

Identification and Analysis of Future Land-Use Conflict
in Mecklenburg County, North Carolina

by

Antonio Cotroneo

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DEDICATION

I dedicate this document to my wife for her constant support, and to my son, who has inspired me throughout this process.

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LIST OF ABBREVIATIONS

LUCIS	Land Use Identification Strategy
GIS	Geographic Information Systems
MSA	Metropolitan Statistical Area
FLUAM	Florida Land Use Allocation Method
GDB	Geodatabase
SUA	Single Utility Unit
MUA	Multiple Utility Unit
CMUA	Complex Multi Utility Unit
AHP	Analytical Hierarchy Process
UA	Utility Assignment
CSD	Conflict Space Diagram

ABSTRACT

Mecklenburg County is growing at an alarming rate and as a result the region is faced with the threat of rapid land use change. Since 2000 the population of the region has grown by 32 percent and the United Nations estimates an additional 71 percent population increase by the year 2030, placing it amongst the fastest growing metropolitan areas in the country. This growth is driven by sociodemographic, economic, and biophysical factors such as: an expanding young professionals demographic, high quality of life, proximity to outdoor recreation, and booming manufacturing, travel, energy, sports, and financial industries. Due to these trends it is crucial to project the magnitude and location of future expansion for the region to aid and support sustainable decision making. Visualizing how land-use change will be spatially distributed, and where competing land-use classifications will be in conflict, leads researchers to examine alternative scenarios and actions for the future of a region. This study isolated and quantified land that will be in potential future conflict, and examined four future land-use scenarios for Mecklenburg County, NC using an adaptation of Margaret Carr and Paul Zwick's Land Use Conflict Identification Strategy (LUCIS) model. LUCIS is a goal driven Geographic Information Systems (GIS) model that produces a spatial representation of where agriculture, conservation, and urban land-use suitabilities will be in future conflict and helps illustrate potential future alternative land-use scenarios (Carr and Zwick 2007). The analysis' results highlighted the escalating drive for future urban expansion into agricultural land, the persistent effort to conserve only those lands currently in conservation, and the continued push of agricultural land to the county's periphery. In addition, the four future land-use scenarios provided a simulated, potential view of the future through the lens of stakeholders who represent the interests of each land-use designation. Overall, this study successfully yielded the requisite information products for utilization by actual stakeholders to iteratively work through similar modeling efforts to assist future planning efforts.

CHAPTER 1: INTRODUCTION

Mecklenburg County is growing at an alarming rate and as a result the region is faced with the threat of rapid land-use change. The causes of land-use change are shared amongst a variety of players, but in general, choices made by developers, businesses, and government entities lead to the promotion of land-use decisions that serve their specific interests. Visualizing how land-use change will be spatially distributed, and where competing land-use classifications will be in conflict, leads researchers to actively engage in empirically based design to illustrate alternative land-use scenarios for the future of the region.

This study identified and quantified the amount of land that will be in potential future conflict, and examined four future land-use conflict scenarios for Mecklenburg County, NC using an adaptation of Margaret Carr and Paul Zwick's Land Use Conflict Identification Strategy (LUCIS) model. LUCIS is a goal driven Geographic Information Systems (GIS) model that produces a spatial representation of where agriculture, conservation, and urban land-use suitability will be in future conflict and helps illustrate potential future alternative land-use scenarios (Carr and Zwick 2007).

GIS is an integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes (Wade and Sommer 2006). A GIS provided this study a framework for gathering and organizing the requisite spatial data and land-use related information so that it could be displayed, analyzed, and properly disseminated.

1.1 Motivation

Mecklenburg County, nestled in southern North Carolina along the South Carolina border, is home to the city of Charlotte and a collection of expanding small to mid-sized cities (Figure 1). According to the U.S. Census Bureau, the population of the Metropolitan Statistical Area (MSA) that encompasses Mecklenburg County has grown by 32 percent since the year 2000. This compared to the U.S. national average of 9.7 percent growth, places the region among the fastest growing metropolitan areas in the country (Chesser 2012). In addition, the United Nations'

Department of Economic and Social Affairs, Population Division estimates an additional 71 percent population increase by the year 2030 (Chesser 2014).

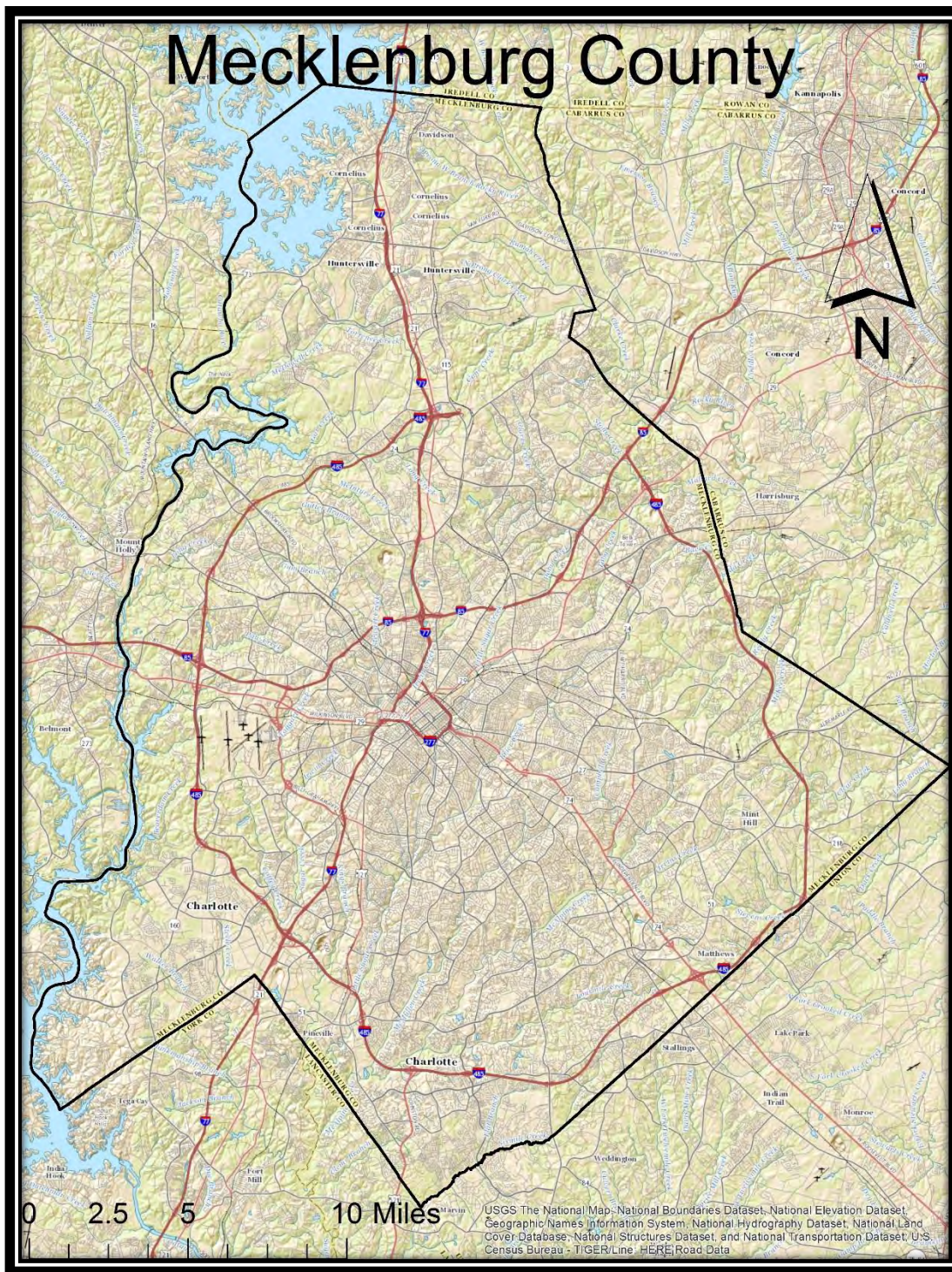


Figure 1: Mecklenburg County

This growth is driven by sociodemographic, economic, and biophysical factors such as: an expanding young professionals demographic, high quality of life, proximity to outdoor recreation, and booming manufacturing, travel, energy, sports, and financial industries. Due to these trends it is crucial to project the magnitude and location of future expansion for the region to aid and support sustainable decision making. If left unmanaged, it could result in inefficient land use designations. A solution to this problem is the geodesign framework, which provides planners, designers, developers, and other community stakeholders a framework to make thoughtful and informed decisions on how to best utilize or preserve land in the study area — now and in the future.

More specifically, geodesign is a design framework and supporting technology that leverages geographic information to create designs that more closely follow natural systems (Esri 2014). In recent history this design paradigm has evolved to include studies conducted in regions around the world that expose relationships between humanity and geography. By integrating design with a combination of science- and value-based information, geodesign uniquely supports a better-informed communal decision making process that curates designer-public collaboration. It brings people together so that participants from different backgrounds and points of view can run what-if scenarios based on their assumptions and assess the consequences of those assumptions (Esri 2014).

In practice, geodesign is performed by practitioners of varying positions along the technological spectrum. There are those who leverage low-tech spatial workflows based on analog information products, such as paper maps, to derive analytical products. And then there are those who build their modeling capabilities on foundations of computation, such as GIS. Both approaches are fundamentally rooted in the same process and functional theory, but choose to execute their iterative methodologies in different manners. Those choices may be based on a variety of factors from the collective knowledge and experience of a project's participants to the data or functionality requirements of a particular stakeholder group (Steinitz 2012).

Scholars across the technological spectrum have influenced the use of geodesign techniques in scenario planning and alternative futures analysis. An example of one of those individuals is Carl Steinitz. Steinitz's (et al. 2003) *Alternative Futures for Changing Landscapes: The Upper San Pedro River Basin in Arizona and Sonora* set the standard for alternative futures

and scenario planning analyses by establishing the most concise and detailed geodesign workflow to date (Figure 2). This workflow consists of six questions that are asked throughout three iterations. Each question produces visualizations that ultimately comprise any number of future scenarios for a particular study area. While Steinitz's model first appeared in his 1990 paper *A Framework for Theory Applicable to the Education of Landscape Architects*, it was the Upper San Pedro River Basin project that saw the research framework function at a more mature capacity.

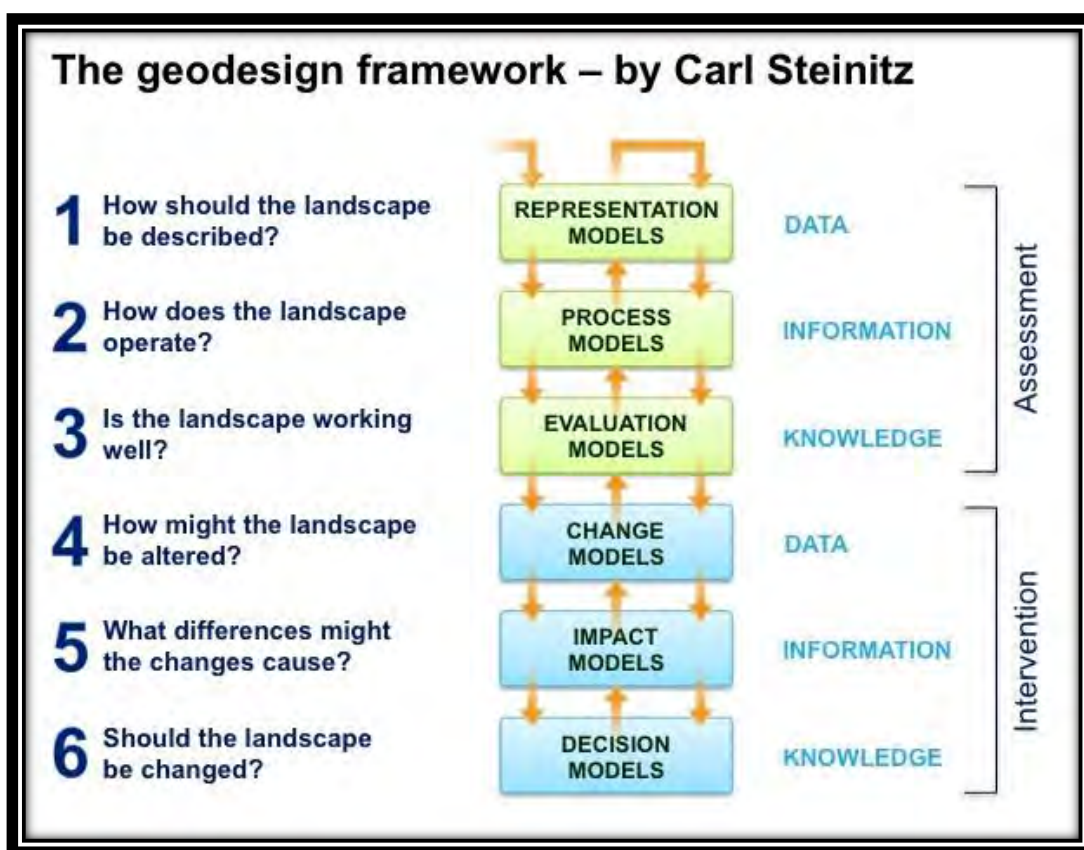


Figure 2: Carl Steinitz's geodesign framework (Steinitz 2013)

For example, this study produced ten distinct alternative futures for the region, each comprised of a series of maps, charts, tables, and graphs that explicitly described the potential changes that each scenario represented. Those outcomes were invaluable to the community and other stakeholders who were able to digest each what-if scenario to best visualize the future in which they wished to reside. And because geodesign is an iterative process, the scenarios

produced by Steinitz and his team were not set in stone. Conversely, each scenario could be revisited and augmented to produce additional visualizations to aid the community in their ongoing planning and design efforts.

In addition to Steinitz's framework, Carr and Zwick's LUCIS model has played a large role in shaping geodesign's core paradigm (Carr and Zwick 2007). Their framework, while different from Steinitz, tackles the same tasks with a more regimented, goal oriented approach (Figure 3). LUCIS produces spatial representations of probable patterns of future land-use divided into a three different categories, making it efficient and effective in examining future scenarios and selecting the most desired option.

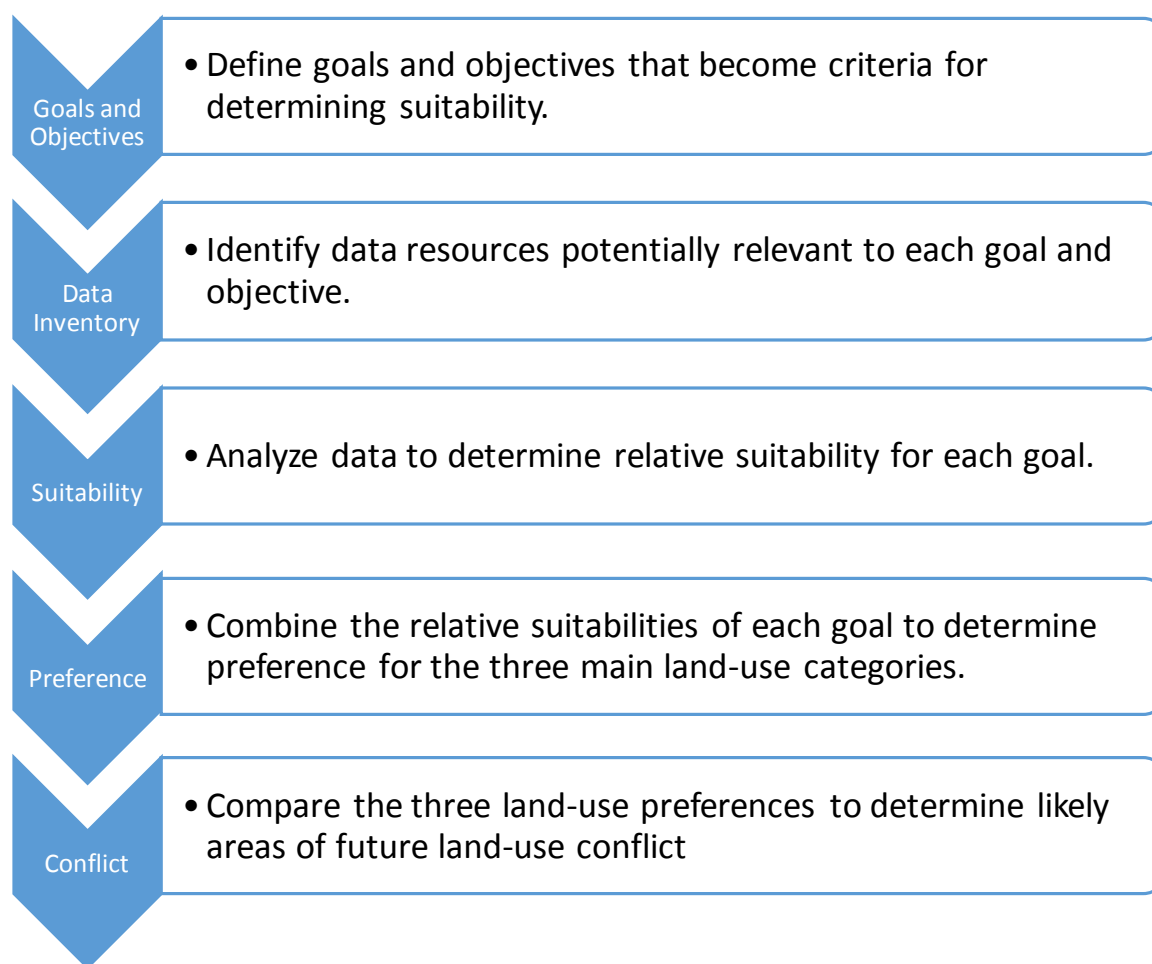


Figure 3: Margaret Carr and Paul Zwick's LUCIS model framework (Carr and Zwick 2005)

1.2 Research Goal

The overall goal of this research was to isolate and quantify future land-use conflict in Mecklenburg County, North Carolina and effectively create future land-use scenarios for the year 2030.

Land-use conflict can be defined as the comparison of the level of suitability for each of the differing land-use categories within a given land unit (Carr and Zwick 2007). A land unit is a raster cell that represents at a minimum, one acre. Where a land unit's suitability metric is equal, land-use conflict is identified. If a specific land-use category has a higher suitability metric for a given land unit than the other categories, then no conflict has been identified. In this case the land unit should retain its current land-use. Using this approach, the potential land-use conflict can be predicted for the entire region (Carr and Zwick 2007).

Implementing an adaptation of the LUCIS model facilitates the achievement of these goals by revealing the impact of incremental land-use change over time. The analytical products of the modeling effort provide insight into the location and magnitude of potential future land-use conflict, and the derived future land-use scenarios offer a mechanism for trustworthy collaboration between stakeholders, government entities, and development groups.

This study's results can be utilized in community planning events as an aid to reach consensus on critical decisions that affect land-use change or during envisioning sessions that give stakeholders the ability to interactively choose where they would like to see future development. Transparent, open efforts such as these may even yield value-based trends that can then be used to create new, more community reflective future land-use scenarios. An example of this approach can be seen in *Alternative Futures for Monroe County, Pennsylvania*, a study conducted in 1993 by Harvard University Graduate School of Design researchers (Steinitz et al. 1994). This scenario-based futures study researched growth trends and prepared six alternative futures for the year 2020. All models were mapped and used in public engagement efforts to allow citizens to visualize the consequences of each scenario.

1.3 Thesis Organization

This thesis document is organized by a collection of chapters, each with its own unique purpose.

The study begins with a review of relevant academic and professional literature that have shaped this study. This includes work focusing on the following concepts: geodesign, alternative futures analysis, scenario planning, the LUCIS model, the analytical hierarchy process (AHP), and pairwise comparison. The following chapter explains the methodology used to conduct this study. Topics covered include the study area, research questions and design, software and data requirements, and the procedures for analysis.

Results follow the methods chapter with the isolation, quantification, and visualization of potential future land-use conflict and an analysis of the four land-use scenarios. The final chapter discusses the conclusions drawn from the study, as well as future considerations of the work and study region.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

This chapter exposes requisite background information and an established literature review. Geodesign, alternative futures analysis, scenario planning, the LUCIS Model, the Analytical Hierarchy Process (AHP), and pairwise comparison are all inspected in the following chapter sub-sections. At a high level geodesign is the theoretical framework that encompasses both alternative futures analysis and scenario planning. The LUCIS model is a tool that facilitates alternative futures analysis and scenario planning processes, and the AHP and pairwise comparison are components of the LUCIS model.

2.1 Geodesign

Changing geography by design has been an ongoing practice for much of human history. The ancient Chinese built their settlements close to mountains and rivers to manifest their idea of a harmonious landscape (McElvaney 2012). The ancient Arabs built their cities to include narrow streets in order to capture the benefits of shading during the hot summer months (McElvaney 2012). Strategic choices, such as these, have been made consistently over time to ensure human safety and protection, sufficient access to resources, and a potential for future growth. The need to make more calculated, analytical decisions in planning fields has escalated over human history.

Throughout the twentieth century the systematic geographic design and planning methodology, now known as Geodesign, took theoretical shape by drawing from the work of Richard Neutra, Ian McHarg, Carl Steinitz, and others (McElvaney 2012). Inherently geography is concerned with place and processes, and design with the intent of creation, but only recently was the term Geodesign coined by Esri founder and President Jack Dangermond (McElvaney 2012). This key action has become a part of an ongoing initiative to join the theoretical knowledge of urban and regional planning with the systematic, computer-based science practice of GIS to assist designers, planners, and stakeholders in making more well-informed decisions for the future of their respective communities.

As mentioned, the ideologies that collectively form geodesign were forged over time. One of these instances was the groundbreaking work, *Survival through Design*, published by Richard Neutra in 1954. In the piece Neutra described his approach to design as the marriage of

both biological and behavioral sciences. This practice, which he coined biorealism, highlighted the inseparable union of both man and nature, and draws attention to the values of incorporating scientific expertise in community planning and landscape architectural practices. Neutra's contemporary Ian McHarg was forging similar ideas when he penned *Design with Nature* in 1969. It was here where McHarg promoted his framework for planning and design that essentially creates harmony between nature and its human inhabitants by considering both environmental and social factors during the decision making process.

