioned by Sudhira et al. (2004), and redevelopment efforts. While it is not surprising that these planners would not consider their planning as ‘poor,’ the interviews indicated that growth is assumed to be inevitable and that market forces and the availability of land take precedence over the process of planning for new development. The necessary progression from interviews with planners was to discuss development with developers

who are often guided by suggestions made by planners. In order to understand this type of pressure, I had to discuss development with developers.

Hanover County Developer Interviews

The interviews in Hanover County began with John Gibbs who developed Pole Green Station. Pole Green Station was my example of linear sprawl in Hanover County. I began this interview by asking Mr. Gibbs about how comprehensive town or county plans affected his ability to buy or develop land in Hanover County. Mr. Gibbs replied that:

> "They have tended to drive the price of land up because there are so many regulations. It has been difficult to buy land because of those regulations."

Mr. Gibbs went on to say that the reason they chose to develop this land as opposed to any other parcel of land was because:

> "We were able to buy it and we were not able to buy other pieces. The land was available. An estate owned it and they wanted to sell it."

I asked Mr. Gibbs if he owned or would own any other land in the area to which he simply replied:

> "Yes, I would and we currently own land in Henrico, Goochland, Fluvanna, and Albemarle."

After the third question, the interview began to get more in depth with the last three questions.

In the second half of the interview, Mr. Gibbs started off by discussing a disadvantage to owning this parcel of land by saying:

"Well, Hanover as most counties don't want residential development so that they can put proffers on us in order to develop land, which means in order to get a lot approved, we have to pay as much as $10,000 or more, which I call blood money. This has had the effect of driving the price of the land up. The most difficult regulatory obstacle in developing this land by far is the wetland and the Army Corps of Engineer requirements."

This interview ended just as the others, with a discussion about the perception Mr. Gibbs had about urban sprawl in the area. Mr. Gibbs apprehensively stated:

"I guess urban sprawl is urban growth and yes it has taken place in Richmond over the past 10 to 15 years. More people require more police and fire protection. They require more schools and more roads. I think Henrico is orderly as well Hanover and overall the Richmond area. With so many regulations, it is difficult to develop something in a haphazard way and a haphazard development would not make good business sense. I call some people coming from the North 'draw-bridgers,' because they get to a spot and develop and then pull the drawbridge up and don't want any other development to occur after them."

My second interview in Hanover County was with Robert Jeter who developed Laurel Meadows subdivision. Laurel Meadows was my leapfrog example of sprawl within the county. Mr. Jeter started the interview by stating that:

"It has become more difficult to develop land in Hanover County because of all of the regulations."

He stated that he chose to develop this particular parcel of land as opposed to any other parcel of land within Hanover County because:

"I was able to purchase the land and it was available. I started the utilities out there, which I got reimbursed for after people started paying their connection fees to the county. Because there were utilities out there, it opened up the area for other development."

I followed up this question by asking Mr. Jeter if he owned or would consider buying land in any other county to which he replied:

"No, because I am more familiar with the way Hanover County works and the area in general."

When I asked Mr. Jeter about advantages or disadvantages to owning and developing this land, he stated that:

"Because of all that you have to go through in order to develop land, it is three times as expensive as it used to be."

I went on to ask Mr. Jeter about difficulty with regulatory obstacles to which he replied that:

"There was not much in the way of regulatory obstacles, but the guy who owned the land did not really want to see anything happen to it."

I ended the interview by asking Mr. Jeter to discuss urban sprawl in the area over the past 10 to 15 years. Mr. Jeter stated that:

"Hanover County is growing but now there is no affordable housing in the county. Everything is too expensive and that is because of all the regulations that developers have to get around, which makes it more expensive and those cost are transferred directly to the buyer."

My last interview in Hanover County was with Robert M. Atack whose company developed Ash Creek subdivision. Ash Creek represents my cluster example of sprawl within the county. Mr. Atack began the interview with some extremely interesting statements:

> "We are in the business of making money. The comprehensive plan in Hanover County was receptive to residential development, we bought Ash Creek and there are two things that drive us: profit and we are tremendously driven by our own ability to capitalize real-estate. It is a highly capitalized business. In the phone book there are three pages of builders but only three total developers because there is a high risk involved. We don't know if the market will turn around by the time the development is approved. In Ash Creek, we have had tremendous success with over 600 homes. Now Hanover County has made it very restrictive to develop there. We are developing land in Hanover County that is 600 acres and we are only getting 60 homes on that land because the county has a zoning ordinance. The county underwrites 10 acre lots. This is the worst thing for sprawl because we are running roads all over the place and the state has to maintain those roads. Also, school busses have to go all over the place to get the kids. Now, this is what Hanover County has done and not the developer. We go with what the market wants! Politics reign."

After an extremely informative introduction Mr. Atack went on to say that:

> "We chose this parcel of land because we had experience with the property across the street from it. We were able to economically pull it off and we took a risk that worked. It had the infrastructure there and it was zoned accordingly."

In discussing the purchase or development of land in other counties Mr. Atack stated that:

> "We own land in all of these jurisdictions for development purpose. All of these are economic decisions based on market positions and our ability to capitalize those deals. In other words, we are looking for a reward but we also have to take into account the risk. The market could go away. Interest rates can go up and unemployment. With interest rates, if they go up, then we have a double edge sword because it is more expensive to develop and slows down the buyers' ability to buy."

As far as advantages or disadvantages to the development of this land, Mr. Atack said that:

> "It was already zoned and it had governmental approval. The county could not affect us very much with this."

I went on to ask Mr. Atack about difficulty with regulatory obstacles in developing this land, to which he replied that:

> "Economics is always the most difficult effect on any land. The government and zoning is [Sic] always a major affect on land. Wetland legislation affects development of land. Of course, the wetlands legislation affects availability of land and it can be very arbitrary. They say it's a science, but they don't have any scientist working there. In the past, anything that was wet, they said put a pipe in it and drain it. I don't understand wetlands myself and I don't understand the concept or the benefits. I hope there is a benefit because the costs are phenomenal. We spent a million dollars in two years messing with some wetlands and I'm not sure I

understand what the benefits were. I hope they saved a salamander or something along the way, I'm not sure it did."

To end this interview, Mr. Atack discussed whether or not sprawl has taken place within the Richmond area over the past 10 to 15 years by stating that:

"It obviously has and we just discussed 600 acres with only 60 lots, which is a perfect example of it. What people say idealistically is we don't want it, but really don't put this in my back yard, move everybody back down there into the city because that is where they belong. Well, when the market is agreeable to that, it happens. It happened in Baltimore and Northern Virginia and you have those dynamics. We are seeing some of this in Richmond, but not affordable housing. So, urban sprawl is sort of a text-book answer in that it is what it is and we have plenty of examples of it. The fault lies politically number one. Planning departments have some of the reflections of the politics that drive it. It comes from up down."

This interview was extremely informative and it really helped me to interpret some of the development in Hanover County.

Henrico County Developer Interviews

In Henrico County, I interviewed HHHunt; a very large development and real estate corporation in the area. HHHunt developed all of my sample sites in Henrico County. My example for leapfrog development in the county was Wyndham. My cluster example in the county was Wellesley and my linear example was Twin Hickory. The interview began with the subject stating that:

"Comprehensive plans do have an affect on our ability to develop land because the first thing we look at before we try to develop land there is the land use plan. With all three of these developments, we feel like they were in line with Henrico County's comprehensive land use plan."

The subject went on to state that the reason they chose to develop these particular parcels of land was because:

"First of all, the location was right and the west end of Henrico County is one of the most desirable places to live in the area because of good schools, accessibility to facilities such as the Innsbrooke office center, and good infrastructure. We specifically picked these parcels of land because we develop larger master planned communities."

The subject also stated that:

"We would consider purchasing land in other counties and we own 500 acres in Chesterfield County that we are currently developing as an 1800 unit community. We also own land in Hanover County. We have looked at developing land in New Kent and Goochland County as well."

In discussing the biggest advantages or disadvantages to owning and developing these parcels of land, I was told that:

"We have been in the Richmond area for over 15 years so we have a good relationship with Henrico County as far as rezoning goes."

I asked the subject about difficulty with regulatory obstacles in developing Wellesley, Wyndham, and Twin Hickory to which he replied:

"All three have been somewhat affected by zoning, but for the most part they are in line with the land use plan for the county. As far as environmental regulations like wetland restriction, Wellesley and Wyndham were not as affected by them because they are older, but we just try to avoid repercussions of those regulations in the first place."

This interview ended just as all the other interviews, with a discussion about the perception of sprawl over the past 10 to 15 years in the Richmond area. The subject stated that:

"In some ways sprawl has probably taken place. It is better if you can use existing infrastructure. The challenge is finding land close to that infrastructure and other utilities."

Chesterfield County Developer Interviews

The interviews in Chesterfield County started with Oliver D. Rudy who developed Sidlaw Hills at the Highlands. This development was my sample site for a leapfrog pattern of urban sprawl. Sidlaw Hills at the Highlands is a smaller section of a larger development in Chesterfield County; The Highlands (Figure 4.13). I began the interview by asking Mr. Rudy about the extent to which comprehensive county plans have had an affect on his company's ability to by land there. His response was that:

"It has become increasingly more difficult to develop in Chesterfield County and the county is doing whatever it can to stop growth. Often money has to be paid to the county in order to develop there."

He informed me that as a result of Sidlaw Hills at the Highlands, the county adopted a septic tank ordinance because there were no sewer lines in the area at the time. The

question was followed by a question regarding why Mr. Rudy decided to develop this parcel of land as opposed to any other parcel of land within the county. Mr. Rudy stated that:

> "The price was right, the land became available, and interstate 288 was in the works and would be close by."

I followed this question by asking whether or not he owned or would consider purchasing land in any other county to which Mr. Rudy conceded:

> "Any land in the Richmond area with good soil and good infrastructure would be open for development."

The second half of the interview consisted of questions regarding advantages and disadvantages to developing this site, regulatory obstacles to developing this site, and a personal perception of urban sprawl. Mr. Rudy stated that:

> "The biggest advantage to developing Sidlaw Hills at the Highlands was the fact that there was no public sewer in place, which allowed for larger lot sizes, the installation of a golf course, and an overall attractiveness to the neighborhood. Some people would consider the lack of utilities and other infrastructure a disadvantage but the larger lot sizes are very nice."

When asked about regulatory obstacles to obtaining the land for development, Mr. Rudy replied:

> "One of the county planners on the board of supervisors that heard my case about the septic tank ordinance did not want to sign off on it, he just abstained and the measure was still approved. This particular board member did not want to approve the development without public sewer."

In closing, I asked Mr. Rudy to comment on his perception of urban sprawl, to which he replied:

> "I think of it as subdivision after subdivision with no rhyme or reason to it. Urban sprawl is a government word not a private word and people want to live where they want to live, so the market drives development and those numbers speak for themselves. I think urban sprawl is a scare word used by those who don't want any development at all."

My second interview in Chesterfield County was with Hank Meyer who developed Gates Mill, which is part of the Woodlake community. Gates Mill was my sample site for a cluster pattern of urban sprawl in Chesterfield County. The interview started by Mr. Meyer stating that:

> "There was no plan in place for Chesterfield County when Woodlake came about. Back then, there was zoning and at that time the land was owned by us and it was zoned agricultural. We had to get a PUD zoning approved for the development of the land and the county was very accommodating in that."

A PUD zoning ordinance gives a developer the ability to develop land with variation from the stated zoning. When I inquired about why Mr. Meyer and his company chose to develop this parcel of land he stated that:

> "We owned it to begin with and the orientation with the lake, the proximity to route 360, and the cooperation of the county to this development gave us the impetus to develop Woodlake and Gates Mill."

I followed this question with a question regarding ownership of other parcels of land in the Richmond area to which Mr. Meyer said:

"We have developments in New Kent and we are working on a project adjacent to interstate 64 in the Bottoms Bridge area. We are also working on a redevelopment project in the city and we are always looking for land to develop, but the competition from other developers and the lack of available land makes it hard to come by."

In the second half of the interview, Mr. Meyer stated that:

"The location of the development in terms of the lake and access to route 360 was a big advantage. Again, the County of Chesterfield has been extremely cooperative in the formulation of the PUD zoning and as a matter of fact, we wrote the zoning ordinance and the county followed suit, which is quite unusual."