2.1.1 Alternative Futures Analysis and Scenario Planning

An integral part of the well-informed decision making process is the ability to quickly evaluate design alternatives, scenarios, and their impacts. Alternative futures analysis and scenario planning have long been practices within the planning and design communities, but recently have become core components of the geodesign process. Alternative futures analysis and scenario planning methodologies have progressed significantly since 1990. In that time a number of studies have been conducted that encompass the current research paradigm, most notably Steinitz's (et al. 2003) *Alternative Futures for Changing Landscapes: The Upper San Pedro River Basin in Arizona and Sonora*.

This study was performed by Steinitz and his colleagues from Harvard University's Graduate School of Design in 2003. The work explored alternative futures of the Upper San Pedro River Basin. While the study produced ten alternative futures as well as a large amount of critical analyses, the overwhelming importance of the study was the illustration of Steinitz's alternative futures methodology itself.

The overview of the approach is organized by the following; (1) the construction of a literature review, (2) an establishment of the research workflow, (3) a description of how the research is organized and in which manner data is obtained, (4) a brief natural and cultural history of the region, (5) the creation of an inventory of issues to be investigated, (6) identification of scenarios to be generated by the research, (7) assessment of the future impacts of each scenario in terms of land use development, hydrology, vegetation, landscape ecology, species and habitats, and visual preference, and (8) the summarization of the potential impacts and conclusions.

Earlier in his career Steinitz was a part of similar studies, such as the *Alternative Futures for Monroe County, Pennsylvania* study, which was conducted in 1993 by Harvard University Graduate School of Design researchers in collaboration with the Environmental Protection Agency (EPA) and local Monroe County government officials (Steinitz et al. 1994). Researchers concluded that due to natural beauty, recreational opportunities, and improved transportation Monroe County, PA would experience large scale growth over the next three decades (Steinitz et al. 1994). As a result, the county faced difficult decisions that pegged conservation efforts against new urban development.

In an attempt to visualize the future, this scenario-based futures study researched growth trends and prepared six alternative futures for the year 2020. These included; (1) following the county's comprehensive plan, (2) allowing development to be market-driven, (3) pursuing the strategic development interests of each township, (4) adopting a policy of land conservation with an emphasis on outdoor recreational opportunities, (5) concentration of new development in a corridor served by public transportation, and (6) conserving all existing undeveloped land (Steinitz et al. 1994). All models were mapped and used in public engagement efforts to allow citizens to visualize the consequences of each scenario.

In addition to the Monroe County study, *Biodiversity and Landscape Planning: Alternative Futures for the Region of Camp Pendleton, California* was a study performed between 1994 and 1996 by the Harvard University Graduate School of design, Utah State University, the National Biological Service, the U.S Forest Service, the Nature Conservancy, and the Biodiversity Research Consortium (Steinitz et al. 1996). Researchers indicated that the study area was one of the most biologically diverse regions in the United States, and that major environmental stressors on the region were being caused by urbanization. In response, the study explored how rapid growth in the region of Camp Pendleton might influence the biodiversity of the area over time (Steinitz et al. 1996).

To frame the research, future change was modeled at the regional level using six different future scenarios, including; (1) a summarized local and regional plan projected over time, (2) spread pattern of low density growth, (3) spread pattern with conservation strategy, (4) private conservation strategy, (5) concentrating centers of development and new communities, and (6)

concentrated growth in a single new city (Steinitz et al. 1996). Stakeholders used the differing models to assess their future development and conservation strategies.

While a small sample of the Geodesign paradigm, these studies exemplify the application and relevance of alternative futures analysis and scenario planning. Through this integrated approach, it is possible to extend traditional planning methods and how geography is viewed by providing innovative contexts and provocative visualization that are steeped in quantitative, science-based methodologies and results. Geodesign, alternative futures analysis, and scenario planning provide a framework for understanding the comprehensive impacts of decisions, allowing decision makers to logically reach conclusions, solve problems, and work towards a more sustainable future.

2.1.2 The LUCIS Model

In essence, LUCIS is a GIS suitability analysis that divides the landscape into three differing land-use classes based on potential future land-use conflict (Carr and Zwick 2005). The model exhibits many of the same theoretical characteristics as geodesign, producing an equivalent to each of Steinitz's iterations (Table 1). The model was conceptually derived from the life's work of Eugene P. Odum, a twentieth century ecologist, who defined a simple compartmental model that simulates human impact on the environment through land-use and ecosystem comparison (McElvaney 2012).

Table 1: Geodesign framework and LUCIS model equivalence

<i>Geodesign Framework</i>	LUCIS Model
<i>Representation Models</i>	Develop goals and objectives
<i>Representation Models</i>	Construct relevant data inventory
<i>Process Models</i>	Determine suitabilities
<i>Evaluation Models</i>	Combine suitabilities to represent preference
<i>Change Models</i>	Visualize suitabilities as high, medium, and low, high being the most suitable
<i>Impact Models</i>	Compare areas of conflict to determine future quantity and spatial distribution
<i>Decision Models</i>	Conclusive results and stakeholder discussion

The LUCIS model was first introduced by Zwick and Carr in their 2005 paper *Using GIS Suitability Analysis to Identify Potential Future Land Use Conflicts in North Central Florida*. The paper introduced a six step process for land-use modeling that included: (1) develop a hierarchical set of goals and objectives that become suitability criteria, (2) collect an inventory of available data, (3) determine suitabilities, (4) combine suitabilities to represent preference, (5) reclassify suitabilities into categories of high, medium, and low, high being the most suitable and (6) compare areas of conflict to determine the quantity and spatial distribution of potential land use conflict.

Following their initial publication, Zwick and Carr published *Smart Land-Use Analysis: The LUCIS Model* through Esri Press in 2007. This full length text provided breakdown of the LUCIS model from its theoretical framework to individual project implementation strategies. Included with the text was the model itself and sample data to test its functionality.

Once the model was officially released, Zwick and Carr's colleagues and students published a number of studies. These papers exhibited the malleability and cross-discipline relevance of LUCIS. Most notably, Abdunaser Arafat displayed how LUCIS could be extended to include additional allocation and statistical tools to build a more complex,

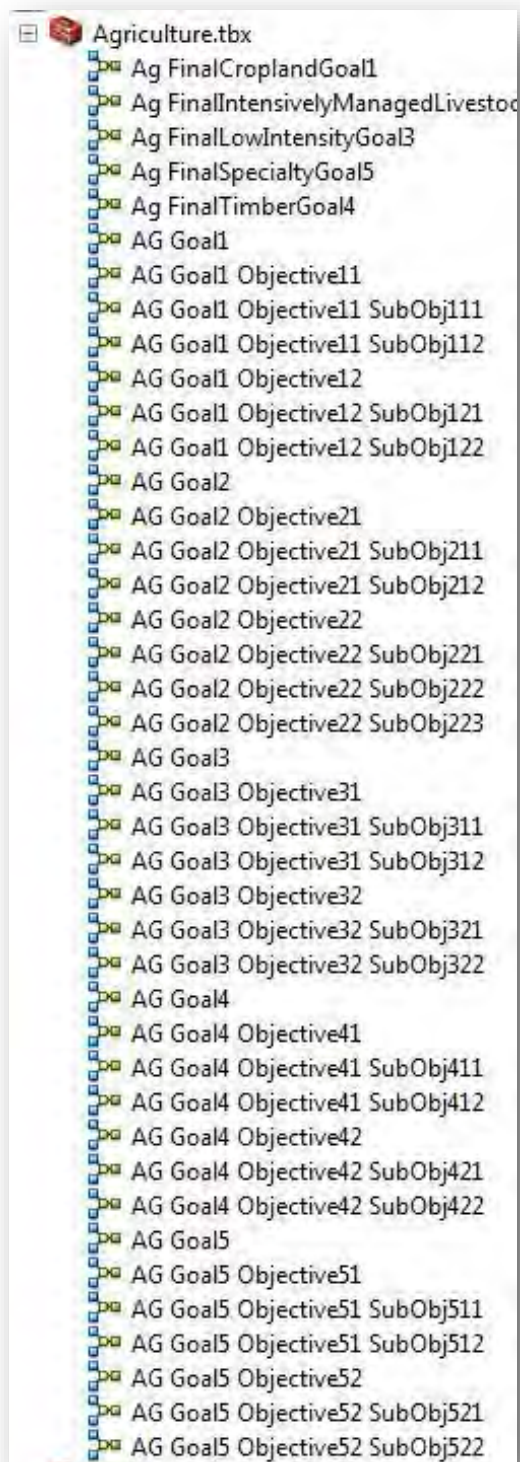


Figure 4: Displays the agricultural land-use goals, objectives, and sub-objectives models

insightful model in successive papers published from 2010 to 2012 (Arafat 2010; Arafat 2011; Arafat 2012A; Arafat 2012B).

Arafat highlights one of his innovative approaches for extending LUCIS in a highly detailed and analytical piece entitled, *Evaluating Accessibility and Travel Costs as Suitability Components in the Allocation of Land Use*. Here he offers the ability to automate the allocation of land use process, and provides an alternative workflow for dealing with suitabilities that differ in criteria from typical land use classifications and analyses. For example, the allocation of land-use in regards to affordable housing instead of residential housing was specific to this study. With this came a number of factors that augmented the overall LUCIS process, such as travel costs, and required a series of customizations to implement.

In addition to Abdalnaser Arafat, other former students of Zwick's continued to test the LUCIS model further by using it as one of many models in a variety of studies. Yong Hong Guo's *Using remote sensing and GIS to monitor and predict urban growth---Case study in Alachua County, Florida* (Guo 2012) used a combination of remotely sensed data and a LUCIS derivative to identify and analyze the probability and predictability of land use change instead of suitability.

Elizabeth Thompson's *Envisioning Urban Growth Patterns that Support Long-Range Planning Goals - A Comparative Analysis of Two Methods of Forecasting Future Land Use Change* (Thompson 2010) successfully evaluated the applicability and effectiveness of the

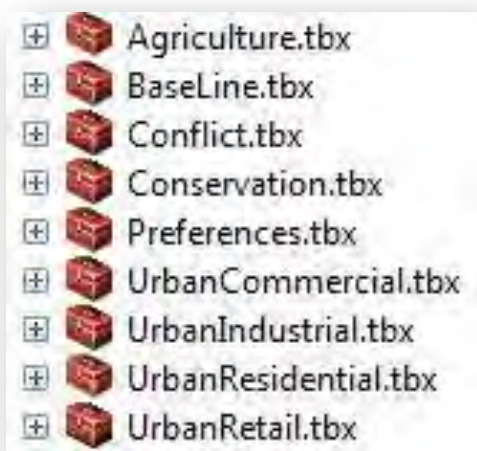


Figure 5: Displays the LUCIS model as it appears collapsed within ArcCatalog

LUCIS and FLUAM (Florida Land Use Allocation Method) models. Overall, it was determined that when compared to FLUAM, LUCIS provided a future land-use scenario where a higher population density could be achieved and those population centers would have greater access to future transit. Accumulatively, this scenario resulted in the potential conservation of three times more energy and less travel time for potential new citizens.

Emily Stallings' *Using GIS to Evaluate Land Use Conflict and Model Potential Environmental Impacts of Future Development Patterns: A Case Study of Central Florida* (Stallings 2010) is a study that completely aligned itself with LUCIS, and stands as one of the main sources of inspiration and guidance for this study. Stallings provided an in-depth walk through of a baseline LUCIS implementation that effectively fills in gaps found in the workflow provided by Zwick and Carr in their 2007 publication. For instance, she offers a methodology for preparing land use data for initial representation mapping and subsequent analysis by using a systematic approach to classify current land use codes within a parcel fabric.

Simultaneous to Arafat and others' work, papers began to emerge that utilized the LUCIS model for suitability analyses outside of land use change. For instance, Melanie Colavito and a team of researchers from Arizona presented a paper at the 2010 Esri User Conference that displayed the use of LUCIS for renewable energy site selection in Cochise County (Colavito et al. 2010). The team expanded on original LUCIS principles by replacing the three land use types of agriculture, conservation, and urban with solar, wind, and bio-energy.

Each of these studies and texts provide extensive insight into varied LUCIS implementation strategies, and core principles such as the use of Single Utility Assignments (SUAs), Multiple Utility Assignments (MUAs), Complex Multi Utility Assignments (CMUAs), and the Analytical Hierarchy Process (AHP). The model as it is implemented in this study is an example of the geodesign framework at a county scale. Spatial decision making models, such as LUCIS, are effective in managing complex decisions and determining compelling results that are regionally flexible and community based (McElvaney 2012).

2.2 Analytical Hierarchy Process and Pairwise Comparison

The AHP is a multi-criteria decision-making approach introduced by Thomas Saaty in 1980 (Saaty 1980). By utilizing a series of pairwise comparisons, or the process of comparing two or more elements in regards to their general preference, the AHP helps digest subjective and objective information and systematically evaluate that information against specific criteria. The resulting metrics aid decision makers in selecting the best possible alternatives to their complex questions.

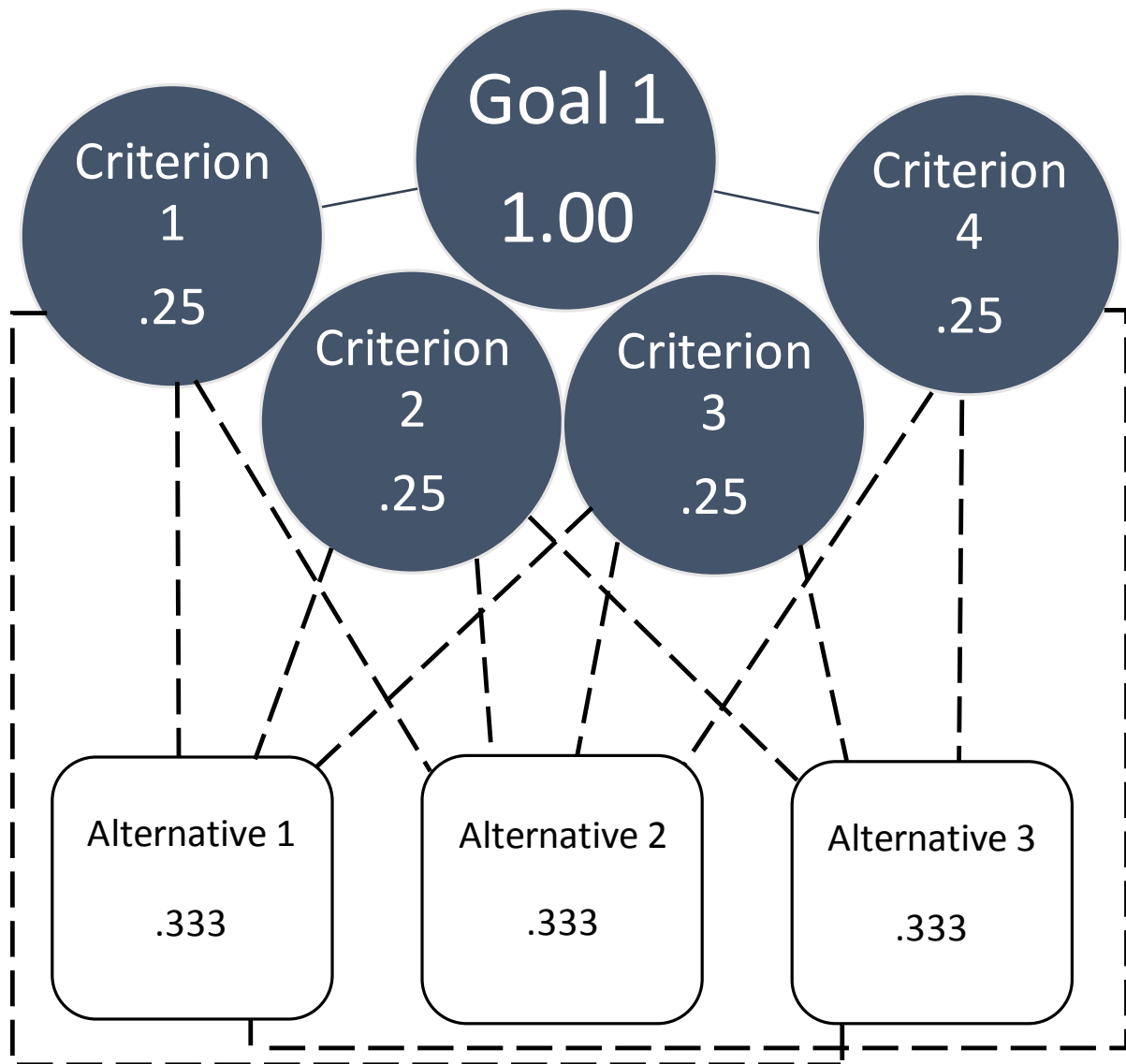


Figure 6: Simple AHP and pairwise comparison visualization

The AHP generates a weight for each evaluation criterion based on its creator's pairwise comparisons (Figure 6). A higher generated weight for one criteria signifies greater importance when compared to its corresponding criterion. The AHP then assigns a score to each alternative in agreement with the pairwise comparisons of the scenarios depending on that specific criterion. Similar to the weighting procedure, a higher score represents superior performance in regards to a particular criterion with respect to a specific scenario. To conclude the process, the AHP

calculates an ultimate value score by combining the criteria weights and scenario scores. From the resulting score a final ranking can be conceived from which a decision can be made.

The benefit of leveraging the AHP is its ease of use and ability to support a large audience. When utilized in the LUCIS model the AHP enables stakeholders from a diverse participant pool to capture community values and align themselves fully with the geodesign framework.

Suitability	Preference weights
Urban	
Urban Goal 1: Residential	0.622
Urban Goal 2: Office/Commercial	0.165
Urban Goal 3: Retail	0.165
Urban Goal 4: Industrial	0.048
TOTAL	1.000
Agriculture	
Agriculture Goal 1: Crops	0.159
Agriculture Goal 2: Managed livestock	0.064
Agriculture Goal 3: Low-intensity livestock	0.317
Agriculture Goal 4: Timber	0.400
Agriculture Goal 5: Specialty	0.060
TOTAL	1.000
Conservation	
Conservation Goal 1: Biodiversity	0.414
Conservation Goal 2: Water	0.192
Conservation Goal 3: Ecological processes	0.162
Conservation Goal 4: Recreation	0.042
Conservation Goal 5: Connectivity	0.140
Conservation Goal 6: Land Values	0.050
TOTAL	1.000

Figure 7: Example of pairwise comparison values calculated to determine AHP weights, which are then used to determine land-use suitabilities (Carr and Zwick 2007)

LUCIS uses the AHP to derive weights that determine the strength individual goals and their associated suitability rasters exert on the final land-use surfaces (Carr and Zwick 2007). For example, if a stakeholder group places an AHP weight of .62 on an urban residential goal, (Figure 7), then each raster cell in the final urban surface will receive 62% of the value from the urban residential goal surface.

CHAPTER 3: METHODOLOGY

This chapter reviews the study area, research questions, software/tool requirements, and the procedural and analytical methodology used to implement an adaptation of the LUCIS model. In addition, this chapter includes data sources used to capture metrics of land-use conflict and the conceptual framework for conducting a thorough analysis of that conflict.

3.1 Study Area

Mecklenburg County, North Carolina was established on November 6th, 1762 in commemoration of the marriage between King George III and Charlotte of Mecklenburg-Strelitz. Its favorable climate and topography have made settlement and growth advantageous to its inhabitants. Located less than a few hundred miles from both the Blue Ridge Mountains and Atlantic Ocean (to the west and east respectively), Mecklenburg County's residents enjoy mild winters and warm summers. According to the U.S. Census' decennial and historical reports, the county has seen its population consistently rise since its inception, growing from approximately 11,000 to over 1,000,000 citizens since 1790. In recent years Mecklenburg County has benefited economically from a diverse group of industry leaders, such as Bank of America and Duke Energy, both of whom are headquartered in the region. Companies within manufacturing, energy, sports, and particularly banking have collectively driven the overall economic success of the region.

The Huntersville-Cornelius-Davidson corridor was an area within Mecklenburg County that was of particular interest when considering this study. This corridor north of Charlotte connects the towns of Huntersville, Cornelius, and Davidson through Interstate 77 (Figure 8). This highway corridor runs directly down the center of the county, and passes into Charlotte's Uptown. Much of the county's available land is located on either side of this corridor. North Carolina's Department of Transportation and the Federal Highway Administration have proposed a plan to widen the highway, and build a new North Corridor commuter rail line (Boykin and Cheney 2014). These transportation additions, in connection with available land, make this area of the county a prime growth zone target. Along with this growth, potential future land-use conflict can be expected.