In response to the question regarding the most difficult regulatory obstacle, Mr. Meyer stated that:

"The Clean Water Act and wetland regulations are the most difficult obstacles to development. The whole process is getting extremely complicated and I guess that is progress but it has made it difficult in developing and even obtaining land for development."

Mr. Meyer commented on urban sprawl in the Richmond area by saying:

"Honestly, urban sprawl has been somewhat constrained by the availability of utilities and Chesterfield County has fashioned their zoning and planning to consider that."

My final interview in Chesterfield County was with the Salisbury Corporation in regards to the Michaux Section D of the larger development; Salisbury. The Michaux

Section D of Salisbury was my sample site for a linear urban sprawl pattern. The interview began by the subject stating that:

> "The Salisbury Corporation was formed in 1956 so most of the property here was acquired before the current regulations were put in place and the road system was put together back in the early 1960's."

When I asked why The Salisbury Corporation decided to develop this parcel of land, the subject stated that:

> "The corporation acquired the 2500 acre tract in 1956 and developed it as it went through. The Michaux section was on the community plan even then and did still have to go through some rezoning in 1987."

In discussing the possibility of purchasing other land within the study area, I was told that:

> "The Salisbury Corporation only deals with the Salisbury development but some of the principles of the company do own other land in Chesterfield, Henrico, and Powhatan. So, I guess as the opportunity presents itself you just have to look at what is available and what are the regulations and the ramifications that apply to it."

The next part of the interview started by me asking what the biggest advantage or disadvantage of owning this parcel of land was. The subject stated:

> "The biggest advantage is that we acquired the land in 1956. It was zoned in accordance with our master plan when zoning originally started because there wasn't much zoning in 1956. So, we were able at that time to basically acquire the zoning that we thought was right for a community of this size. So, when they went

to their zoning, this property never had to go through the zoning process. I think the zoning process today is very cumbersome and expensive from a developer stand point. Sometimes with zoning, they seem to listen to vocal people give their opinions as opposed to what is really the best land use for the county."

I followed the previous question by asking what had been or was the most difficult regulatory obstacle in developing this land. The subject replied as follows:

"We did not really have to go through any regulatory processes when the land was acquired but since that time we have had to go by the current rules and regulations and guidelines that have been implemented since we started our development. So, we did our master plan based on the standards that were in effect in the late 1950's and early 1960's. When we develop adjacent land, we have to look at drainage requirements, best management practices and other wetland criteria. Some of those regulations, we feel, don't allow you to create the best development that we could. If you save an acre of wetlands in the middle of development that was created by a drainage blockage and all it does is create a mosquito pool as opposed to something along the James River or a 100 or 1000 acre site, it is more expensive to develop and there are a lot of costs added because of government regulations and the time it takes to go through the process doesn't add value to the development. You are just increases cost without adding value."

In closing this interview, I asked about the perception of urban sprawl in the Richmond area over the past 10 to 15 years. The subject said:

"I, to some extent understand urban sprawl, but this community was designed to be a 2500 acre community with 5, 2, and 1 acre lots with some of the property built up

> as condominiums, townhouses, apartments, and village center commercial. So, we think it was designed to be what it is today and what it has become. A premier neighborhood in Chesterfield County and if you look at it today, it was started in 1956 and it looks somewhat similar to the streets downtown. But, we found that a lot of people wanted to have a half acre or a one acre lot so you have to have the right blend there."

While planners sought to shape development in their jurisdiction through targeted areas for growth and conservation, they were sharply contrasted with attitudes of developers whose objective is to make a profit on an investment. The study done by Zhang (2001) showed that social-economic factors were most important for the attraction of a community to a new development, which can lead to sprawl. It was apparent after interviews with developers that they wanted to take advantage of this attraction to new growth. While Gillham (2002) states that it is regulations, standards, and practices that largely determine the shape, size and configuration of the land subdivisions, houses, cul-de-sacs, parking lots, and strip commercial development that have come to characterize our sprawling suburbs, it is also the attitudes that Americans have about their right to land ownership combined with market forces that are preconditions to sprawl. By interviewing developers in the Richmond area, I was able to understand not only attitudes that Americans have about land ownership, but also stances that developers take on market forces and their ability to capitalize on an investment. There is consensus that the Federal government impedes local development.

Interpretation

Map Interpretation

The maps of urban or built-up land cover show that new urban growth has occurred within the study area. Without urban growth, there would be nothing to classify as urban sprawl. The percentage of natural to urban ground-cover change over the nine year time period increased by almost 25%, a great deal of change that provides a strong chance that a substantial amount of urbanization in Richmond, Virginia over the period of time between 1992 and 2001 could be classified as urban sprawl. By including road data, I was able to visualize clearly where patterns of linear sprawl were taking place. Leapfrog patterns of sprawl appeared to be somewhat disconnected from other areas of existing or new urban growth areas. Cluster patterns of sprawl appeared to be part of existing built-up land. Cluster patterns also appeared to grow out of what was once a leapfrog pattern of development in some areas. However, the patterns of sprawl represented in my research are not exclusive of neighborhood statistic calculations that give measurements of the density of new growth areas and display the connectivity and fragmentation of those new growth areas. The maps that I produced with the neighborhood statistics are important in showing where urban land density increased and decreased. There is a clear increase in the density of urban land to the southwest of the city in Chesterfield County. However, increases in urban land density are apparent throughout the study area (Figure 4.11) & (Figure 4.12).

Neighborhood Statistics Interpretation

Neighborhood statistics were performed on the land use data in order to understand and visualize how disconnected and dense patches of new growth were. It was clear with the density maps of urban land in 1992 and urban land in 2001 where the greatest level of increased urban density took place. In addition to the density of urban land in 1992, 2001, and new urban growth, this technique allowed me to examine how disconnected areas of growth were. The highest density of new urban growth occurred to the southwest of the city in Chesterfield County. The lowest density occurred in Hanover County while Henrico County experienced moderate new urban growth density. I did not take into account the density of new urban growth in Richmond because new growth was minimal within city limits and the results that I was most concerned with were growth densities and patterns in the counties that surround the city. Neighborhood statistics not only allowed me to view the density and connectivity of new urban growth but it also allowed me to quantify density of new urban growth within a specified window of one kilometer by one kilometer. Putting categories of low, medium, and high density on new growth, as the well as the ability to display how connected patch densities are, was crucial in clarifying the quantification of urban sprawl for the purposes of my research.