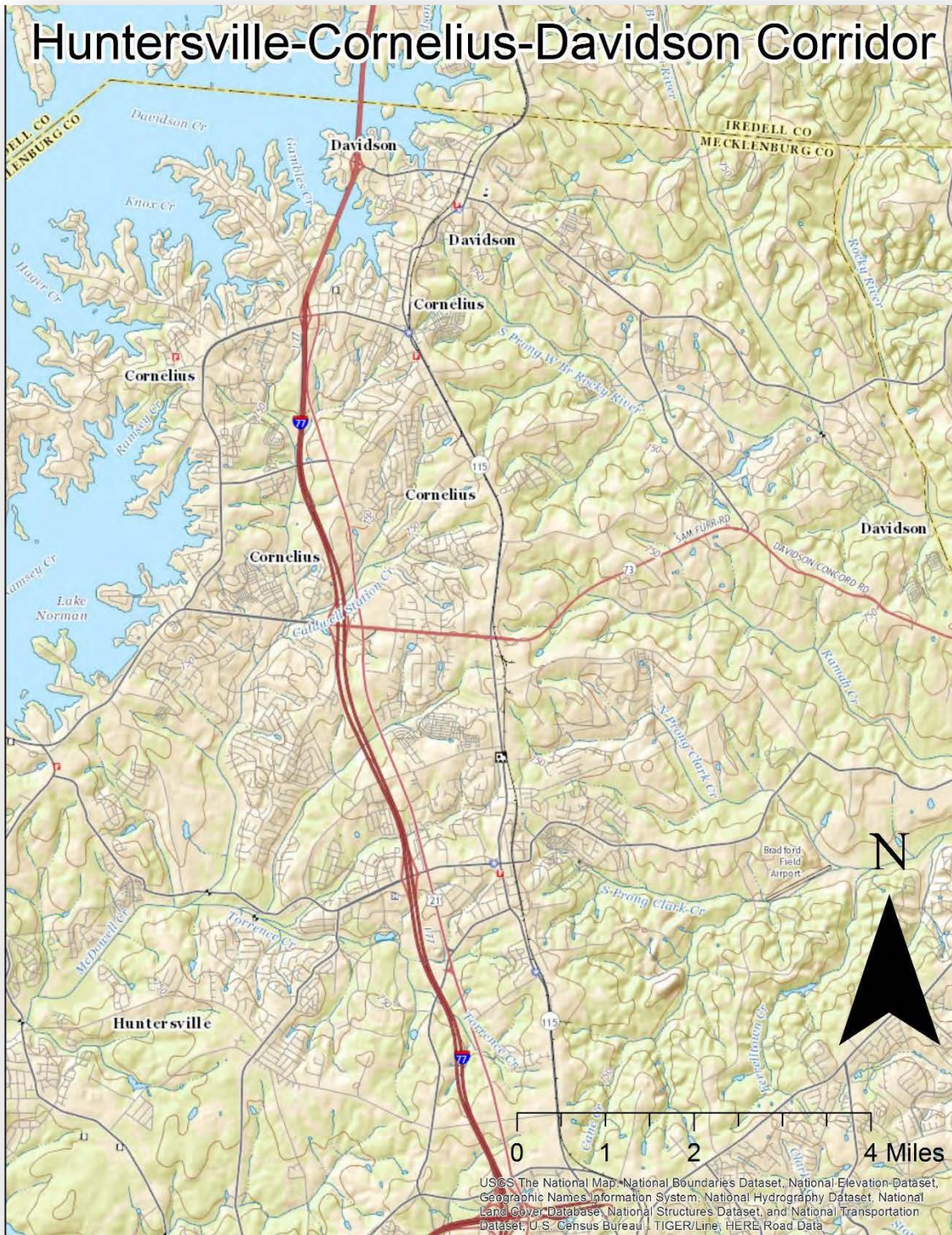


Figure 8: Huntersville-Cornelius-Davidson corridor

3.2 Research Questions

As stated, LUCIS is a goal driven GIS model that produces a spatial representation of where land-use suitabilities will be in future conflict and illustrates alternative land-use futures (Carr and Zwick 2007). In order to successfully implement an adaptation of the LUCIS model, a collection of goals, objectives, and sub-objectives must be defined. These definitions serve to frame the overall research questions and eventual suitability models that are utilized during the analysis process.

Land-use conflict is defined as the state of equal interest in the same land by different groups (Carr and Zwick 2007). Land, or land units, were represented by 50-acre raster cells that masked the entirety of the study area. This study determined the lands suitable for (1) conservation, (2) urban growth, and (3) agricultural use in Mecklenburg County and compared the resulting surfaces to derive the most likely locations for future land-use conflict. The suitable locations for conflict were allocated to one of the three broad land-use classifications to create four unique future land-use scenarios: the baseline scenario, agricultural scenario, conservation scenario, and urban scenario (Carr and Zwick 2007).

The baseline scenario weighed each of the land groups equally during pairwise comparison to produce a land-use conflict constant that was later utilized in scenario comparison. Each of the other three scenarios highlights one of the three land groups by weighing it heaviest to account for the adoption of land-use decisions that are in alignment with that land group. The overall research questions were outlined by the following goals and objectives (Table 2) derived from a larger set used by Carr and Zwick in their North-Central Florida case study (Carr and Zwick 2007).

Table 2: Major goals and objectives of the LUCIS model

		<i>Agriculture</i>
<i>Statement of intent</i>	Identify lands most suitable for agricultural use	
<i>Goal 1</i>	Identify lands suitable for croplands/row crops	
<i>Goal 2</i>	Identify lands suitable for livestock	
<i>Goal 3</i>	Identify lands suitable for timber	

<i>Conservation</i>	
<i>Statement of intent</i>	Identify lands most suitable for permanent protection through the application of conservation strategies
<i>Goal 1</i>	Identify lands suitable for protecting native biodiversity
<i>Goal 2</i>	Identify lands suitable for protecting water quality
<i>Goal 3</i>	Identify lands suitable for protecting important ecological processes
<i>Goal 4</i>	Identify lands suitable for resource-based recreation
<i>Urban</i>	
<i>Statement of intent</i>	Identify lands most suitable for urban development
<i>Goal 1</i>	Identify lands suitable for residential land-use
<i>Goal 2</i>	Identify lands suitable for office/commercial land-use
<i>Goal 3</i>	Identify lands suitable for retail land-use
<i>Goal 4</i>	Identify lands suitable for industrial land-use

3.3 Software and Tools

The hardware, software, and tools used to complete this study reflect previous implementations of the LUCIS model, and other studies that exercise alternative futures and scenario planning analyses. Such requirements are organized below in Table 3 by software, software extensions, and models.

Table 3: Required software to implement the LUCIS model

Software	Type	Use
ArcGIS for Desktop	<i>Software</i>	<i>A series of GIS software programs that collect, store, analyze, map, and visualize geographic data. ArcGIS for Desktop is comprised of ArcMap, ArcCatalog, ArcGlobe, and ArcScene, as well as complimentary administrative and programming tools.</i>
Spatial Analyst	<i>Extension</i>	<i>Augments capabilities of ArcGIS for Desktop by adding a range of spatial modeling and analysis tools.</i>
LUCIS Model	<i>Model</i>	<i>Geospatial model intended to project future land-use conflict and allocate land-use based on measures of suitability.</i>

ArcGIS for Desktop 10.2.2 was used as the sole facilitator for data management, mapping, and analysis throughout this study. All data obtained to conduct this study (see Section 3.4) was processed, cataloged, and managed (see Section 3.5) using the ArcCatalog window within ArcMap. The Spatial Analyst extension to ArcGIS for Desktop 10.2.2 was used as a requirement to implement this adaptation of the LUCIS model. The LUCIS model relies heavily on analyses such as Euclidean distance, reclassification, and raster calculation, all of which require the Spatial Analyst extension.

The LUCIS model itself was purchased, along with *Smart Land-Use Analysis: The LUCIS Model* (its accompanied text), as a disc. This disc provides the model, sample data, practice exercises, and usage recommendations. Built using an older version of ArcGIS for Desktop and ModelBuilder, the LUCIS model could not be used as is, requiring this study to use the model as a guide. While the same modeling structure and steps were used, this study's adaptation of the LUCIS model built each modeling component independent of its originator (see Section 3.5).

3.4 Data requirements/Data sources

A number of different datasets were required to complete this study, all of which were sourced directly from both the City of Charlotte and Mecklenburg County using their newly created open data portals, Open Charlotte and Mecklenburg County Open Mapping. These data warehouses are one-stop-shops for the most current and accurate city and county datasets. The only exceptions to this rule were the two datasets sourced for the North Carolina Department of Environment and Natural Resources, the Biological Wildlife Habitat Assessment and the state Agricultural Assessment. Using Ian McHarg's broad dataset categories described in *Design with Nature*, data were categorized as geophysical, biological/ecological, demographic, economic, political, cultural, and infrastructure.

Table 4: Required datasets to complete the LUCIS model

<i>Data Category</i>	<i>Datasets</i>
<i>Geophysical</i>	Soils, Floodplain, Rivers, Greenways, Lakes and Ponds, Wells, Streams, Watershed, Agricultural Assessment
<i>Biological/Ecological</i>	Wetlands and Biological Wildlife Habitat
<i>Cultural</i>	Land Cover, Historic Sites, Parks, and Public Art
<i>Infrastructure</i>	Airport, Bike Lanes, Bus Stops and Routes, Streets and Highways, Railroads, Light Rail, Public Transit, Grocery, Hospitals, Libraries, Post Offices, Recreation Centers, and Building Footprints
<i>Political</i>	County Boundary, City Zoning, County Parcels, Town Zoning, Historic Districts, Fire Departments, and Police Departments

3.5 Procedures/Analysis

This study aligned itself with the procedural and analytical design workflow developed by Steinitz, and implemented an adaptation of the LUCIS model. From the LUCIS model, this adaptation borrowed: the data model, goal and objective naming conventions and definitions, and the hierarchical modeling process and structure. A detailed breakdown of each component in the design overview (Figure 9) is reviewed in the following sub-sections.

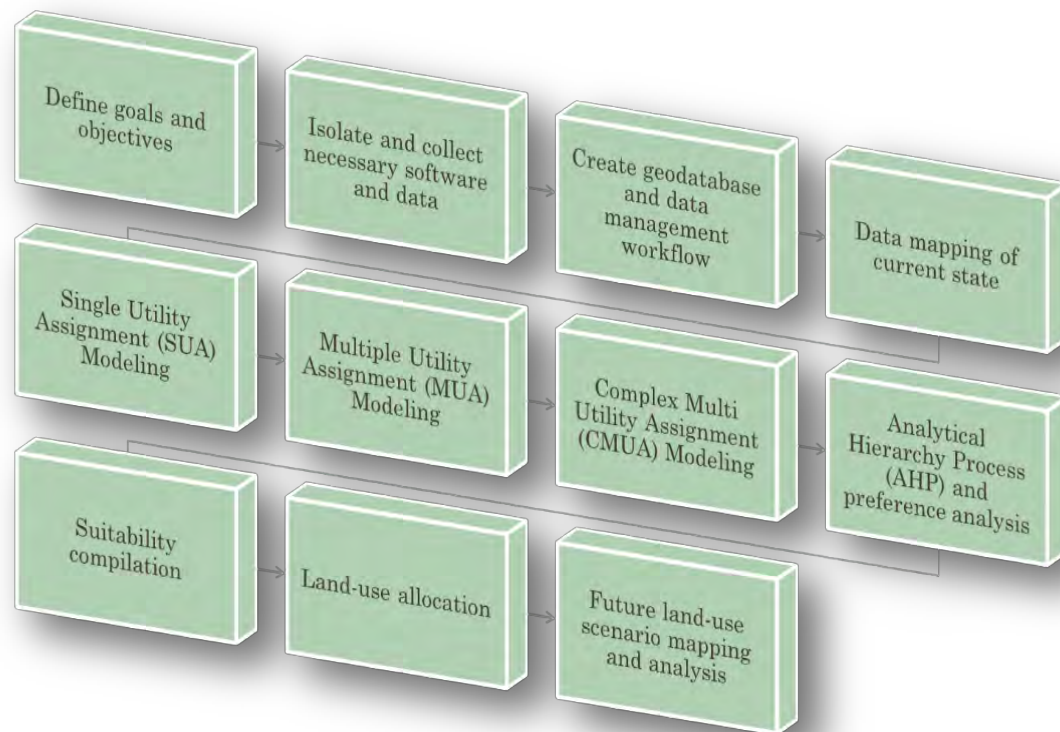


Figure 9: Research design

3.5.1 Representation Modeling

The definition of goals and objectives, the isolation and collection of software and data, the creation of a data management structure, and the mapping of the current study area were collectively equivalent to the representation modeling component of the geodesign framework. These steps, like all steps in the LUCIS model, were accumulative. The definition of goals, objectives, and sub-objectives established the required data and suitability criteria for use later in the process. Data discovery and collection drove the study's data management rules and database structure, and allowed for data that represent the present state of the study area to be mapped.

This study began with a concise statement of intent and a clear definition of goals and objectives that became the criteria in which the overall model was built. Goals and objectives included the isolation of the following land-use suitabilities; (1) lands most suitable for agricultural use, (2) lands most suitable for permanent protection through the application of

conservation strategies, and (3) lands most suitable for urban development (Carr and Zwick 2005). The goals, objectives, and sub-objectives used in this study (see Section 3.2 and Appendix A) reflect the basic criteria laid out by Carr and Zwick in *Smart Land-Use Analysis*. This choice was made to ensure that the adapted model could produce baseline land-use conflict and future land-use scenario visualizations to be shared with the community. In the future the community can refine the goals, objectives, and sub-objectives, if necessary, to meet their specific needs.

The establishment of goals and objectives was followed by the isolation and collection of the necessary software, tools, and data to execute the model (Sections 3.3 and 3.4). A data management structure (Figure 10) was created to store and manage the data that was collected. A file geodatabase (GDB) was chosen as the storage and management system for all of the study's geographic information. A GDB is a database or file structure used primarily to store, query, and manipulate spatial data. Geodatabases store geometry, a spatial reference system, attributes, and behavioral rules for data. Various types of geographic datasets can be collected within a geodatabase, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others (Wade and Sommer 2006). The GDB used in this study was given the NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet projected coordinate system and North American Datum of 1983 as its spatial reference system. This reference system was chosen because it is a North Carolina standard and all of the data collected for this study were in this spatial reference system.

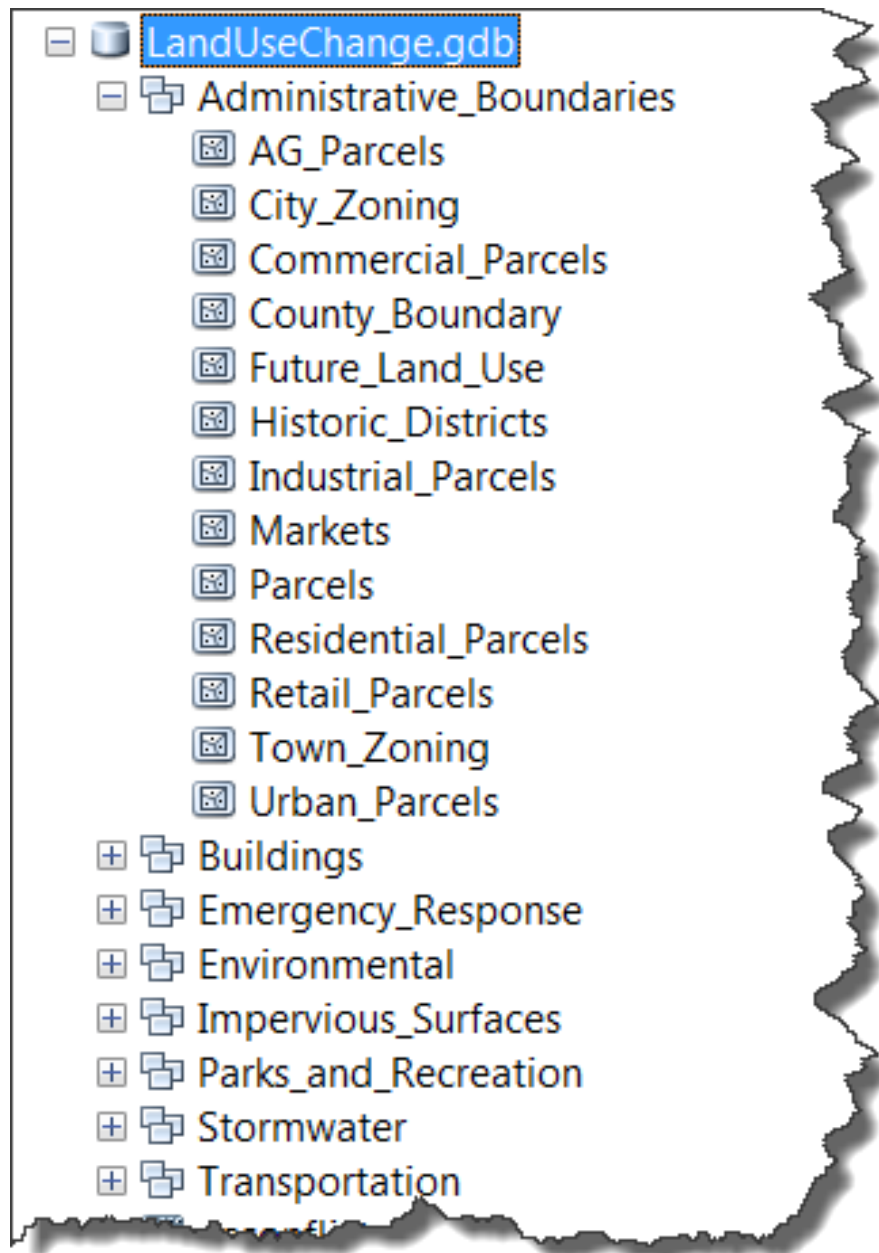


Figure 10: File geodatabase displaying the administrative boundaries feature dataset and its associated feature classes.

The majority of the data collected was in formats that required processing to store and manage within a GDB, such as shapefile format. Each shapefile was converted into a feature class to be stored in the GDB alongside similar data, in a feature dataset, using the Feature Class to Feature Class tool in ArcMap. An example of this process can be seen Figure 11 below.

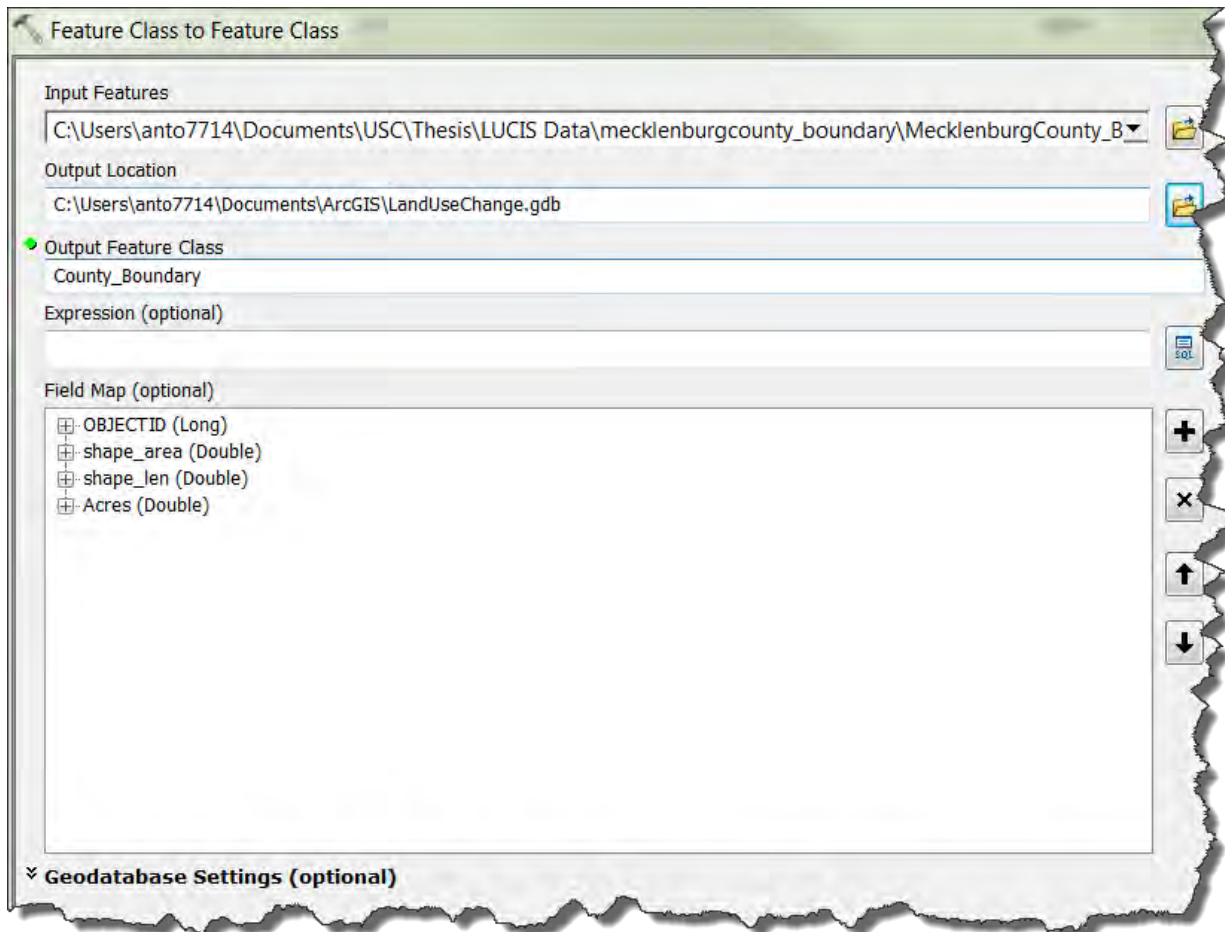


Figure 11: Feature class to feature class tool in ArcMap

Once all of the requisite data was stored in the GDB, preparation for later analysis was performed. The extraction of necessary data from larger authoritative datasets was executed first (i.e. collapsed land-use classifications from parcel fabric). The collapsed land-use classification process was the most critical of all data processing tasks. This task ensured that parcel data was reclassified into a handful of manageable categories that could be used to develop Utility Assignments (UAs). This process was achieved manually using recommendations found in Emily Stallings' *Using GIS to Evaluate Land Use Conflict and Model Potential Environmental Impacts of Future Development Patterns: A Case Study of Central Florida* (Stallings 2010). Each land-use code within the parcel fabric was parsed and designated to a specific collapsed land-use class field that was added to the parcels feature class (Appendix B).

Other vital data processing tasks included the conversion of datasets from vector to raster (i.e. floodplain polygons to surfaces), and the limiting of larger datasets to the spatial study extent using surface masks. The first of these two tasks required the use of the Feature to Raster tool (Figure 12). For example, the 100-year floodplain dataset was converted from vector to raster to create a surface that covered the entire study area. The floodplain raster surface was then reclassified to display the land within the floodplain as 1 and all other land as 0. This task did not apply to each and every feature class in the GDB. The majority of the datasets were used to create derivative raster surfaces during the Utility Assignment (UA) phase.

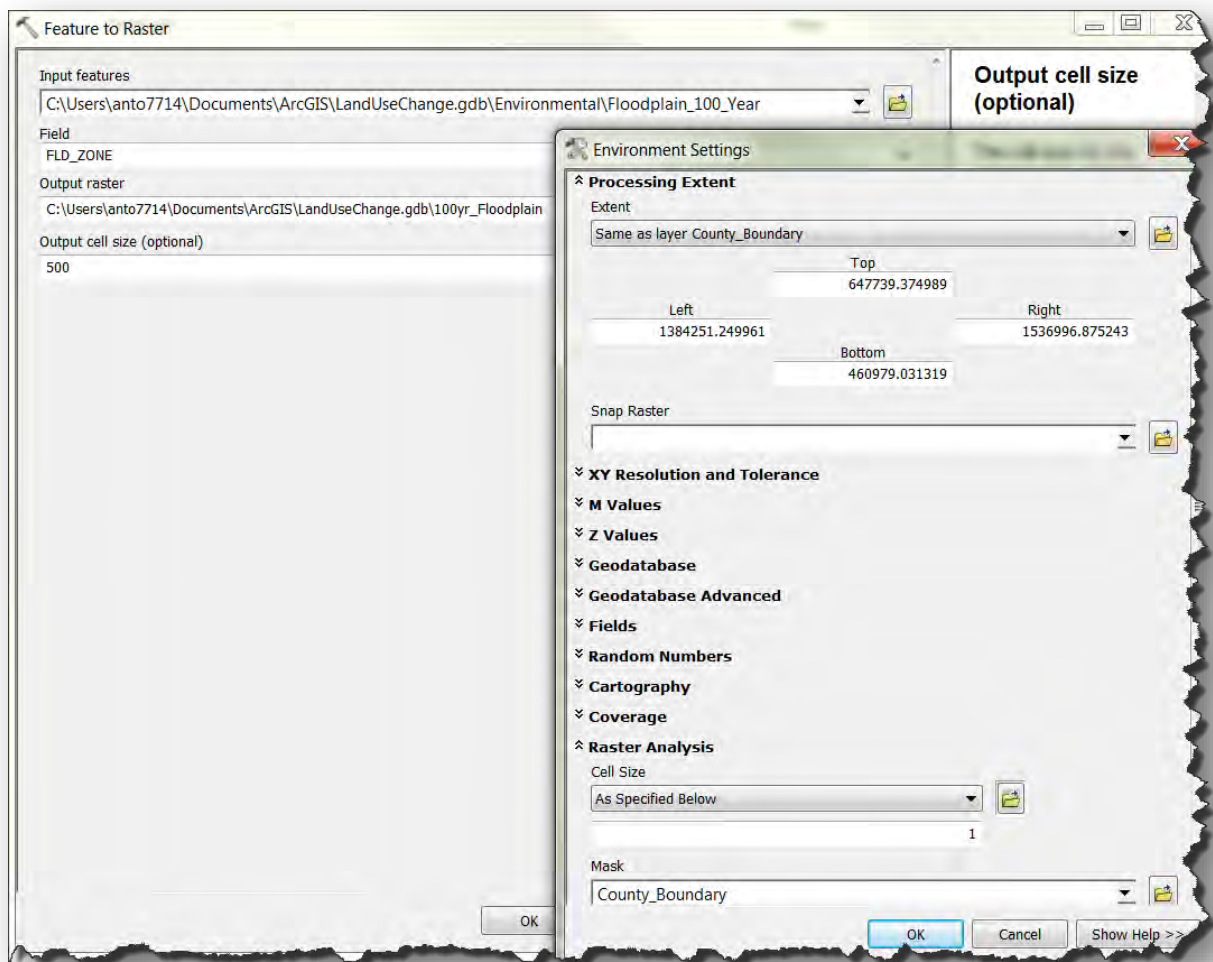


Figure 12: Feature to raster tool execution example used during data processing

The second of these two tasks was accomplished by using the Clip Raster tool to limit statewide datasets, like the agricultural assessment, to the study area (Figure 13). Each of these data processing tasks were completed and integrated into the data management structure before the study transitioned into the suitability modeling (or process modeling) phase.

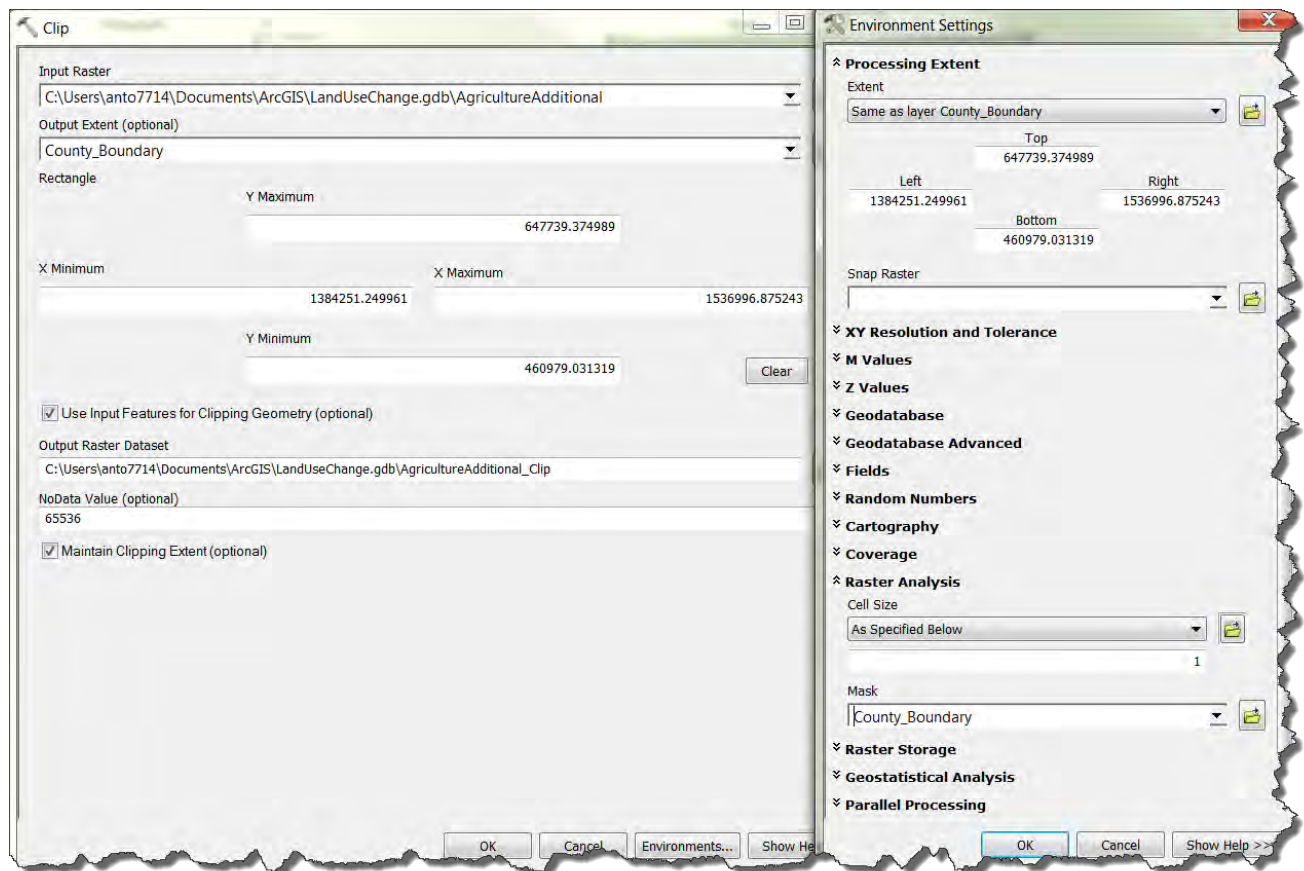


Figure 13: Clip raster tool used in data processing

The prepared data was mapped to display the results of the representation modeling component of the geodesign framework. These maps expressed the state of the landscape and how it is currently functioning. This provided a comprehensive understanding of the underlying geography, exposing interesting patterns and trends, for example the current distribution of collapsed land-use classifications (Figure 14).

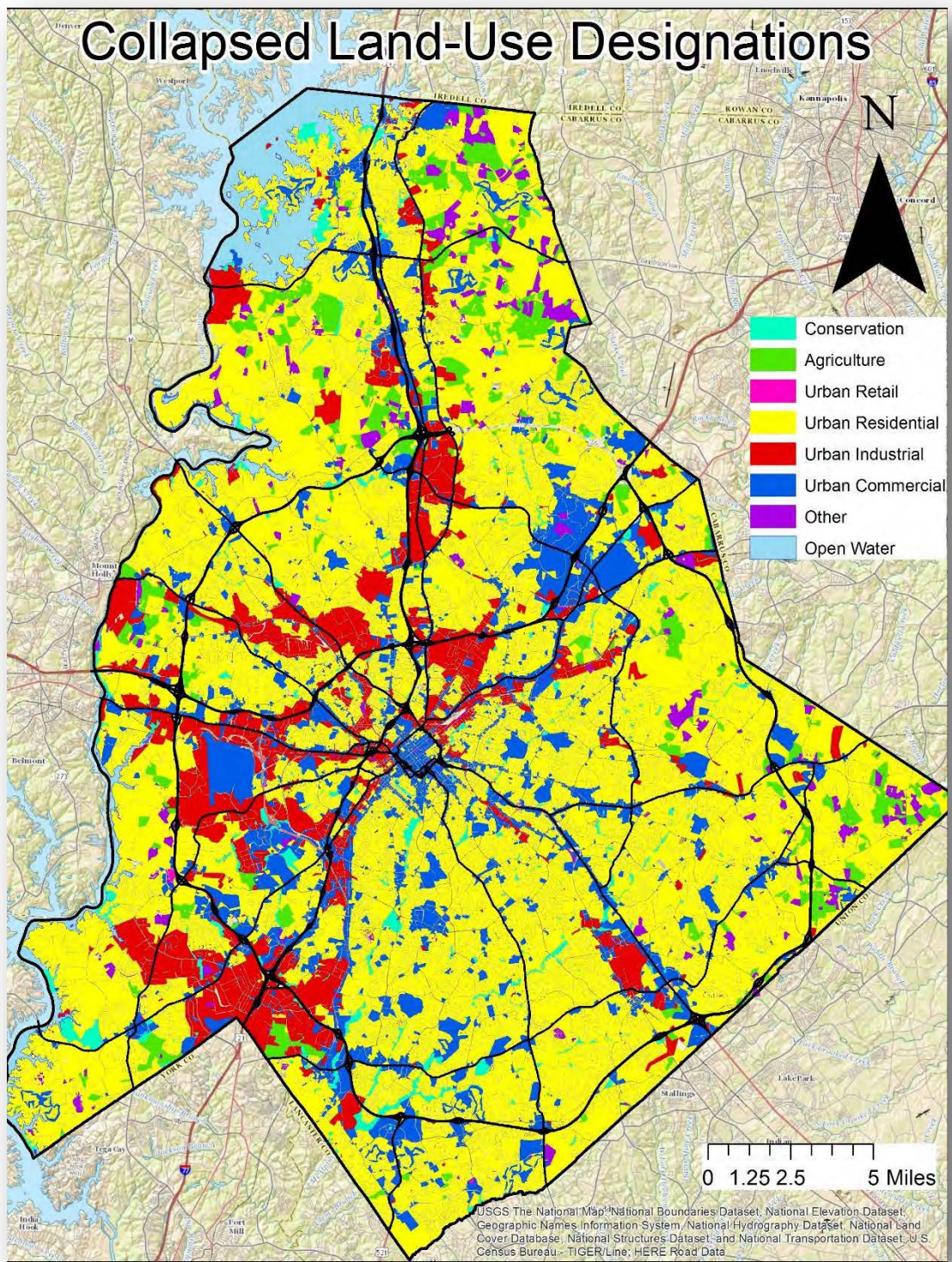


Figure 14: Collapsed land-use designation representation

3.5.2 Process Modeling

The utility assignment analyses followed the steps that comprised representation modeling, collectively representing an equivalent to process modeling component of the geodesign framework. At a high level these steps transformed the collected data from a series of attribute values contained in their original features, to utility values that could be ranked and assigned to a single land unit (or raster cell). The values created in this process were plugged into land-use suitability models, which were executed and analyzed to determine the relative suitability for each goal (CMUA), objective (MUA), and sub-objective (SUA) defined at the study's onset.

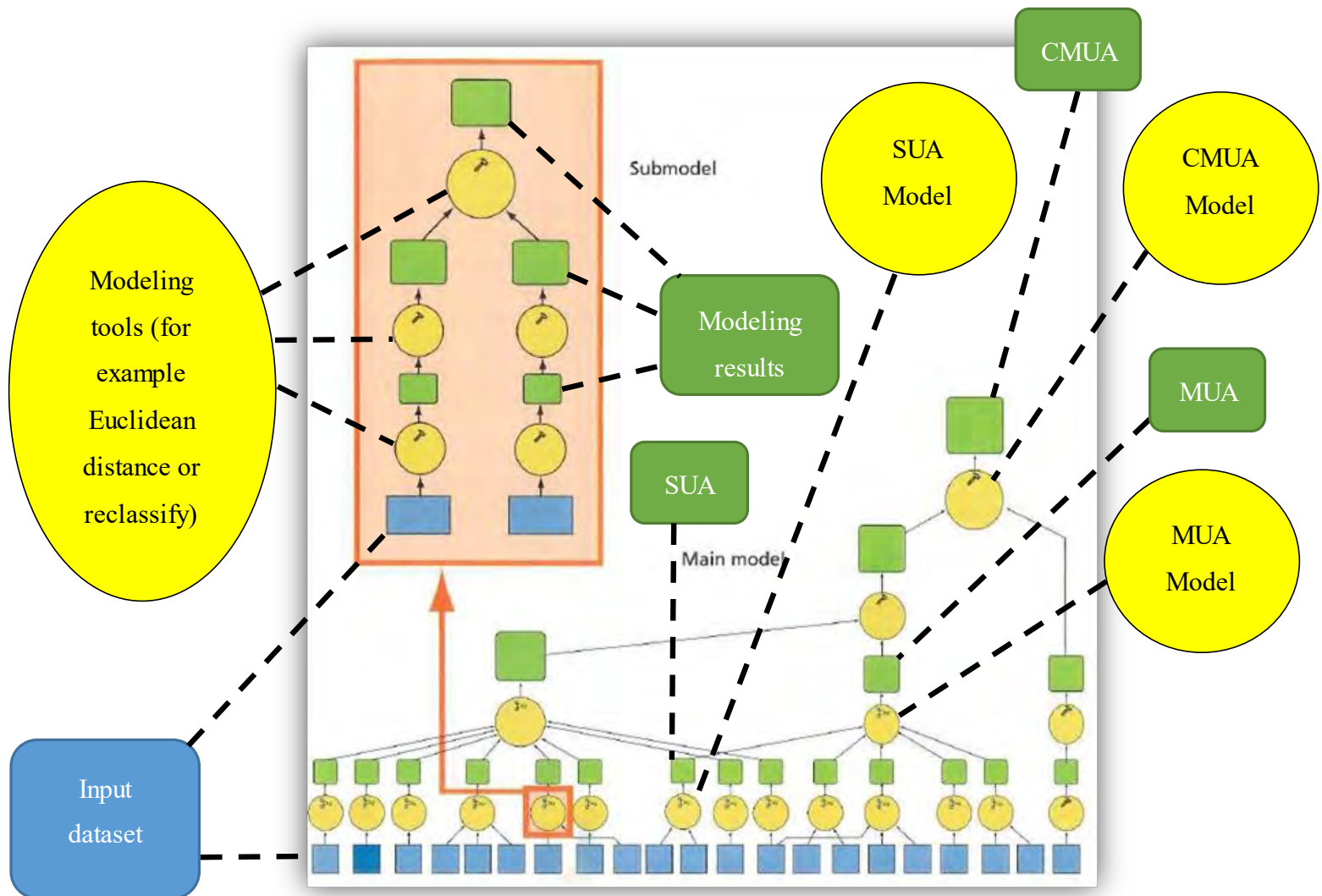


Figure 15: Analysis model displaying the multiple levels of SUAs, MUAs, and CMUAs use to create final suitability surface (Carr and Zwick 2007).

Figure 15 takes a more detailed, theoretical look at how the suitability modeling process functioned. The model had a bottom-up hierarchical structure that began by determining the suitability of each of the defined sub-objectives (SUAs), which in turn affected the determination of objectives (MUAs), and eventually goals (CMUAs). The blue boxes at the bottom of Figure 15 represent the input datasets used to determine a utility assignment. Input datasets were data collected at the study's onset or were derived utility assignments depending on the hierarchical level of the model being executed.

The blue boxes at the lowest level in Figure 15 were, in this case, the datasets as they appear in the GDB in Figure 10. The captured data was transformed through the use of tools, like ArcGIS' Reclassify Tool, to rank and measure suitability. Suitability measures were passed up the model's hierarchy as utility assignments were combined to progressively create more complex suitability surfaces. This process eventually yielded three suitability surfaces each representing one of the broad land-use classifications. A description of each goal, objective, and sub-objective, and the theoretical reasoning for including them into this analysis can be found in the Appendix A.

3.5.2.1 Single Utility Assignment

Since the model was performed from the bottom up, the first step in execution was the establishment of single utility assignments (SUAs). The first example of this process can be seen in Figures 16 and 17. This SUA required the identification of potential residential lands free of flood potential. A floodplain dataset was used to create a surface depicting areas unfit for residential housing. Residential housing cannot be built in a floodplain in this scenario. Lands that were in a floodplain were reclassified to possess an SUA value of one (not suitable), whereas lands that were not within a floodplain were designated an SUA value of nine (highly suitable).

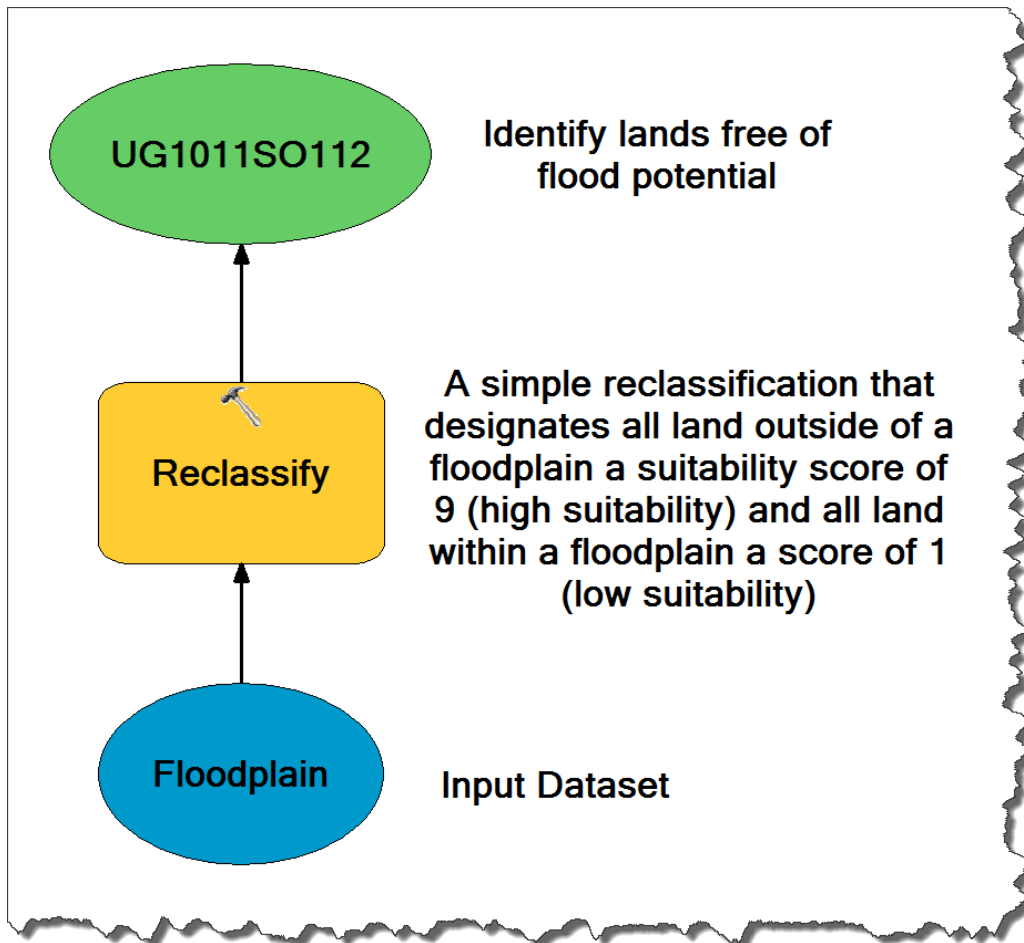


Figure 16: Analysis model for the urban sub-objective "identify lands free of flood potential"

A more complex example of an SUA can be seen in the sub-objective that required the identification of potential residential lands proximal to hospitals. This sub-model (Figure 18) took the point locations of all the Mecklenburg County hospitals and performed a Euclidean Distance analysis. Zonal statistics (Figure 19) were run on the Euclidean Distance's analytical product to determine the mean distance and standard deviation of existing residential area from hospitals. The resulting zonal statistics were used as the measure in which suitability values were assigned to the SUA using the Reclassify tool. Raster cells with values of 0 to the mean (13,614 feet) were assigned a suitability value of 9, because they are closer than the average existing residential parcel to county hospitals. The remaining raster cells were assigned suitability values from 8 to 2 (decreasing suitability), in standard deviation increments.