I found that there was a mix of low, medium, and high density development throughout the study area. The threshold for these densities was approximately 0-400 30 meter pixels per square kilometer for low density, 401-700 pixels for medium density, and 701-1200 pixels for high density (Table 3.2). By creating density maps, I found that there is not a single city center but that the Richmond MSA is polycentric as stated by Gillham (2002) in regards to Los Angeles. The findings with regards to the

neighborhood statistic calculations revealed that density of new development in Richmond, Virginia is variable and highly disconnected in many places (Figure 4.10). Neighborhood statistics allowed me to view my findings as had Wilson et al. (2003, 284),

> "The model can be used to describe urbanization processes in a way that offers insight into changing and emerging landscape patterns, without applying subjective labels."

Interpretation of Comprehensive Plan Analysis

Studying comprehensive plans for each jurisdiction was an important part in clarifying something that may be called sprawl when in fact that particular growth was planned. It is difficult to label new development as sprawl when the planning department has set forth guidelines for that new growth. I interpreted the comprehensive plans for Chesterfield, Hanover, and Henrico Counties as plans that do accept growth but only in certain areas. In each of the comprehensive plans that I reviewed, there were areas that needed reinforcement in order to curb urban sprawl. Despite inclusion of basic growth management principles the comprehensive plans for Chesterfield, Hanover, and Henrico Counties did not directly mention urban sprawl. Goals such as minimum lot sizes and facilitating public services for rural communities sound great in principle but are not necessarily feasible without the proper infrastructure. If communities are disconnected then the infrastructure in between them has the potential to become lined with commercial and industrial activities and create patterns of linear urban sprawl. In Chesterfield County, areas of deferred growth mentioned in the comprehensive plan have become developed from 1992 to 2001. After reviewing the comprehensive plans for each jurisdiction within the study area, it is clear that there is a difference in planning for the

placement of new development and allowing new development to occur in a haphazard manner. Goals and implementation are sharply contrasted through a review of the comprehensive plans for the three counties.

Based on my interpretation of county plans, a plan is not a remedy for the pattern and density at which new urban growth proliferates therefore creating urban sprawl. Rather, a comprehensive plan is a set of guidelines that the county should follow and goals therein must be implemented in order to avoid haphazard, sparsely concentrated, disconnected development patterns. I found the comprehensive plans to be generally well organized, easy to read and interpret, and well thought out on a county by county basis.

An interesting topic that was not very prevalent in the comprehensive plans was redevelopment. Thomas (2002) found that the value of redeveloping brownfields has become an undependable deterrent to sprawl. Lee et al. (1998) argue that as urbanization proliferates, the issue is not really sprawl versus compact development forms, but whether urban growth should be planned for more efficiently with growth management policies. It appears that growth management goals are present in all three of the comprehensive plans that I examined. Further, Gillham (2002) concedes that zoning or lack there of cannot be blamed too much for sprawling development because cities like Houston, which has zoning is dramatically different from places like Nantucket where zoning bylaws do work to protect the historic character of the area. With aspects of market forces and economic initiatives present in all three comprehensive plans, responsible growth is also a preferred goal with respective to new development in these three jurisdictions.

Interpretation of Interview Responses

All of the planners and developers I spoke with knew there was a great deal of urban growth from 1992 to 2001. There was one primary response from all three of the planning departments. They believed that development of all kinds seemed to "follow the roof-top." This was followed by a general sense that development in the Richmond, Virginia area is not as much driven by a set of guidelines found in a comprehensive plan, but rather by the market forces at work in the area. Coincidentally, all of the developers I spoke with agreed that one of the major factors in developing land was how profitable it would be. The Chesterfield and Henrico County Planning Departments were very open to the idea of growth and were willing to work to accommodate that growth in return for an increase in the economic base. However, Hanover County did not seem to want any growth at all and were admittedly in a different position than the other two counties with regards to population.

In Henrico County, the comprehensive plan followed development rather than the development following the guidelines set forth in the plan. This also was the case for Chesterfield County where Mr. Meyer and the subject from the Salisbury Corporation implied that they wrote out what type of zoning they needed for their developments and the county approved. The subject from the Salisbury Corporation mentioned that,

> "It was our company who [sic] wrote the zoning that we felt was appropriate for the entire Salisbury community."

It also appeared that market forces were highly influential in the development trends of Henrico and Chesterfield Counties. In Henrico County, the planning department mentioned a possible example of leapfrog development in the county as Wyndham,

which coincidentally was the exact neighborhood that I sampled for a leapfrog pattern of development.

What makes Hanover County different is the fact that its population of 86,320 in 2000 is not as great as that of Henrico (262,300 in 2000) and Chesterfield County (259,903 in 2000) and residential developments are not as dense. While the comprehensive plan for Hanover County seems to be extremely restrictive on growth, it appears as though when growth does occur in the county, it is synonymous with low density 'bedroom' communities with no sense of place or connectivity to any other developments or commercial centers. In rating which counties have experienced the most sprawl, I would say that development patterns in Hanover County are most indicative of sprawl even though the density of new development is lowest in that county. Hanover County is followed by Chesterfield County and lastly Henrico County. This is ironic because the density of new development is greatest in Henrico and Chesterfield, but the pattern and character with which development has occurred in Hanover is synonymous with sprawl. In Hanover County, low density disconnected developments are encouraged as in the example that Mr. Atack spoke of in which a new development of 600 acres only has 60 lots. As developers seek to develop land in Hanover County, they are driven not only by the ability to make a profit but also by the way in the county plans new development. Mr. Atack suggested that Hanover County is encouraging urban sprawl because the developments are low density and spread out, which means that people have to drive further and many public services are limited because of the highly dispersed development patterns there.