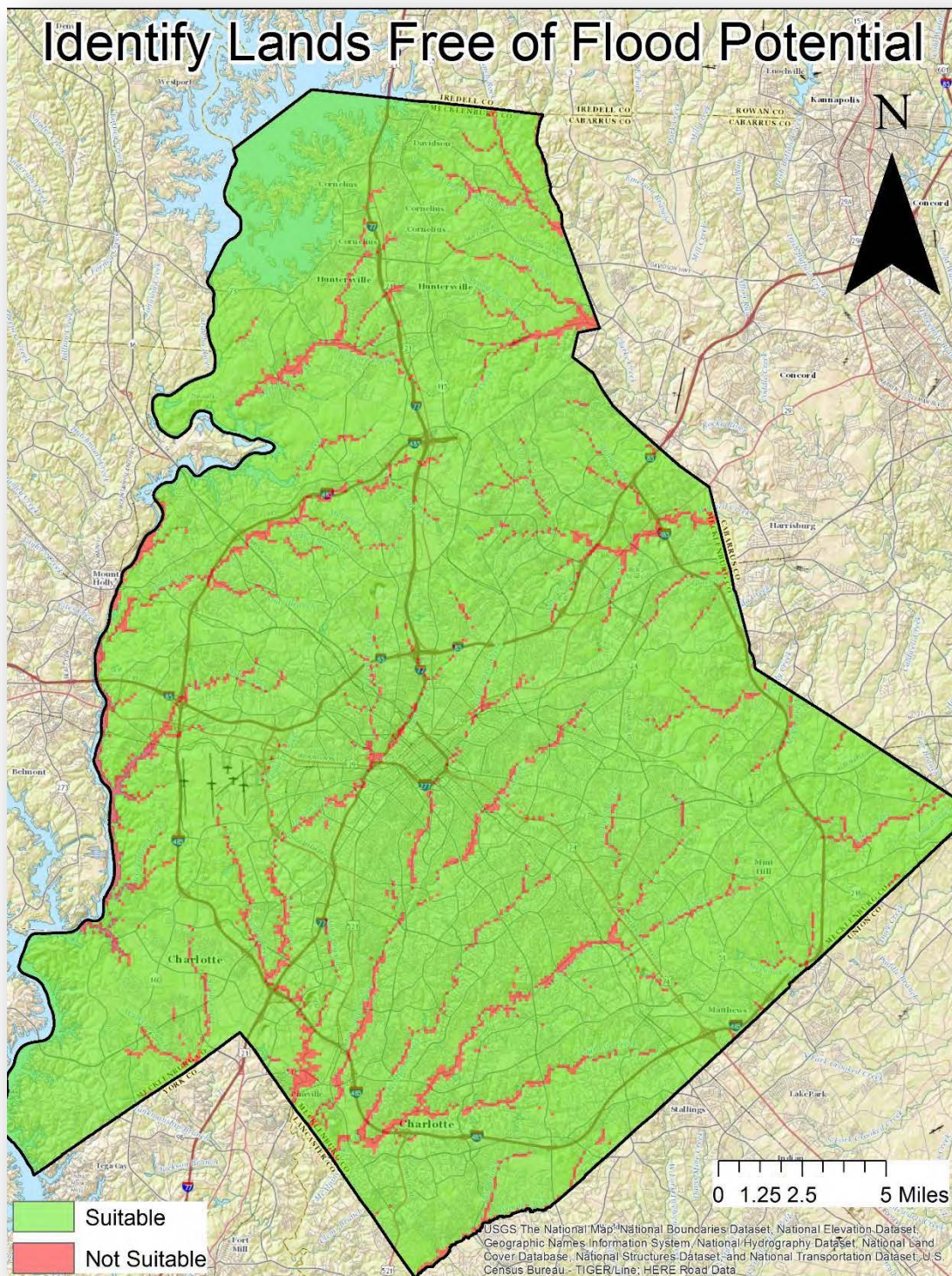


Figure 17: Results of the SUA "identify lands free of flood potential"

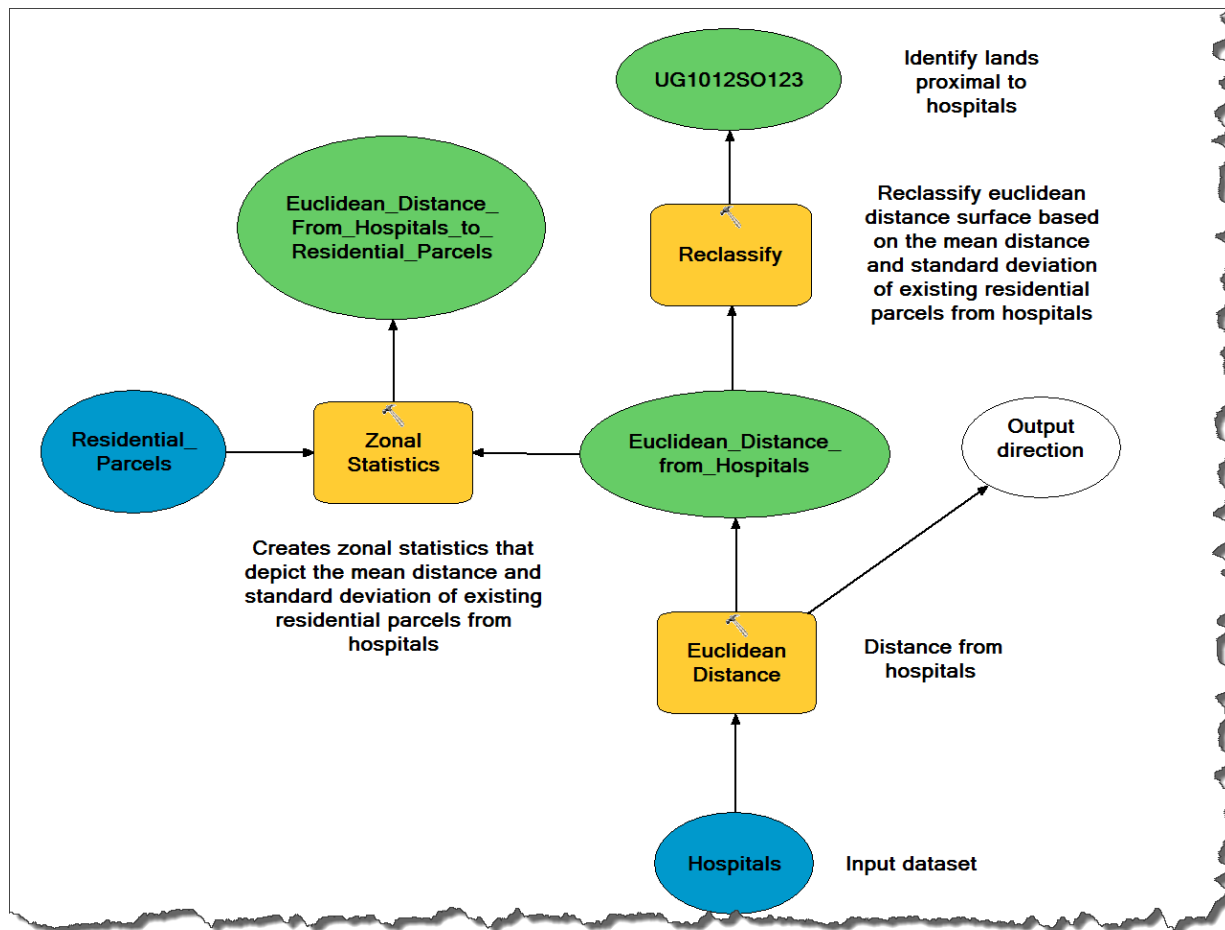


Figure 18: Analysis model for the urban sub-objective “identify lands proximal to hospitals”

OBJECTID*	Generalized_LandUse	ZONE_CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Urban Residential Single Family	1	21070	7865422923.586978	0	55746.921875	55746.921875	15840.194111	10056.492759	333752889.912476
2	Urban Residential Multi Family	2	1938	723454667.13866	0	48456.726563	48456.726563	11387.303188	7126.954627	22068593.577698

Figure 19: Zonal statistics applied to Euclidean distance from hospitals

The standard deviation determined by the zonal statistics tool was 2,226 feet. Raster cells located between the mean distance from hospitals (13,614 feet) and the mean plus a standard deviation (13,614 feet + 2,226 feet = 15,840 feet) were assigned a suitability value of 8. This process was used throughout this reclassification process to account for raster cells at all increments away from hospitals (Table 5). For a complete compilation of data ranges and suitability assignments for all goals, objectives, and sub-objectives, see Appendix A.

Table 5: Data range and suitability value assignments for potential residential lands proximal to hospitals based on zonal stats

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 13,614</i>	9
<i>13,615 – 15,840</i>	8
<i>15,841 – 18,066</i>	7
<i>18,067 – 20,292</i>	6
<i>20,293 – 22,518</i>	5
<i>22,519 – 24,744</i>	4
<i>24,745 – 26,970</i>	3
<i>26,971 – 29,196</i>	2
<i>29,197 – all remaining</i>	1

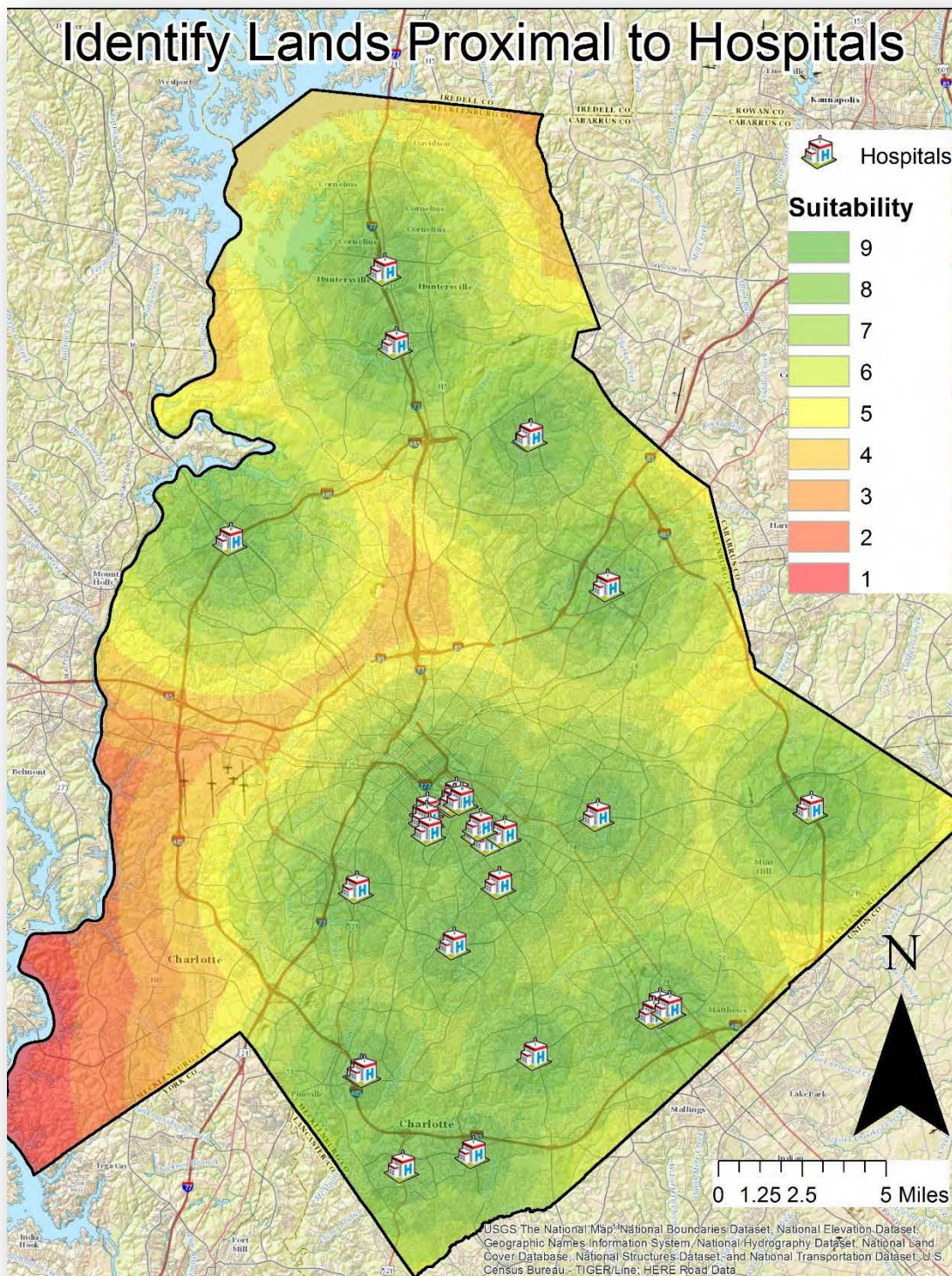


Figure 20: Results of the SUA "identify lands proximal to hospitals"

3.5.2.2 Multiple Utility Assignment

Once each SUA suitability surface was created for all of the sub-objectives, they were combined to create MUAs. Each MUA was created using the same process, the only difference between them being: the number of SUAs used to derive each MUA, and the weights given to the set of SUAs used in that sub-model. An example of this process is the urban objective that determined lands physically suitable for residential land-use. Figure 21 displays the sub-model used to accomplish this task. Residential flood suitability and residential quiet suitability were the two SUAs used as input datasets in this sub-model. The Raster Calculator tool multiplied each input dataset by a weight, derived from the modeler's intuition, and added them together. The rationale for these choices was that flood potential was far more critical than quiet areas, because of a direct correlation to increased building costs and access to insurance. In the future these weights could be improved by utilizing community and stakeholder input.

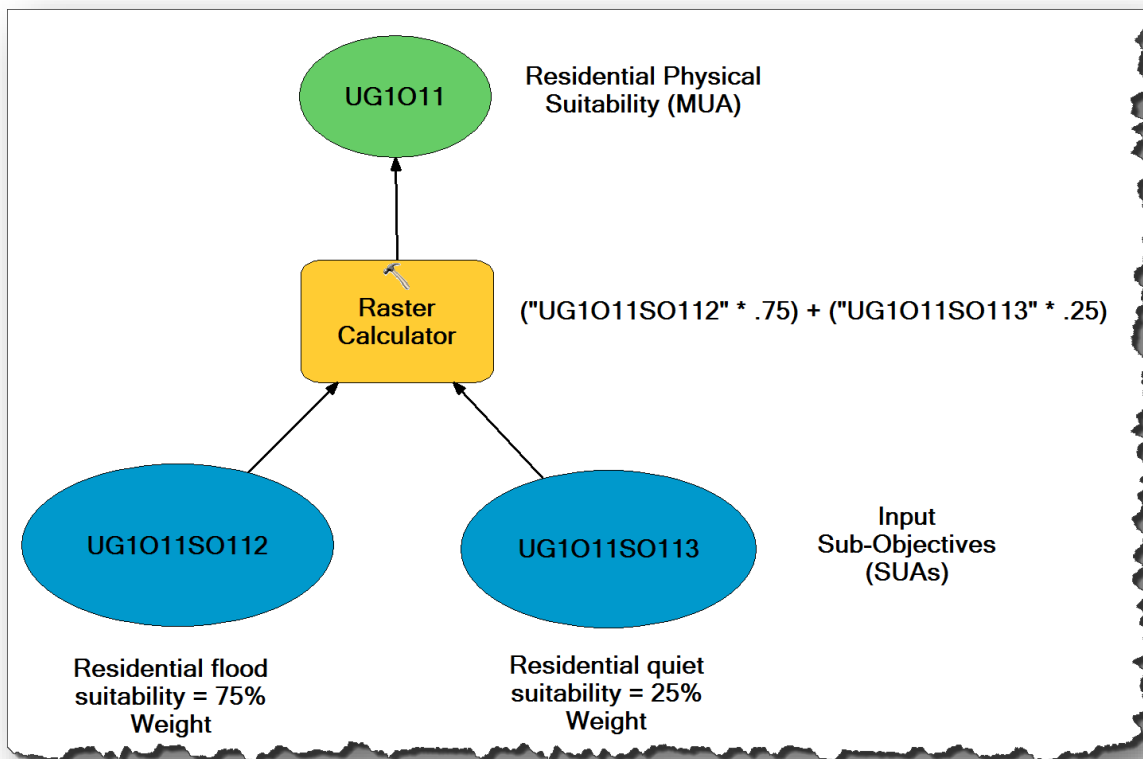


Figure 21: Analysis model for the urban objective "identify lands physically suitable for residential use"

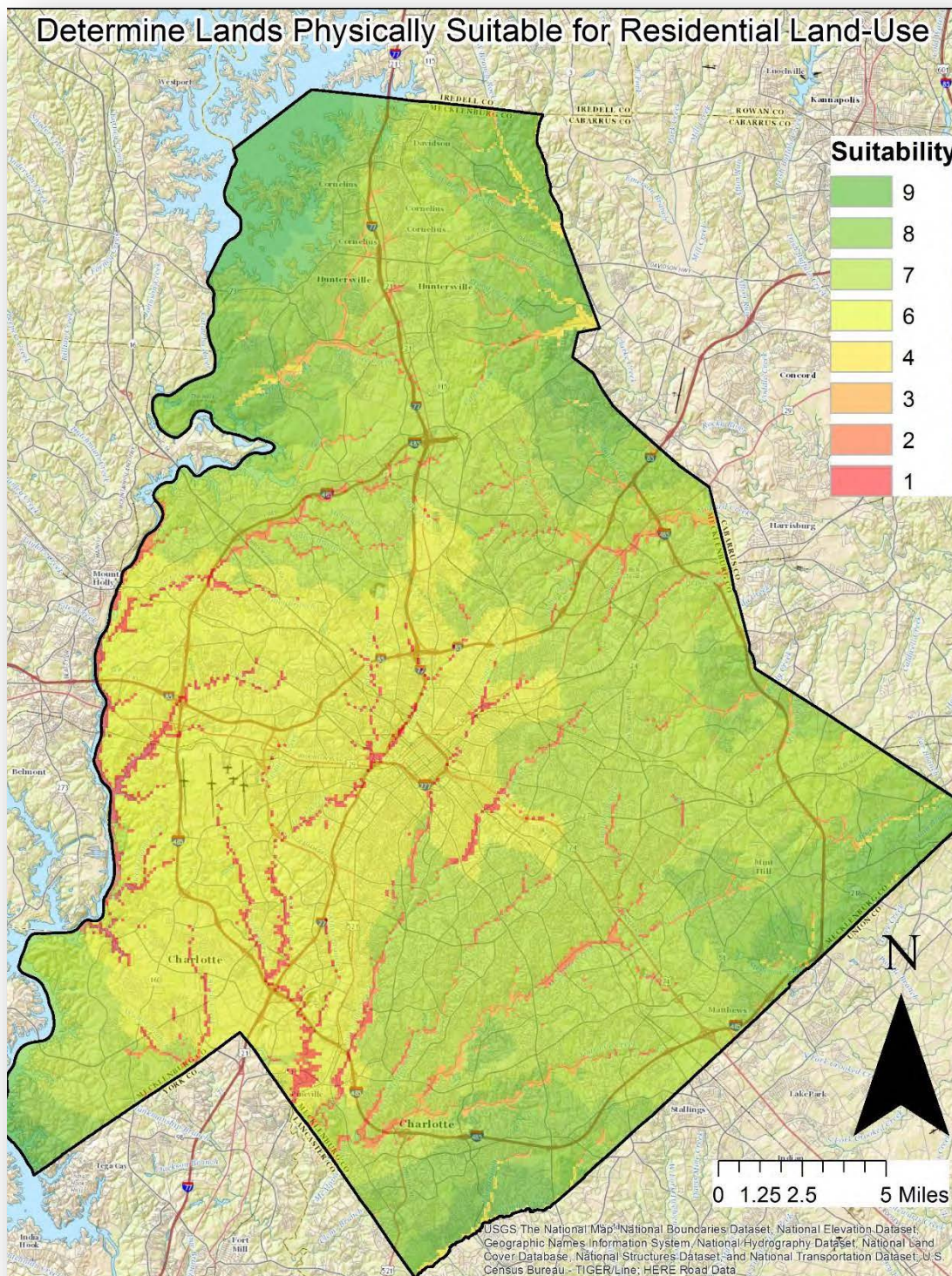


Figure 22: Results of the MUA “identify lands physically suitable for residential use”

3.5.2.3 Complex-Multi Utility Assignment

The relative suitability MUAs were then combined to create CMUAs. Each CMUA fulfilled the goals established during the study's goal and objective definition phase. An example of this process is Urban Goal 1 (Figures 23 and 24), which was to identify lands suitable for residential land-use. This sub-model used the physical and economic suitability of residential land MUAs as its input datasets. The MUAs were multiplied by equal weights and then added together using the Raster Calculator tool. This too was an intuitive decision based on the belief that physical and economic suitability were equally important in determining where residential development will occur.

This process was coupled with a complementary analysis that functioned under the assumption that current residential land is highly suitable for future residential land-use, and should receive the highest suitability values possible. The current residential parcels were converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool. Land that contained residential parcels was given a suitability value of 9 and land that did not contain residential parcels was designated a value of 1.

The reclassified surface and the equally weighted MUAs were then used as input datasets in a conditional expression. Using the Raster Calculator the sub-model conditionally chose all raster cells from the reclassified residential parcels surface that had a value of 9 and assigned them a value of 9 in the new Urban Goal 1 raster. For all other raster cells the sub-model assigned the value derived from the equally weighted MUAs raster (Equation 1). All CMUAs were derived in similar fashion, the only differences being the specific MUAs and land-use parcels used in the sub-model.

Equation 1: Conditional expression used to derive the urban goal; identify lands suitable for residential use

$$\text{Con}(\text{"Residential Reclass"} == 9, 9, \text{UG1_weight})$$

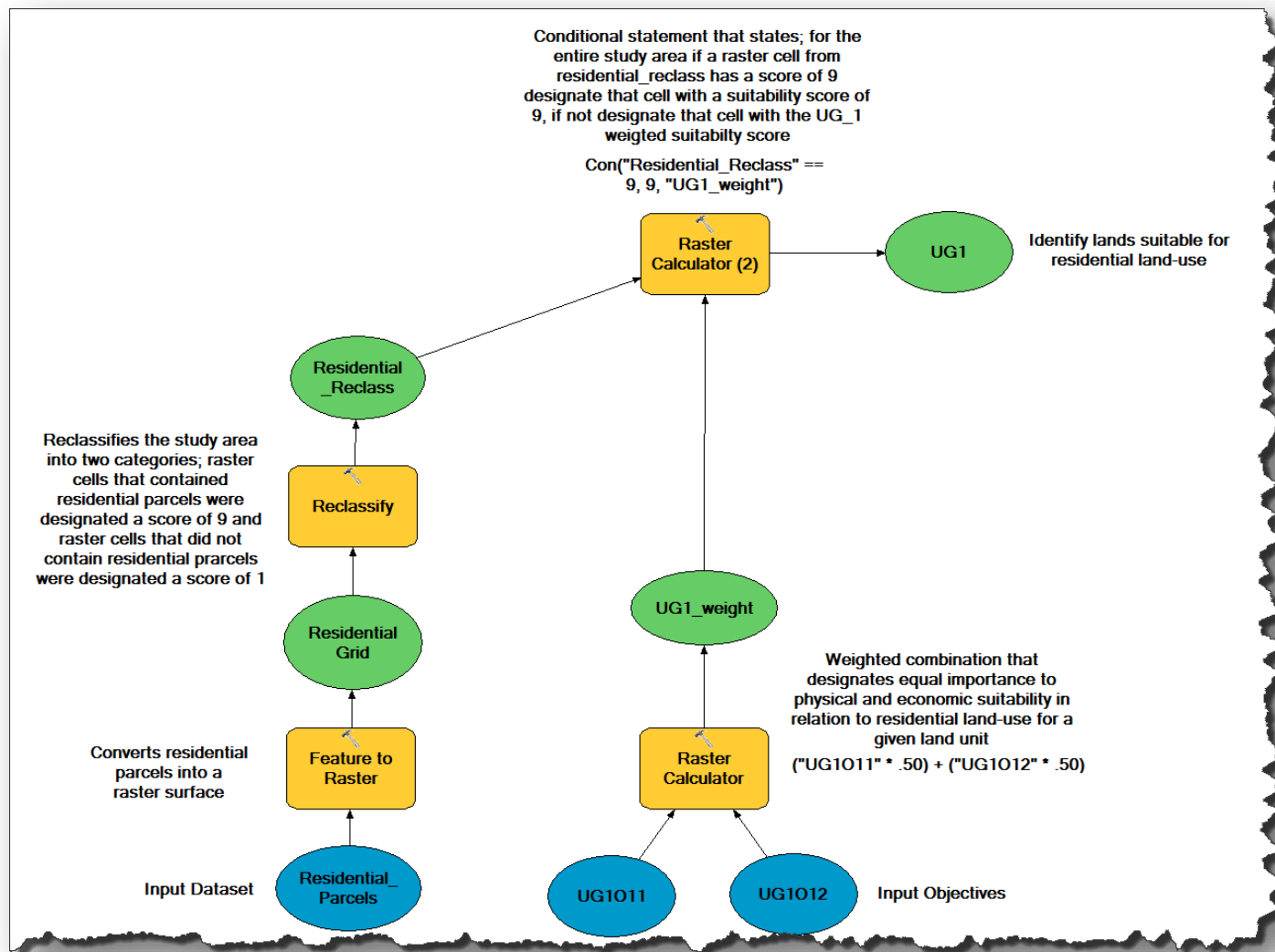


Figure 23: Analysis model for the urban goal "identify lands suitable for residential use"

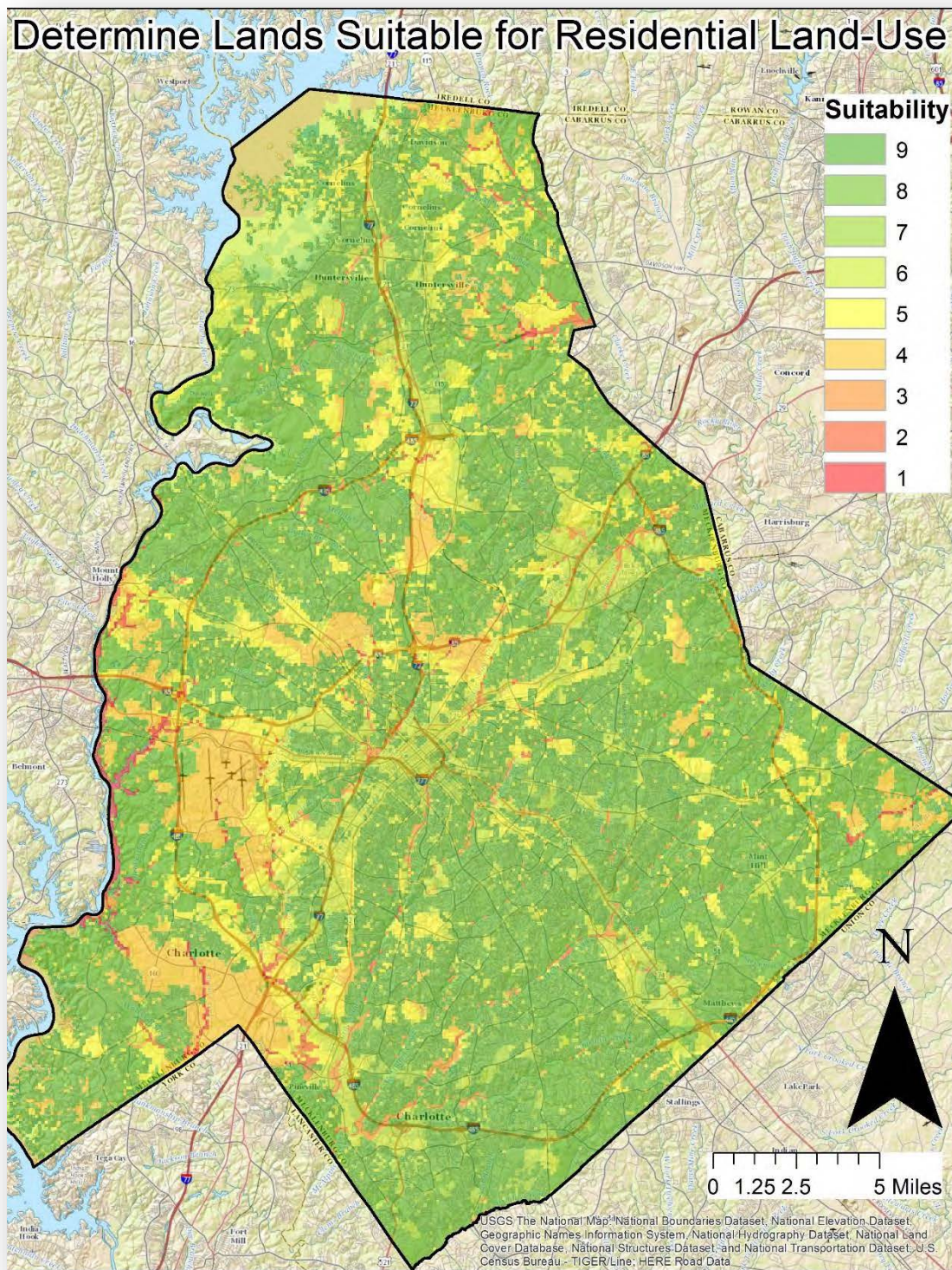


Figure 24: Results of the CMUA “identify lands suitable for residential use”

3.5.3 Evaluation Modeling

In this adaptation of the LUCIS model, pairwise comparison and goal weighting analyses were equivalent to evaluation modeling in the geodesign framework. This process weighed and combined the CMUAs for each land-use category to establish final collapsed suitability rasters. Typically, CMUAs are weighted by the AHP using stakeholder rationale. This study differed in its approach due to a lack of resources and access to stakeholder involvement. Instead, CMUAs were weighted equally (with the exception of urban goal 1, identify lands suitable for residential land-use) to accommodate this change (Table 6). Urban Goal 1 was given a heavier weight to accommodate the growing need to house existing and projected citizens under the assumption that the desire for urban residential land logically outweighs the desire for alternative urban land, such as urban industrial. Because weights were used to determine which goals were valued more than others within a specific land-use type, the preference of urban residential land over other forms of urban land only affected the urban land-use classification.

Table 6: Suitability weights which are in turn used to derive urban, agriculture, and conservation suitability surfaces.

Goal	Description	Suitability Weight
<i>Agriculture</i>		
<i>Goal 1</i>	Identify lands suitable for croplands	.34
<i>Goal 2</i>	Identify lands suitable for livestock	.33
<i>Goal 3</i>	Identify lands suitable for timber	.33
	<i>Total</i>	1.0
<i>Conservation</i>		
<i>Goal 1</i>	Identify lands suitable for protecting native biodiversity	.25
<i>Goal 2</i>	Identify lands suitable for protecting water quality	.25
<i>Goal 3</i>	Identify lands suitable for protecting important ecological processes	.25
<i>Goal 4</i>	Identify lands suitable for resource-based recreation	.25
	<i>Total</i>	1.0
<i>Urban</i>		
<i>Goal 1</i>	Identify lands suitable for residential land-use	.40
<i>Goal 2</i>	Identify lands suitable for office/commercial land-use	.20
<i>Goal 3</i>	Identify lands suitable for retail land-use	.20
<i>Goal 4</i>	Identify lands suitable for industrial land-use	.20
	<i>Total</i>	1.0

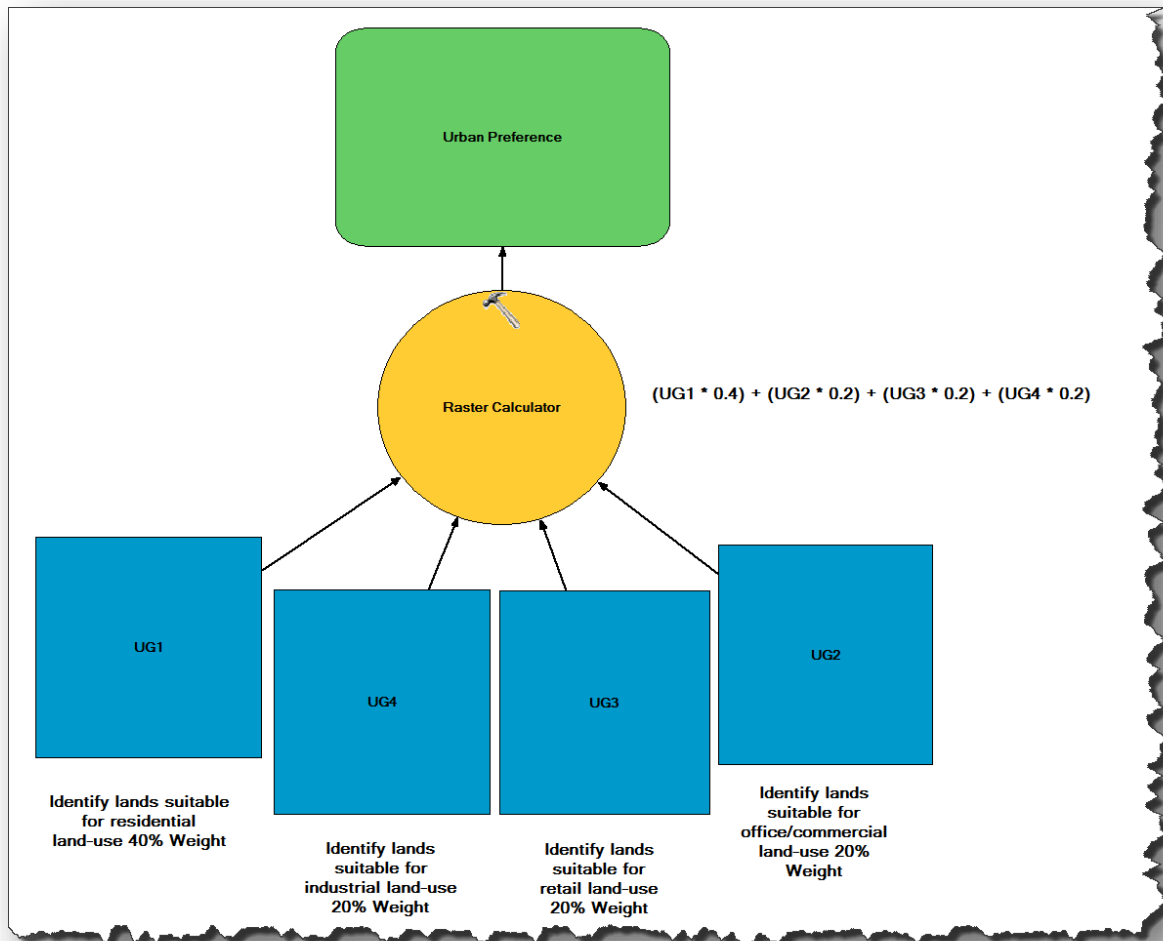


Figure 25: Urban preference model

CMUAs and their derived weights were combined using the Raster Calculator tool (Figure 25) to create three final land-use suitability surfaces, one for each classification (see Section 4.1). This sub-model multiplied each CMUAs (or goals) by their respective pairwise comparison weight and added the results together to produce a single suitability surface for each land-use class.

3.5.4 Change Modeling

There were three main tasks that were required to isolate and quantify potential land-use conflict: (1) remove land within the study area whose use will not change, (2) normalize and collapse suitability results, and (3) combine the normalized and collapsed suitability results to identify and measure areas of conflict.

3.5.4.1 Developable Land

When calculated within a GIS, land-use suitability is an indication of the degree to which any given unit of land (i.e. raster cell) is suitable for a land-use category (Carr and Zwick 2007). But regardless of the degree of suitability found from the application of LUCIS, in reality the uses of certain land units are highly unlikely to change. For instance, there is very little likelihood that a unit of land currently classed urban industrial will be converted to conservation over time. To accommodate this phenomenon a raster mask consisting of existing urban land, open water, and major roads was created.

First, urban parcels were converted into raster cells using the Feature to Raster tool and then reclassified using the Reclassify tool. Land units that contained current urban land were reclassified to NoData, and all other land was reclassified to 1. Similarly, a hydrology feature class containing all open bodies of water was converted to raster using the Feature to Raster tool. All lands that were considered open water were reclassified to NoData, and all other land was reclassified to 1. Finally, a major roads feature class was converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool. All land units that contained major roads were reclassified to NoData and all other land units were reclassified to 1. Each mask was multiplied together using the Raster Calculator tool and the resulting surface exposed only developable land within the study area (Figures 26 and 27).

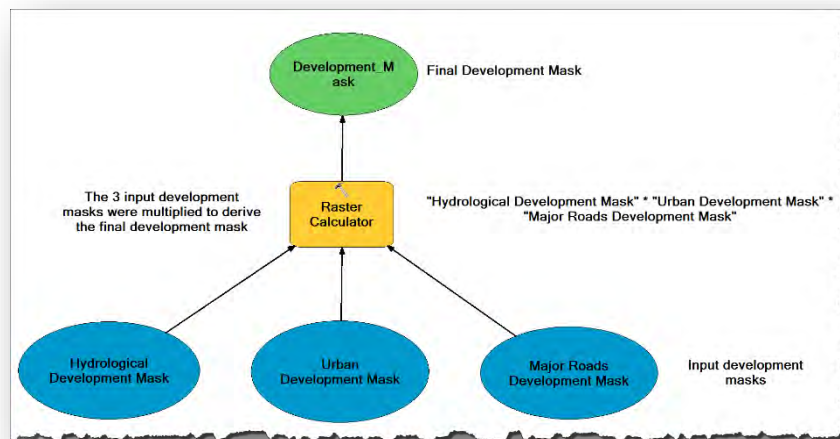


Figure 26: Developable land model

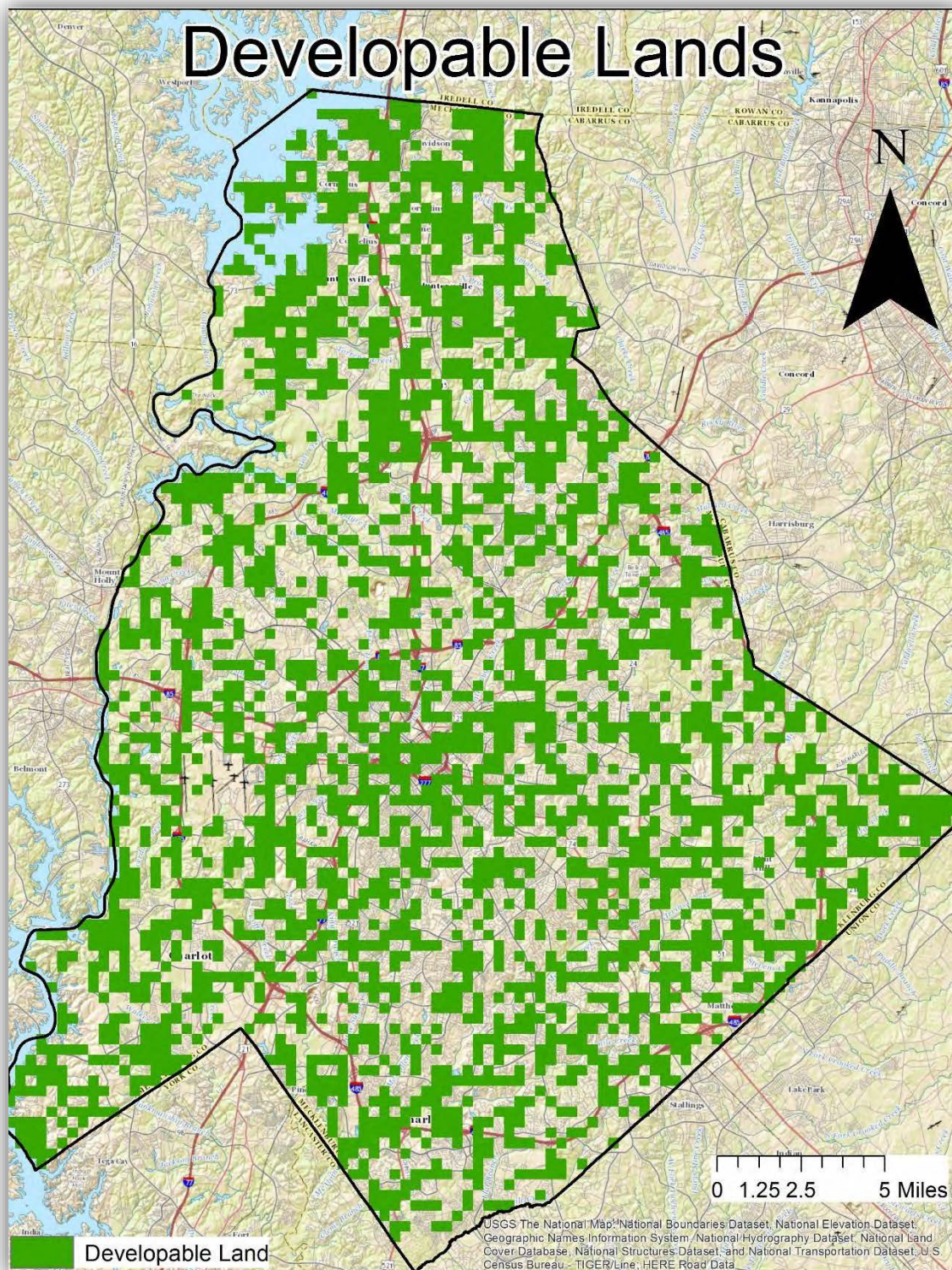


Figure 27: Developable land within the study area

3.5.4.2 Isolation and Quantification of Future Land-Use Conflict

In order to isolate, quantify, and visualize potential future land-use conflict, the three final land-use suitability surfaces were normalized and combined. This was accomplished by dividing each final land-use suitability surface, which contained values between 1 and 9, by 9 using the Divide tool. The resulting surfaces were limited to the development mask and contained values between 0 and 1. For example, the final urban suitability surface was divided by 9 (Figure 28) and resulted in a normalized suitability surface with values ranging from 0 to 1 (Figure 29).

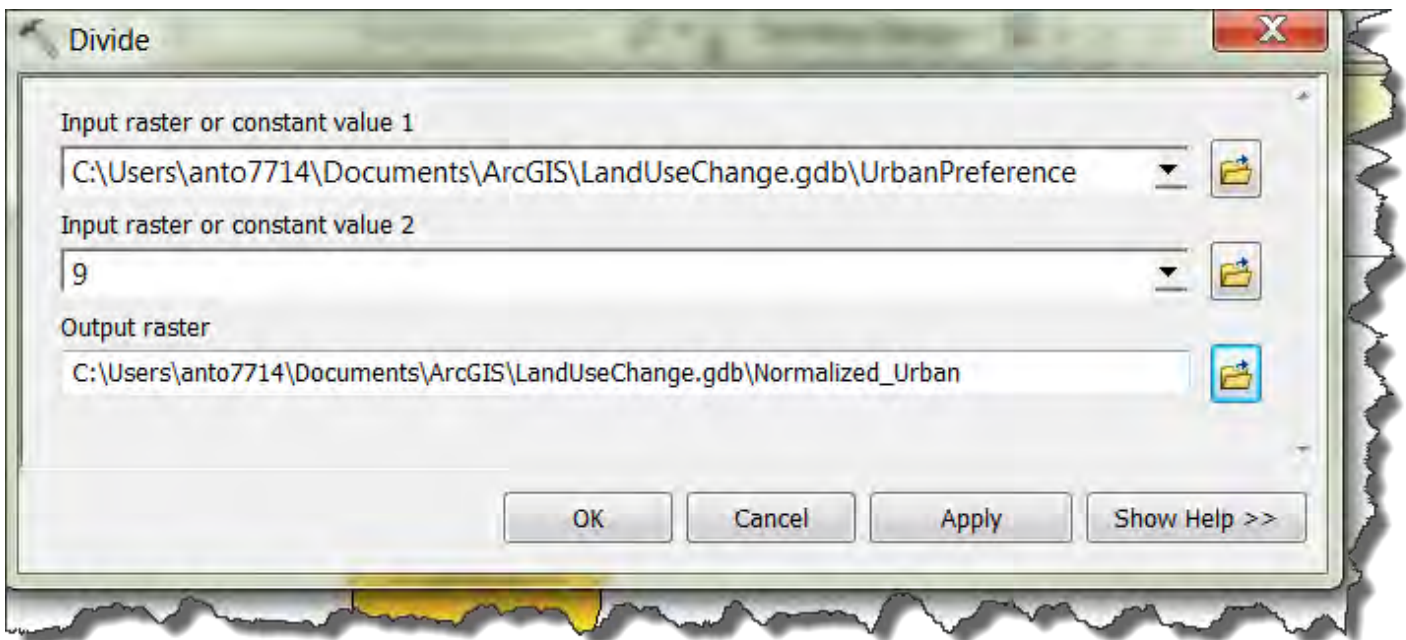


Figure 28: Divide tool used to derive the normalized land-use class suitability surface