In Henrico County, part of the comprehensive plan is focused on large tract mixed use developments. In ground truthing my sample sites in Henrico, I found that the character of those developments is highly representative of mixed use communities. It appears as though the comprehensive plan for Henrico County has been adhered to by the developers of my sample sites. However, some of those developers suggested that Henrico County has been so accommodating in re-zoning and other ordinances that it was the developer who wrote the standards with the respective counties that followed suite. In fact, just as Mr. Meyer and the subject from the Salisbury Corporation stated in regards to Gates Mill and The Michaux Section D in Chesterfield, the same type of cooperation was common for Henrico and HHHunt with Wyndham and Twin Hickory. However, in Henrico those developments did match up with the types of communities that were planned for by the county: large mixed use tract developments. This also falls in line with the goal of Henrico to increase the tax base there. Both Chesterfield and Henrico Counties have taken steps to accommodate population growth and other development forces that can create the appearance of sprawl. Hanover County is markedly different from Chesterfield and Henrico County because while it has controlled population growth by way of restrictive development standards, the county has not been able to create high density new residential developments.

Chapter 5: Discussion and Conclusion

Quantitative Results

I reached quantitative conclusions for this research through GIS data collection and analysis, neighborhood statistic calculations, and visual detection of sprawl patterns. The quantitative results of this research generally support the first hypothesis found in chapter one. It is apparent through quantification of the pattern, density, and shape of new growth areas that urban sprawl is a part of urbanization processes in the Richmond, Virginia area.

Land Use Change 1992 to 2001

There is a clear increase in the amount of urban land from 1992 to 2001. The increase in built-up land use was visible with a cursory analysis of reclassified maps of the NLCD sets and confirmed through further calculations showing increases in the percentage of urban land. In 1992 urban land constituted approximately 15% of the study area. In 2001 urban land accounted for approximately 20% of the study area. The initial review of land use / land cover maps and the fact that urban land increased by approximately 25% over the nine year time period, facilitated the idea that urban sprawl patterns would be detected within the study area because without any new urban growth, it is not possible to have any urban sprawl.

It must be noted that classification schemes were not identical with regards to NLCD sets. As stated in the methodology section, the 1992 data is based on actual land use / land cover type. The 2001 National Land Cover Data set is based on the impervious cover of the land, which indicated urban or built-up land for the purposes of my research.

The classification in 1992 is based more on a traditional classification of satellite imagery, where the 2001 data are based on imperviousness of the land cover (United States Geological Survey, 2004). I used four classes from each year (Table 3.1) to determine the extent of sprawl within the study area. From 1992 to 2001, the differences in land cover / land use classifications did not justify discarding this data for my research. I was comfortable using these classes to represent urban land because they could only represent a built-up or developed landscape.

Patterns of Urban Sprawl

I based initial patterns and classifications of new growth as urban sprawl on a visual assessment of maps showing urbanized land throughout the study area. I also based my initial classifications on the recognition that a parcel or patch of land changed in 1992 from a given land use to urban or built-up. I detected many possible patterns of urban sprawl outside of the city limits based on land use change from non-urban to urban. The farther from the city the particular land cover, the more visible these patterns became. This seems to be because there is so much urban or built-up land in the actual City of Richmond that it was difficult to detect any land use change there. It comes without surprise that most of the patterns within the city would be characteristic of urban growth. However, as the city grows, it often takes the shape of what some would classify as a cluster pattern of urban sprawl.

Because the study area as a whole did see a dramatic 25% increase in urbanized land cover, it was not difficult to detect any of the possible patterns of sprawl that I was interested in; linear or strip along highways, cluster or expansion, and leapfrog or relocation. This is because the first step in discovering sprawl patterns in my research

was to determine the level of urbanization over the given time period. Following the recognition of new urban land, I was able to use different color schemes with the mapping capabilities in the GIS to show the urban land from 1992 in grey and urban land in 2001 in red. This made it much easier to visually see where I could find cluster and leapfrog patterns of urban sprawl.

Incorporating transportation data greatly facilitated the recognition of linear or strip sprawl patterns. Development within the buffer zones was classified as linear sprawl because that pattern of new development was more easily detected with the inclusion of road data. While some of what I classified as linear sprawl could also be classified a cluster sprawl, there were more clear patterns of strip development along highways than away from transportation networks. Some development along the highways was very compact; indicating cluster sprawl, but the fact that it occurred along roads was indicative of a linear pattern of sprawl.

I selected final patterns and locations of sprawl from density maps of new urban growth. After running neighborhood statistics on new urban growth, areas of different densities of development were clear. This allowed me to sample one of each type of sprawl based on the density of pixels within a one kilometer by one kilometer window of analysis. The combination of density maps and road data was crucial in isolating definitive sprawl patterns: cluster, leapfrog, and linear.

Neighborhood Statistics

Using neighborhood statistic calculations in my research was important in understanding the density and connectivity of new development. This is often the basis for classifying new development as sprawl rather than simple growth. In order to

justifiably label a patch of new growth as sprawl, I felt that it was vital to be able to put a number on how dense that growth was. In the case of density, I wanted to be able to say that something was cluster because numerically, it was very dense and compact. Neighborhood statistics also strengthened my results because the data allowed me to visualize how connected new patches of growth were to other areas of development. In classifying something as leapfrog or relocation urban sprawl, I was interested in numerically reporting how dense new development was in relation to other growth areas. I also used these same data in conjunction with road data to determine where linear or strip patterns of urban sprawl were taking place.

Qualitative Results

I conducted personal interviews with developers and planners and examined land use regulations, zoning practices, and jurisdictional master plans to reach qualitative conclusions for my research. Collectively, the qualitative data helped explain some of the results of the quantitative portion of my research. The hypothesis for the second research question is supported by the data I collected during personal interviews with developers and land owners as well as examinations of jurisdictional land use regulations. It is clear that some of the new urban growth within the study area is directly related to jurisdictional planning documentation, zoning practices and ordinances, and the appeal of land to developers for profitability reasons.

Comprehensive Plan Examination

Although reviewing county comprehensive plans allowed me to gauge planning practices within each county, this approach did not explain the patterns and densities of

new development throughout the study area. Despite planned development in specified areas, the density and pattern at which that development occurred is characteristic of urban sprawl for the purposes of my research. I found the highest densities of new growth in Chesterfield and Henrico Counties. This makes sense because only Hanover County provides plans for minimum residential lot sizes. I also found contradictory goals in the comprehensive plan for Hanover County. Hanover County seeks to efficiently provide public services to the public while encouraging low-density rural development. These goals contradict one another because rural development areas are not as easily accessible as higher density development areas and therefore lack efficient public services. The comprehensive plans can explain some of the growth within the study area but they can not explain the density, pattern, and connectivity of that growth. This was a crucial part of my research because it allowed me to further understand planning practices and development trends in the study area.