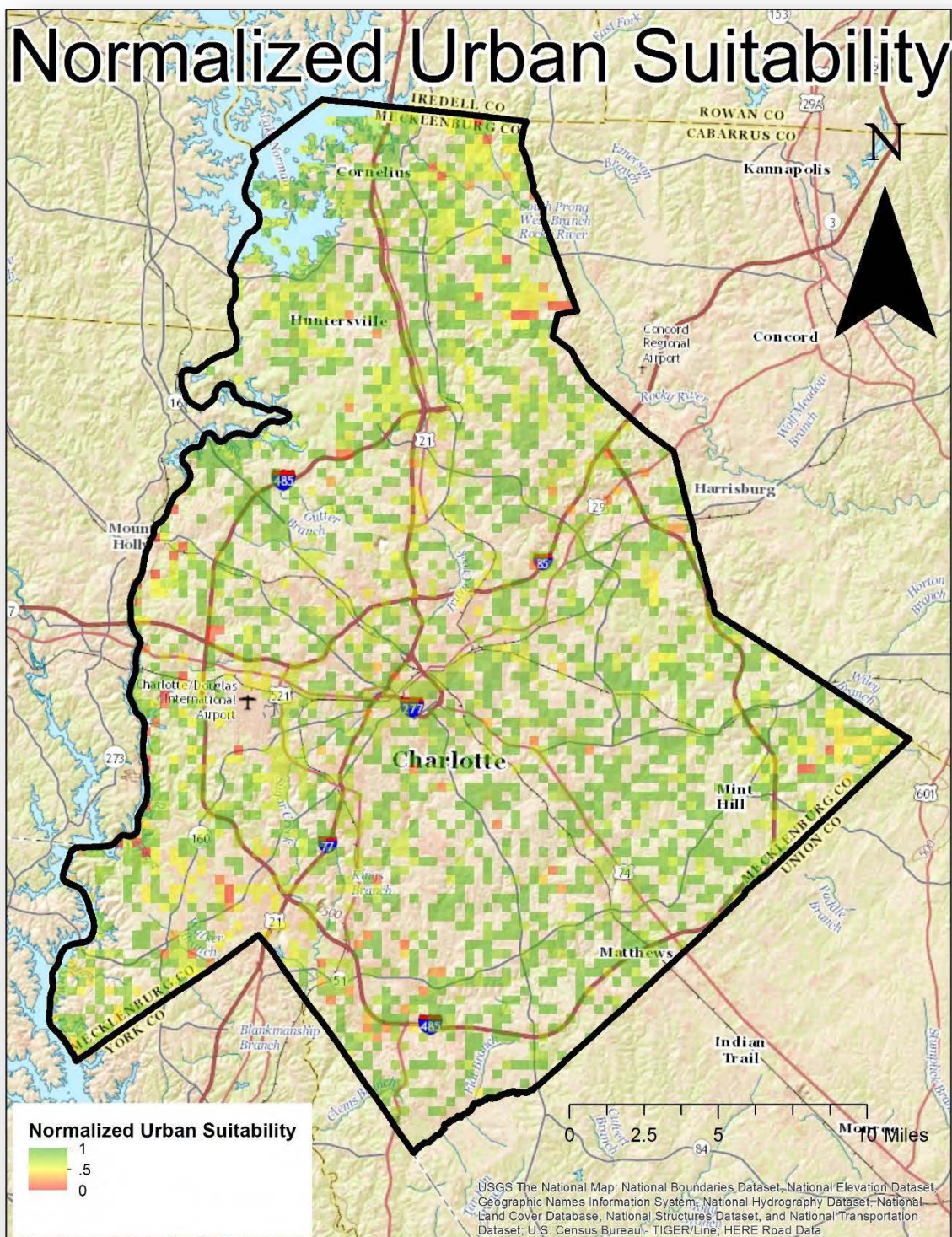


Figure 29: Normalized urban suitability derived from divide tool

Each surface was then reclassified using the standard deviation classification methodology to create three normalized classes that corresponded with high (3), moderate (2), and low (1) suitability. To achieve this task, each surface was reclassified using the Reclassify tool. For example, the normalized urban suitability surface was used as an input dataset in Figure 30 and Table 7. In the Reclassify tool the standard deviation classification method was selected. Because three normalized classes were desired, an interval size that resulted in a number of classes divisible by three was sought out. A quarter standard deviation was chosen because it resulted in 18 classes that could be reclassified into three classes, six data ranges per class. This process was used for each normalized suitability surface resulting in three normalized and collapsed suitability surface.

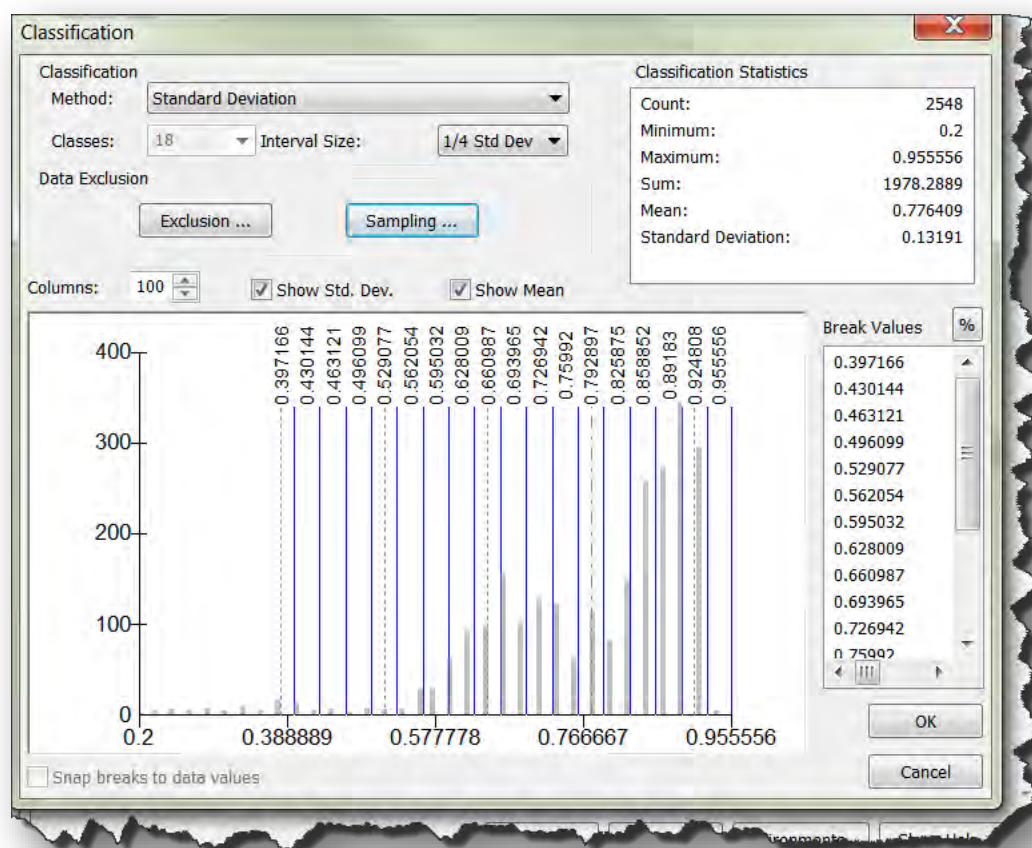


Figure 30: Standard deviation classification methodology used in normalized urban suitability raster reclassification

Table 7: Data range and values for standard deviation reclassification of the normalized urban suitability raster

<i>Data Range</i>	<i>Reclassification Value</i>
0.2 - 0.397166	1
0.397166 - 0.430144	1
0.430144 - 0.463121	1
0.463121 - 0.496099	1
0.496099 - 0.529077	1
0.529077 - 0.562054	1
0.562054 - 0.595032	2
0.595032 - 0.628009	2
0.628009 - 0.660987	2
0.660987 - 0.693965	2
0.693965 - 0.726942	2
0.726942 - 0.75992	2
0.75992 - 0.792897	3
0.792897 - 0.825875	3
0.825875 - 0.858852	3
0.858852 - 0.89183	3
0.89183 - 0.924808	3
0.924808 - 0.955556	3

The strength of mapping “collapsed suitability” is that suitable values may be easily combined to show different relationships among the three categories (Carr and Zwick 2007). Collapsed suitability surfaces (see Section 4.2.1) did not differ greatly from before they were normalized, collapsed, and limited in size, but a more refined picture of where land-use classes were suitable and at what magnitude was clearer.

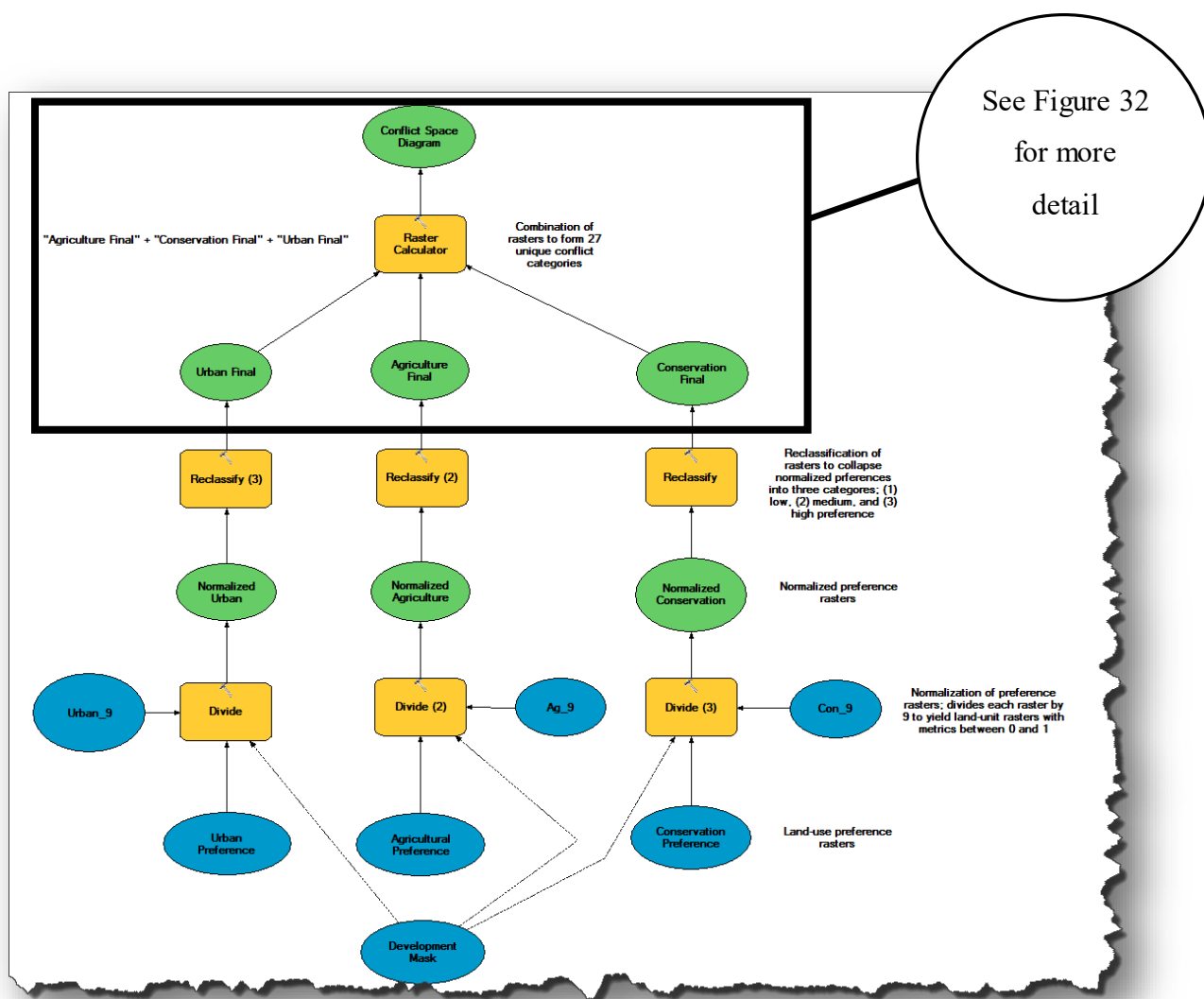


Figure 31: Conflict space diagram model

The collapsed suitability surface values were changed from (1) low, (2) moderate, and (3) high, to three categories that could be easily combined to create the conflict space diagram.

Table 8: Suitability categories used to create the conflict space diagram

<i>Land-Use Class</i>	Multiplied by	Low	Moderate	High
<i>Agriculture</i>	100	100	200	300
<i>Conservation</i>	10	10	20	30
<i>Urban</i>	1	1	2	3

This was achieved by combining the suitability surfaces using the Raster Calculator tool (Figures 32 and 33). The resulting conflict raster was composed of 27 unique conflict categories, which collectively make up the conflict space diagram. Each category is examined in Table 9.

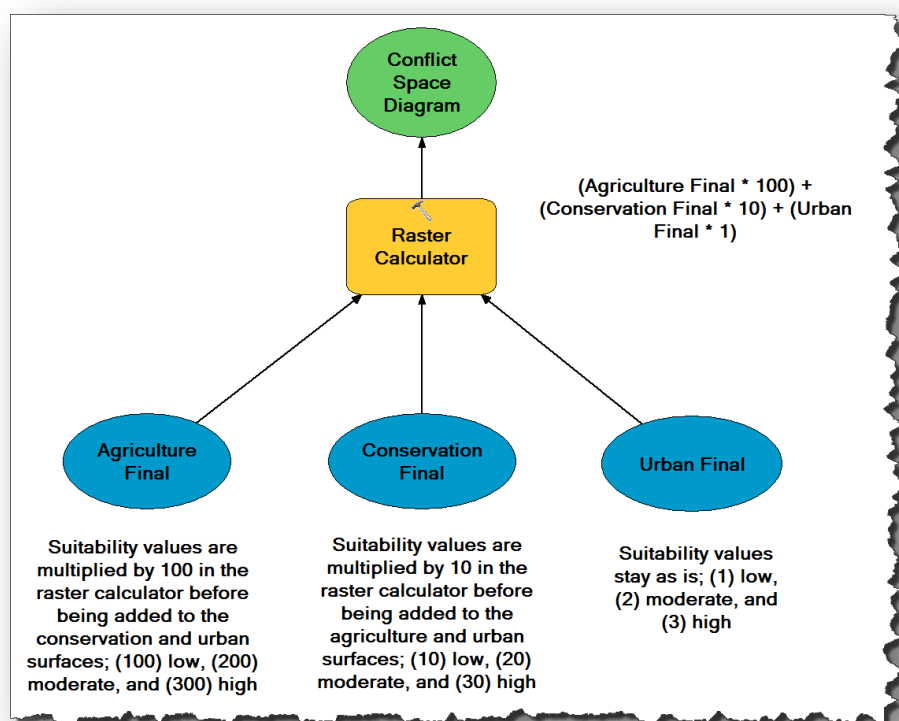


Figure 32: Combination of normalized and collapsed suitability surfaces to create the conflict space diagram that segments conflict in 27 unique categories

Figure 33 depicts this modeling process in relation to the physical raster cells that contained each inherited suitability value. From left to right, the suitability preference surfaces were multiplied by 100, 10, or 1 and then added from top to bottom starting with agriculture. The resulting conflict raster was made up of raster cells that contained a specific code that corresponded with a conflict type within the conflict space diagram. For instance, the circled raster in the bottom left of the conflict raster reads 333. This means that the agriculture raster cell contained a value of 300, the conservation raster cell contained a value of 30, and the urban raster cell contained a value of three. This code corresponded with the conflict type “major conflict”, where each land-use classification holds both high and equal preferred interest in that specific land-unit.

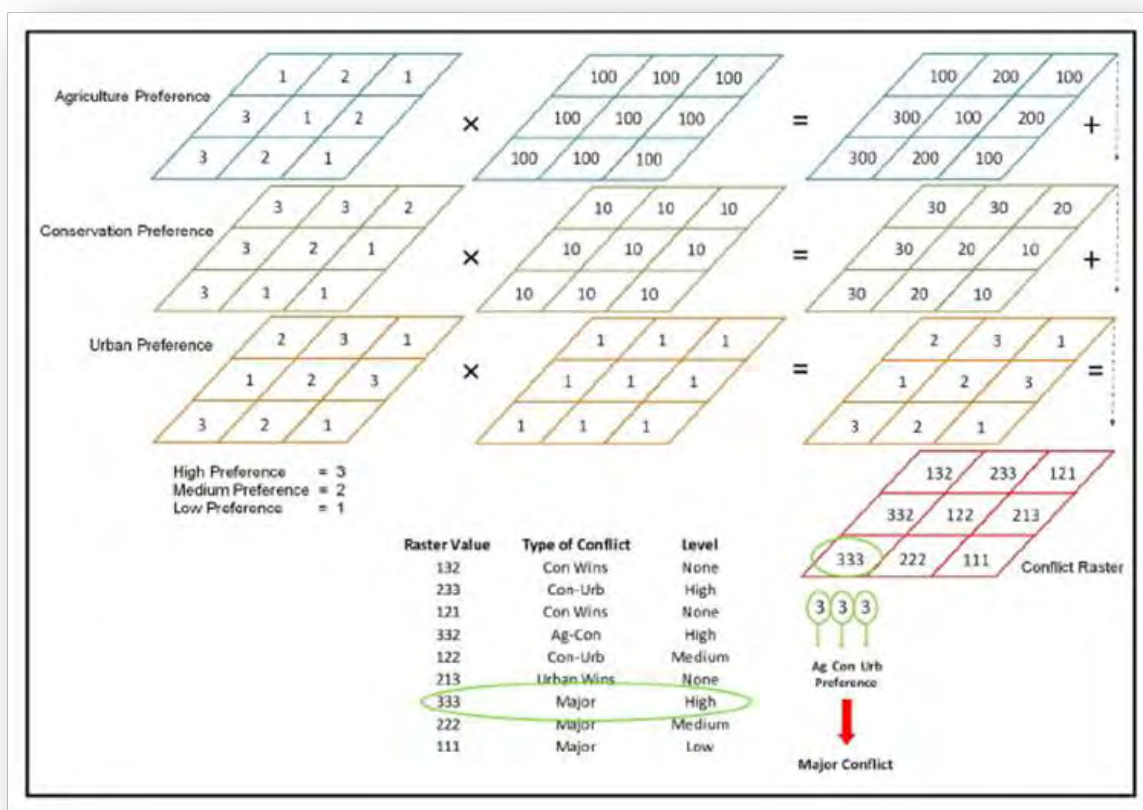


Figure 33: Conflict types and raster yielded by the combination of normalized and collapsed suitabilities

Table 9: 27 unique conflict categories

Areas of Conflict		Areas of No Conflict	
Code	Description	Code	Description
111	All in Conflict, all low preference	112	Urban Preference dominates
122	Moderate Conservation preference conflicts with moderate urban preference	113	Urban Preference dominates
133	High conservation preference conflicts with high urban preference	121	Conservation preference dominates
233	High conservation preference conflicts with high urban preference	123	Urban Preference dominates
221	Moderate agricultural preference conflicts with moderate conservation preference	131	Conservation preference dominates
212	Moderate agricultural preference conflicts with moderate urban preference	132	Conservation preference dominates
222	All in conflict, all moderate preference	211	Agricultural preference dominates
313	High agricultural preference conflicts with high urban preference	213	Urban Preference dominates
323	High agricultural preference conflicts with high urban preference	223	Urban Preference dominates
331	High agricultural preference conflicts with high conservation preference	231	Conservation preference dominates

Areas of Conflict		Areas of No Conflict	
332	High agricultural preference conflicts with high conservation preference	232	Conservation preference dominates
333	All in conflict, all high preference	311	Agricultural preference dominates
		312	Agricultural preference dominates
		321	Agricultural preference dominates
		322	Agricultural preference dominates

The identification and quantification of future land-use conflict was charted and mapped (see Sections 4.2.1 and 4.2.2) using a series of conflict space diagram visualizations. These results were then used in further analysis to create a baseline future land-use scenario and three class specific scenarios.

3.5.5 Impact and Decision Modeling

The results of implementing an adaptation of the LUCIS model have the potential to be used for many purposes, one being the creation of future land-use scenarios. This study derived four future land-use scenarios from the land-use conflict modeling results discussed in the previous section: the baseline scenario, agricultural scenario, conservation scenario, and urban scenario. The baseline scenario weighed each of the land groups equally during pairwise comparison to produce a land-use conflict constant that was later utilized in scenario comparison. Each of the other three scenarios highlights one of the three land groups by weighing it heaviest to account for the adoption of land-use decisions that are in alignment with that land group. In terms of the geodesign framework, future land-use scenario mapping was equivalent to impact modeling. The results of impact modeling can then be used in the future by designers, planners, developers, and

other community stakeholders to execute the decision modeling component of the geodesign framework.

3.5.5.1 The Baseline Scenario

The baseline scenario began with a calculation of acres necessary to support the increase in human settlement (Equation 2 and Figure 34). With 456,813 projected new citizens and a current gross population density of approximately three people per acre, Mecklenburg County will need 152,271 additional urban acres to support the estimated population of the year 2030. That is approximately 96% of the 158,038 acres of future developable land.