Interviews with Developers and Planners

My interviews with planners and developers were extremely helpful because I was able to see both sides of the development story in the Richmond area over the past 10 to 15 years. With an increase population and development, the task of the county planning departments was to implement their comprehensive plan to accommodate new growth. Differences among the planning departments stemmed from the different goals of each county. Chesterfield and Henrico County were very interested in increasing the tax base there as well as encouraging responsible growth. While Hanover County was also interested in responsible development, they were less interested in increasing the tax base and more concerned about preserving the rural character of the county. All three of the

planning departments mentioned leapfrog development as a negative type of growth. Overall, development in Richmond over the past 10 to 15 years is largely driven by market forces and the cooperation therein of planning departments with local developers. However, there was a consensus among developers that federal regulations and planning practices helped to impede their ability to develop new land.

Although the comprehensive plans point the way about where new growth should occur, it is the developer who must find the balance between what the market wants and project feasibility. The goal for a developer is to generate the most profit from a new project, but the planning departments and other regulations are often viewed as barriers between a developer and maximization of profits. The developers I spoke with approached the interviews with the admission that their only goal was to make money and that growth had to go somewhere. The balance was found between planners who were willing to accommodate inevitable growth and developers who were willing to abide by standards set forth in comprehensive plans and other governmental regulations. Sudhira et al, (2004) suggested that while many models seek to measure urban sprawl, they do not relate to anything more than urban growth. It is therefore vital to understand what is involved in the process of urban sprawl, which entails cooperation between planning departments and developers who have the capability to avoid haphazard development patterns.

> "The inadequacy of some of these models is that the models fail to interact with the causal factors behind the sprawl such as population growth, availability of land, and proximity to city centres and highways (Sudhira et al. 2004, 30)."

In Richmond, Virginia, I was able interact with aspects of planning decisions, population dynamics, land conversion practices, and market forces in order to measure urban sprawl there.

Conclusions

Wilson argues that without a universal definition of sprawl it is extremely difficult to model (2003). Not all urban growth is considered sprawl because what is sprawl to some may not be to others. "Creating an urban growth model instead of an urban sprawl model allows us to quantify the amount of land that has changed to urban uses, and lets the user decide what he or she considers to be urban sprawl (Wilson et al. 2003, 276)." As claimed by Allen et al. (2003), the complexities of urban systems make them to difficult to address with a model based on a single approach. My research built upon the ideas of Wilson et al. (2003) who incorporated neighborhood statistics. Accordingly, I delineated a window of one kilometer by one kilometer over the entire study area to measure densities of new growth areas. Further, I created maps of the given densities to visually assess the spatial distribution of new growth areas thereby classifying them as one of three types of sprawl.

This research conceptualized urban sprawl from a geographic perspective in order to assess the spatial distribution of development patterns. I did this by using Geographic Information Systems, interviewing developers and planners, and examining planning documents within each county jurisdiction of the study area. Development patterns that exhibited characteristics of sprawl based on the literature were classified as such. By using a Geographic Information System (GIS) and taking advantage of planning documentation as well as interviews with developers and planners, I was able to answer

the two research questions posed in chapter one. The first question asked if urban sprawl had taken place based on the characteristics of new growth. The answer to this question was based on the use of neighborhood statistics which measured the density, connectivity, and pattern of new growth. So, urban sprawl did take place in Richmond, Virginia over the past 10 to 15 years based on low to high density disconnected areas of new growth. The second question dealt with why some areas were developed and others were not. In talking with planners and developers and reviewing comprehensive planning documentation, I found that the presence or absence of new urban growth was directed by zoning practices and ordinances, and largely by the profitability of land.

By using the GIS, I was able to determine densities of new urban growth and by mapping them I was able to view how connected new growth areas were to each other and the urban core in The City of Richmond. The highest densities of new growth occurred in Chesterfield and Henrico Counties. However, the most disconnected new urban growth was in Hanover County. This allowed me to sample areas of suspected sprawl in Chesterfield, Hanover, and Henrico and interview the developers of new growth. Not only was I able to describe sprawl in the study area with the use of the GIS, but I was also able to characterize the developments that were represented in my sample by ground-truthing sites and interviewing developers. Many of the developments that I sampled were high density communities that offered a wide variety of housing; the opposite of what traditional sprawling neighborhoods look like. The balance between the capabilities of the GIS and the qualitative explanations of the growth mapped out by the GIS was a crucial part of my research. I found that Richmond, Virginia was very similar to how Gillham (2002) describes Los Angeles sprawl from a jet plane window:

"Huge expressways snake out over the land, generating a wide, loosely formed network across the world below. The system is punctuated at predetermined intervals by interchanges in cloverleaf, diamond, and other geometric forms that connect to a secondary network of arterial roadways lined with glittering commercial buildings. These, in turn, lead to a winding labyrinth of neighborhood roads, a web of caterpillars connecting to the individual housing cells that make up most of the landscape below-a landscape stretching beyond the horizon (2002, xiii)."

Both the GIS and the neighborhood statistic calculations helped me describe the spatial distribution of urban sprawl in the Richmond, Virginia area. Results were fairly consistent with studies done by Sudhira (2004) and Wilson et al. (2003). I was able to create new data from existing data, which is consistent with the description by Burrough et al. (1998) of the functionality of a Geographic Information System. More importantly, I was able to quantify and map urban growth (Wilson et al 2003) thereby giving me the ability to classify new development as one of three types of urban sprawl. While mapping new urban growth was a crucial step in my research, the fact that I was able to classify that growth as sprawl based on the idea of density and connectivity of new development (Sudhira et al. 2004), was of utmost importance. The density of new development is greatest in Henrico and Chesterfield, but the pattern and character with which development has occurred in Hanover is most synonymous with sprawl. In Hanover County, low density disconnected developments are encouraged like the example that Mr. Atack spoke of in which a new development there is 600 acres but can only have 60 lots. Hanover County is most representative of the some of the ills related

to sprawl as stated by Nechyba et al. (2004); the loss of open space, the loss of the sense of community, patchwork housing, developments in the midst of agricultural land, increased reliance on the automobile, the separation of residential and work locations, and the spreading of urbanized developments across the landscape. As developers seek to develop land in Hanover County, they are driven not only by the ability to make a profit but also by the way in the county plans new development. Mr. Atack suggested that Hanover County is encouraging urban sprawl because the developments are low-density and spread out, which means that people have to drive further and many public services are limited because of the highly dispersed development patterns there.

My interviews with developers and planners revealed that urban sprawl entails more than an assessment of new growth patterns and densities. Rather, sprawl is also described by the character of new developments and the way in which they are planned. Where densities were between 0 and 400 30 meter pixels per square kilometer in the study area, sprawl was still detected because of the layout and character of the development. This was especially true in Hanover County where the density of new development mostly fell under this category. Sprawl became more apparent as I assessed the results of neighborhood statistic calculations in conjunction with interviews with planners and developers to reveal that in all cases of different densities of disconnected developments, planners where aware of the inefficiency of this growth,

> "Whether the patterns of development are too low, or leapfrog, or disorderly, there are some places in Chesterfield County where more efficient use of land and facilities could have taken place, but we think it is important to remember that development is dependent on the market too. Sprawl is based on a value system

and the value in Virginia follows what the market wants. What people want is where and how the developers will build."

"It depends on how you define sprawl but there are areas within Hanover County that are disconnected and where adequate public facilities have not been provided efficiently."

It was crucial to be able to visually assess what each of my sample sites looked like and then be able to discuss with local planning departments and developers how they felt about that growth. Urban sprawl in Richmond, Virginia is not only characterized by leapfrog land use patterns, development along highways, and low-density single use development occurring over a relatively short period of time as stated by Ewing (1997), but also by the community characteristic set forth by planners and implemented by developers described by Lee et al (1998) in that the process of urbanization and suburbanization has allowed for urban expansion into rural areas taking the form of low density development, predominantly single family residential subdivisions and strip commercial development.

"The result of this development process is commonly called 'urban sprawl.' In this form, urbanization spreads outward in a haphazard pattern, consuming more land than is necessary and creating excessive public costs for community facilities and services (Lee et al., 1998, 865).

Limitations of This Study

One limitation of my research lies in the NLCD from 1992 and 2001. Because the data are based on different ways of identifying urban or built-up land, I cannot be sure that this did not have any consequences on my results. It is possible that there was actually

more or less urban development than I found in my reclassification of the data. Also, because the 2001 National Land Cover Data set is still in the development stages, I had to get much of the data from a contractor for the United States Geological Survey. As always, with geospatial data there are certain levels of uncertainty such as the accuracy of the data. However, both data sets from 1992 and 2001 were useful in showing where built-up land was located within the study area. Therefore, the data that I used were adequate in providing information about urban sprawl trends in Richmond, Virginia.

I found some important limitations while conducting interviews with developers and planners. In general, I found both groups to adhere to the common paradigms of their professions; developers were concerned about profit and planners wanted to make sure that the market could develop within the parameters of their growth and comprehensive plans. Six out of the seven developers that I interviewed were not concerned with urban sprawl because they did not believe that there were any negative effects from this type of development pattern. For the most part developers were suspicious at best of the questions that I asked of them. Most of them wanted to discuss profitability of development as a primary objective. Conversely, the planners that I interviewed were much more concerned about sprawl and had important input as to the development in their respective county. However, most of the developers were open about why they did not feel as though sprawl was an issue in each case. They felt as though sprawl was a term used to slow growth down and that development in Richmond was simply new growth.

I did have some trouble trying to contact a developer for a potential sample site in Chesterfield County. His company had gone out of business and I was not able to contact

him at which point I chose another sample site and interviewed a different developer. There was also one developer in Hanover County that did not want to discuss anything initially. After I spoke with him a second time and explained that my interviews were for research purposes only, he agreed to meet with me. An overall limitation in my research is whether or not planning departments and developers were completely honest with me, and whether they simply wanted to be "polite" and avoid controversial issues. It became apparent that my research topic was much more politically charged than I initially anticipated it would be. Accordingly, this "halo effect" Babbie (1973) underscores how controversial the project became; more so than I initially anticipated it would be.

Implications for future research

The manner in which I examined urban sprawl within the study area leaves room for further research. In quantitatively measuring sprawl, NLCD sets could be limited to less than what I used as urban or built-up land. The classes that I used to represent urban land were simply developed classes, but some of these could be excluded to key in on low, medium, or high intensity developed uses. In 1992, I used the urban recreational grasses class, which could arguably be excluded to tease out built-up land. In my research, urban sprawl was operationalized based on the density and connectivity of new urban growth areas. The lower the density of new growth areas, the higher the likelihood that those areas would be classified as sprawl. My research is based on an analysis of development at the landscape level only. Future research on urban sprawl in Richmond, Virginia could also look at a longer period of time thereby accounting for more than a nine year time period. For the purposes of my research, nine years was a sufficient amount of time to be able to see if urban sprawl had taken place or not. I also did not include many variables

that may have influenced urban sprawl trends within the study area such as the existence of wetlands or preserved land that would inhibit the proliferation of development in a given area. In performing neighborhood statistic calculations, the size of the window used could be adjusted larger or smaller to extract different results as well. The window used in neighborhood statistic calculations is the filter that is passed over the entire study area in which densities of development are seen. In my research, that window was approximately one kilometer by one kilometer.

Qualitatively, there is also room for improvement with developers and planners as well as the reviews of jurisdictional planning documents. I would like to see future research focus more on zoning practices and the ideas that developers have about urban sprawl within jurisdictional boundaries. In order to gauge public opinion on urban sprawl, it is important to speak with more than one group of stakeholders. In my research, I was only concerned with developers and planners because I felt that they represented those that had the greatest influence on future development. However, it would be interesting to see how local residents who live in areas of high and low sprawl would respond to questions about urbanization and development. As Gillham (2002) argues, attitudes that Americans hold about their right to land ownership combined with market forces and a large industry in real estate and construction, are preconditions to sprawl and these conditions have been the same for much of America's urbanization.

> "Although land, markets, automobiles, and communications networks form the framework of sprawl development, a regulatory environment of codes and standards act together with financial practices to create the finished product (Gillham, 2002, 23)."

Just as Mr. Rudy, one of the developers I spoke with stated in regards to Richmond, Virginia:

> "Any land in the Richmond area with good soil and good infrastructure would be open for development."

Geographers often speak in spatial terms of any variable such as patterns of urban development. These spatial patterns are seen as part of a relocation or contagious diffusion process (Abler, Adams and Gould 1971). GIS and urban geography offer us tools to guide and assess the debate over the difference between patterns of urban sprawl and patterns of urban growth.

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Data Sources

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Appendix I

Semi-Structured Instrument for Developers / Land Owners	
1)	To what extent have comprehensive town or county plans had an affect on your ability to buy and develop land within this county?
2)	Why did you choose to develop this particular parcel of land as opposed to any other parcel of land?
3)	Would you consider purchasing land in any other county; Chesterfield, Hanover, or Henrico; or the City of Richmond for development purposes? Or do you currently own any land in these areas? If so, how many lots / acres?
4)	If no, why not?
5)	What has been the biggest advantage or disadvantage to owning this parcel of land, i.e. the jurisdictions flexibility with zoning and or variances, jurisdictional development strategies, profitability, or something else?
6)	What would you say has been or was the most difficult regulatory obstacle in obtaining this land for development?
7)	What does the term urban sprawl mean to you? Would you say that urban sprawl has taken place in Richmond over the last 10-15 years? If so, what would be some characteristics of sprawl as far as you are concerned? If not, how would you characterize urban growth within the Counties of Chesterfield, Hanover, Henrico and the City of Richmond?

Appendix II

Chesterfield County Planning Semi-Structured Instrument	
1)	How would you describe the development of Chesterfield County over the past 10 to 15 years?
2)	Could you discuss any areas within the county that are or were in the past targeted for development? How about any areas within the county that were targeted for preservation?
3)	I noticed that the comprehensive plan for Chesterfield County is somewhat broken up by community, village, or corridor; is there a reason behind this and to what extent has this been effective in preparing for growth?
4)	The overall growth management approach for Chesterfield County, as stated in the comprehensive plan, is "orderly development;" to what extent has this approach been successful over the past 10 to 15 years?
5)	How have zoning ordinances or variances had an effect on the overall plan for Chesterfield County, i.e. minimum lot sizes or industrial and commercial location?
6)	With and increase in population of almost 20 % between 1990 and 2000, how effective would you say Chesterfield County has been in accommodating that growth?
7)	One of the goals for promoting economic growth in the county is to "responsibly use existing and proposed infrastructure;" have there been any instances over the past 10 years or so where new infrastructure had to be put in place to accommodate a new commercial or industrial area that was unplanned?
8)	In general, it appears that the plan for Chesterfield County accepts growth and that such growth is welcomed in certain areas; however, based on the density and pattern of new development in the county, would you say that Chesterfield County has experienced any level of urban sprawl over the past 10 to 15 years?

Appendix III

Hanover County Planning Semi-Structured Instrument	
1)	How would you describe the development of Hanover County over the past 10 to 15 years?
2)	Could you discuss any areas within the county that are or were in the past targeted for development? How about any areas within the county that were targeted for preservation?
3)	I noticed that in the comprehensive plan for Hanover County, that two new zoning districts were created; the agricultural-residential district and the rural conservation district, which allows for decreased density of lot sizes and to "preserve the rural character of the county;" with a projected increase in population, could you discuss how effective those new districts have been at increasing the overall density of new development?
4)	Under the land use plan goal number two the third objective is to "encourage development of neighborhood patterns which permit a full range of public services to be provided efficiently, economically, and conveniently;" does this apply to rural residential development and if so would you say that any new roadways would be necessary to facilitate this goal?
5)	As a follow up; having rural residential development coupled with the previous objective could you see the possibility for uncontrolled development in the form of commercial or industrial areas in between residential areas if public services are to be provided?
6)	Under the land use plan goal number three the second objective is to "discourage the linear spread of commercial activities along thoroughfares in favor of planned commercial facilities at selected places;" could you describe any instances where this goal has not been met?
7)	Within the comprehensive plan for Hanover County, have any of the sections; land use, public utilities, transportation, public works, and community facilities, been more effective than others as far as implementation and why?
8)	With and increase in population of almost 27 % between 1990 and 2000, how effective would you say Hanover County has been in accommodating that growth?
9)	In general, it appears that the plan for Hanover County accepts growth and that such growth is welcomed in certain areas; however, based on the density and pattern of new development in the county, would you say that Hanover County has experienced any level of urban sprawl over the past 10 to 15 years?

Appendix IV

Henrico County Planning Semi-Structured Instrument	
1)	How would you describe the development of Henrico County over the past 10 to 15 years?
2)	Could you discuss any areas within the county that are or were in the past targeted for development? How about any areas within the county that were targeted for preservation?
3)	Under the general goal section of the land use plan the ninth goal is "to encourage large tract planned mixed use developments which promote economies of sale, energy conservation, and efficient use of infrastructure and revenues;" how successful has the county been in achieving this goal? And have there been any instances where one land use has taken precedence over another in a planned development such as this by way of zoning variances for example?
4)	In the residential goals section of the land use plan one of the goals is "to encourage planned large tract development where feasible;" are there or have there been in the past requirements for minimum lot sizes for these type of developments?
5)	One of the economic goals of the county is "to attract new and expanding commercial and industrial activities that will increase the economic base;" for the most part, where would you say that most new industrial or commercial facilities have located within the county?
6)	As a follow up; how does the county approach the idea of redevelopment in terms of new and expanding commercial or industrial activities?
7)	How would you describe the coordination between the three parts of Henrico County's comprehensive plan: The (2010) Land Use Plan, Major Thoroughfare Plan, and Open Space Plan?
8)	With and increase in population of almost 17 % between 1990 and 2000, how effective would you say Henrico County has been in accommodating that growth?
9)	In general, it appears that the plan for Henrico County accepts growth and that such growth is welcomed in certain areas; however, based on the density and pattern of new development in the county, would you say that Henrico County has experienced any level of urban sprawl over the past 10 to 15 years?

Vitae

Berkley Almeida was born in Richmond, Virginia on August 26, 1979. Undergraduate studies of Geography led Berkley to Pursue a Master of Science Degree in Geography, which he completed in the spring of 2005. Berkley will accept a job as a geospatial analyst with the National Geospatial Intelligence Agency (NGA) in the summer of 2005. He will possibly pursue a PhD sometime in the future after working for the government for some time.