Equation 2: Fundamental land-use equation that calculates the acres of land needed to support human settlement (Carr and Zwick 2007)

$$\frac{\text{Population Increase}}{\text{Gross Urban Density}} = \text{Acres of Land Needed to Support New Human Settlement}$$

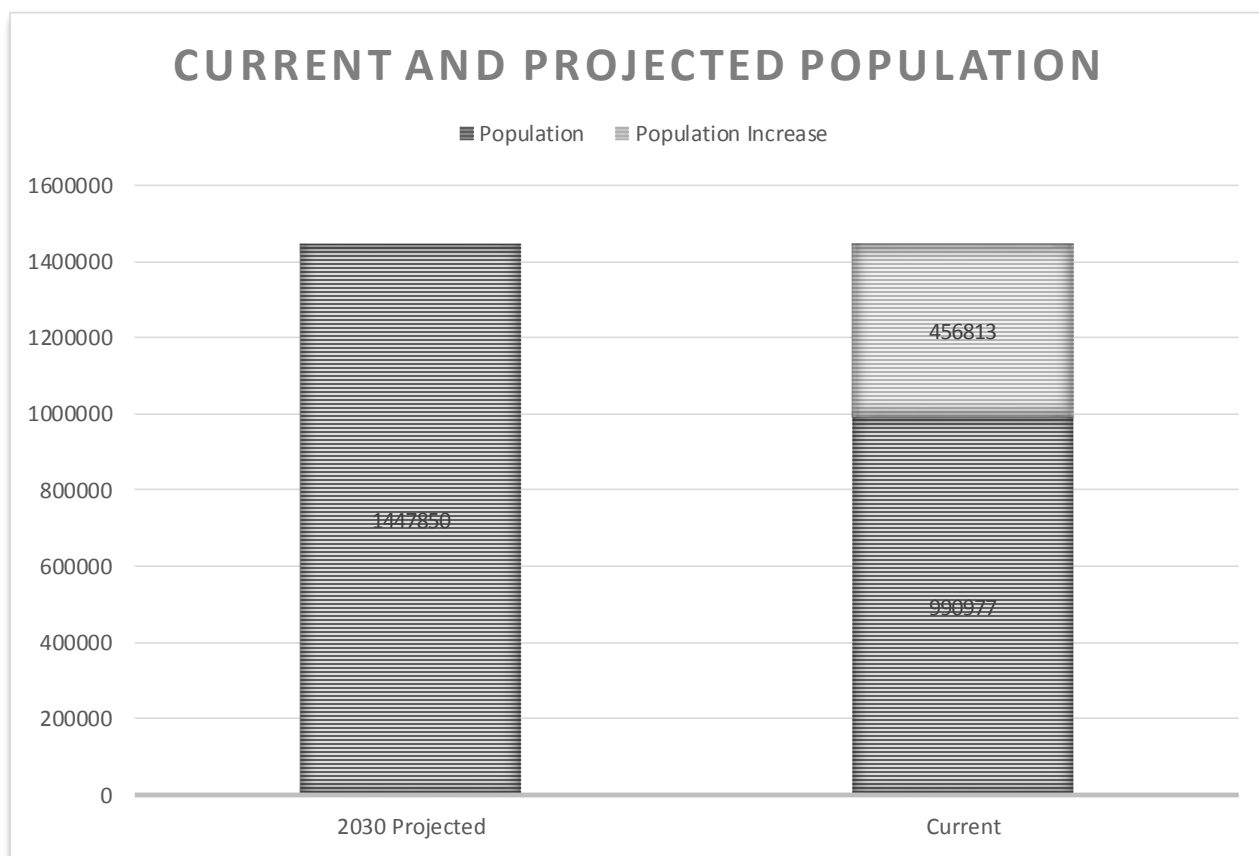


Figure 34: Current and projected future population as well as projected population increase

Using the conflict space diagram, future land-use was visualized by allocating population based acreage to their most suitable locations, beginning with future urban land that did not demonstrate conflict with other land-uses.

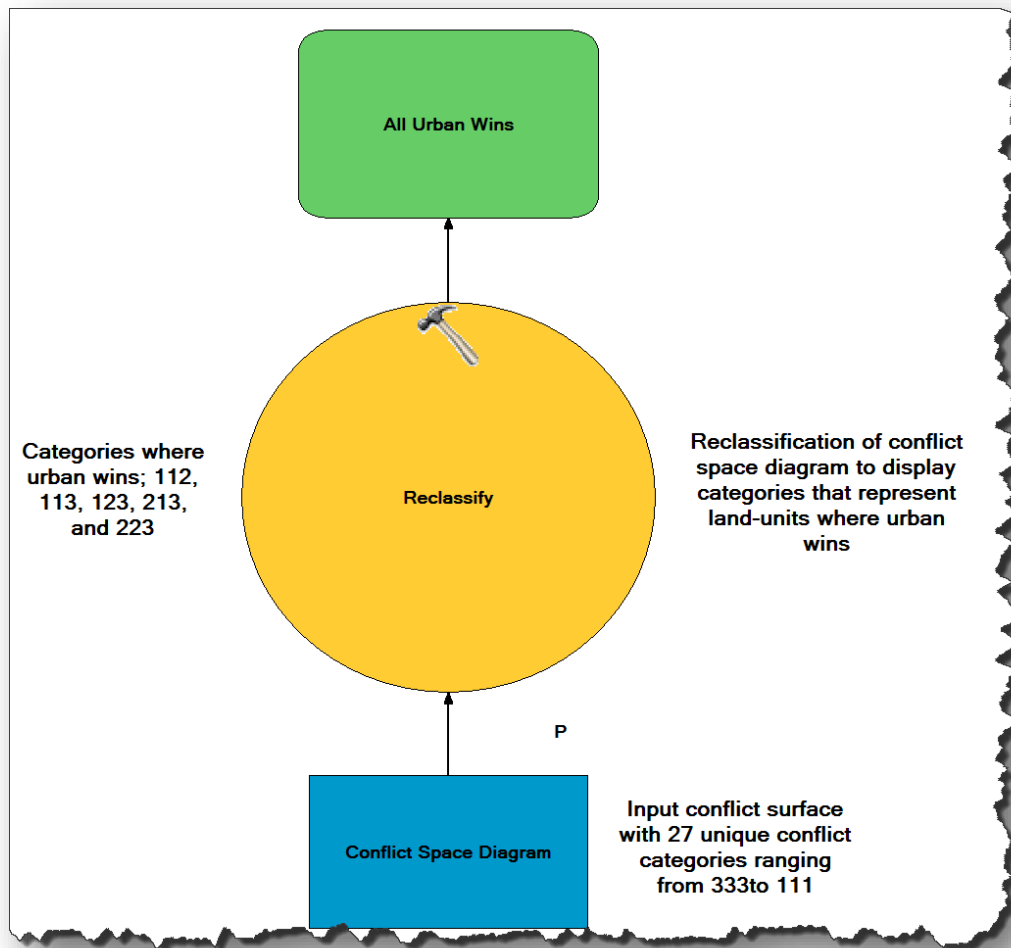


Figure 35: Allocate cells to urban land-use where urban wins

Additional land was allocated to future urban land from conflict space diagram (CSD) results that displayed moderate and major conflict with agriculture or conservation land (CSD codes: 122, 133, 233, 212, 313, and 323). This was achieved by reclassifying the CSD to create a conflict mask that identified any conflict between agriculture, conservation, and urban land-uses. This mask was then used as the environment in which the Raster Calculator tool conditionally

chose raster cells that had higher normalized urban suitability when compared to other normalized land-use suitabilities (Equation 3, and Figures 36 and 37).

Equation 3: Conditional statement used to choose where urban land-use preference wins over agricultural and conservation land-uses based on higher normalized suitability values

Con(Normalized Urban \geq Normalized Agriculture, Normalized Urban, Con(Normalized Urban \geq Normalized Conservation, Normalized Urban, NoData))

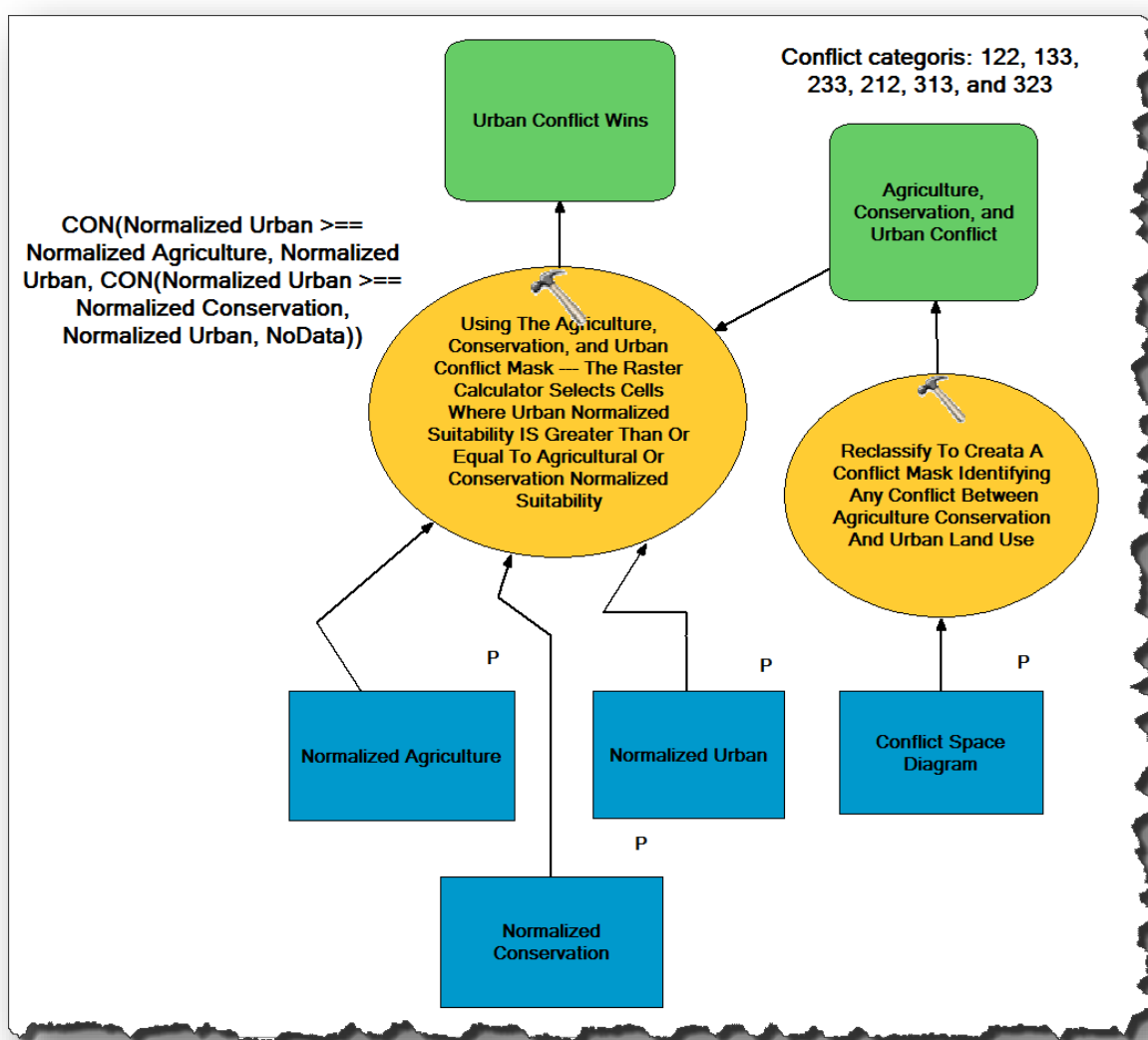


Figure 36: Model to allocate cells where urban conflict wins

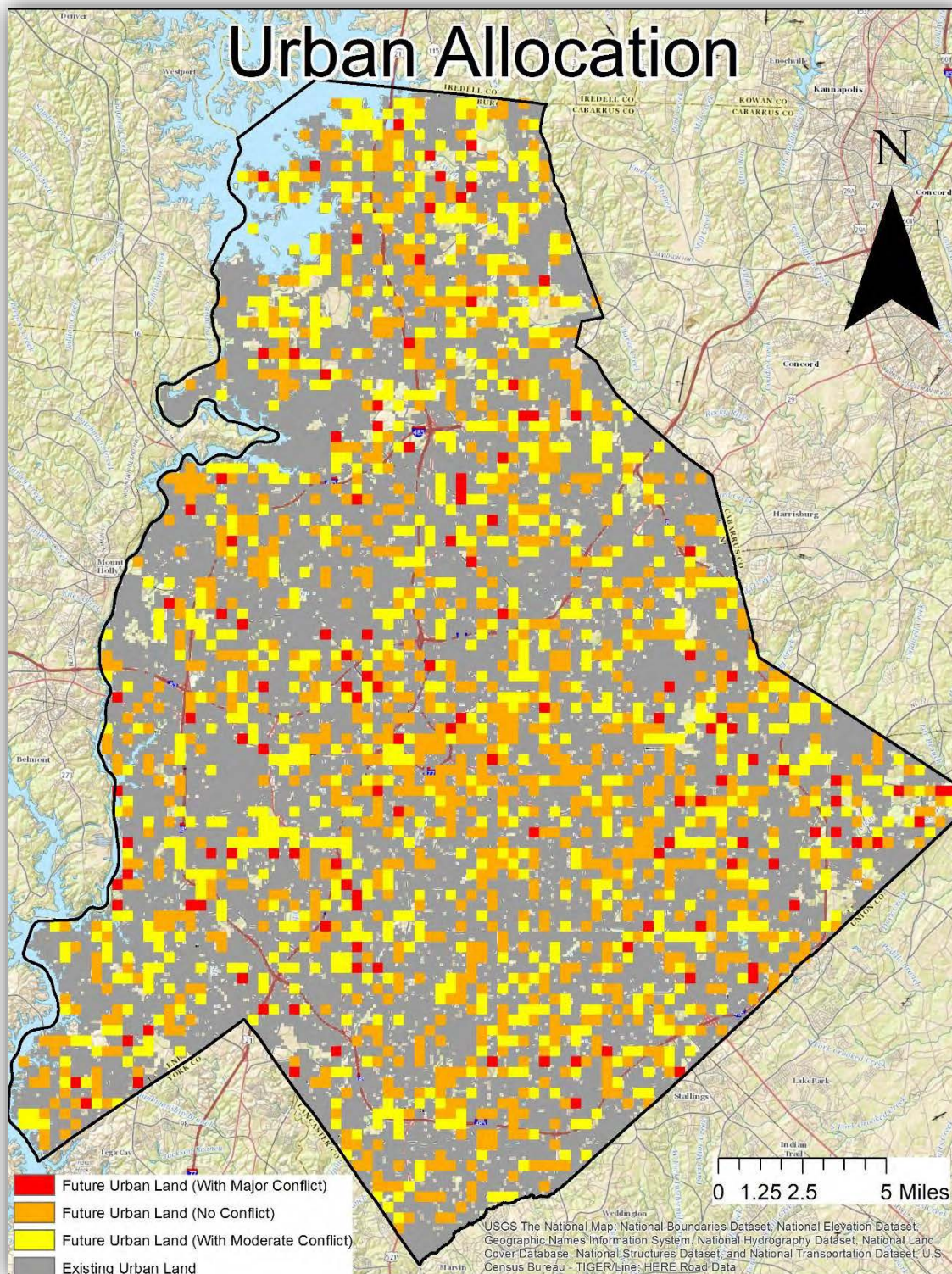


Figure 37: Future urban land in the base line scenario

The lands allocated to future urban land in the baseline scenario were removed from the development mask to reveal the remaining lands available for future land-use allocation (Figures 38 and 39).

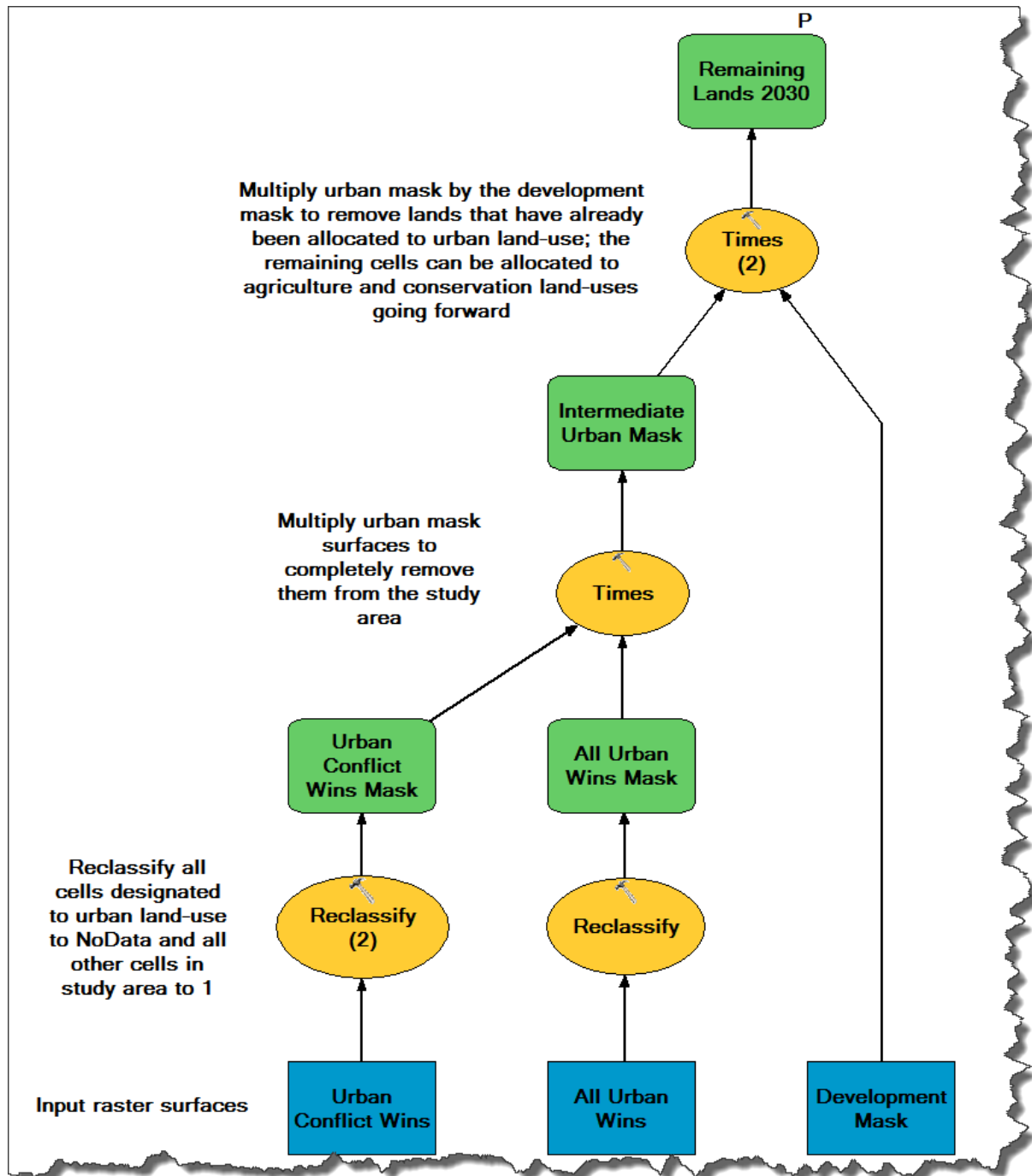


Figure 38: Model for the creation of the remaining lands 2030 mask

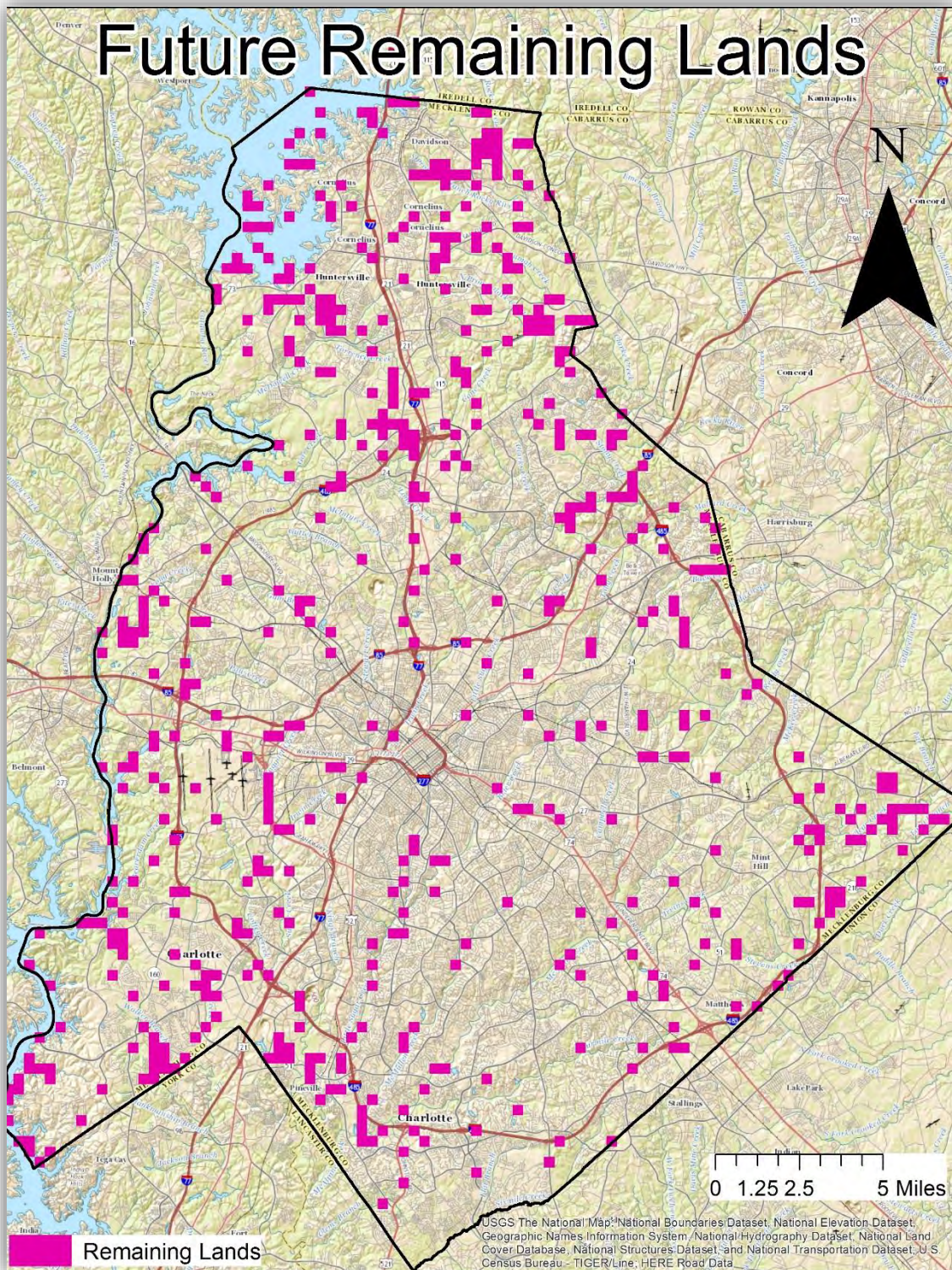


Figure 39: Remaining future lands for land-use allocation

From the available remaining land, acres were allocated to agriculture where agriculture was preferred and not in conflict with other land-uses. In addition, acres that had higher normalized agricultural suitability when compared to other land-uses were also allocated to future agriculture (Figures 40, 41, and 44).

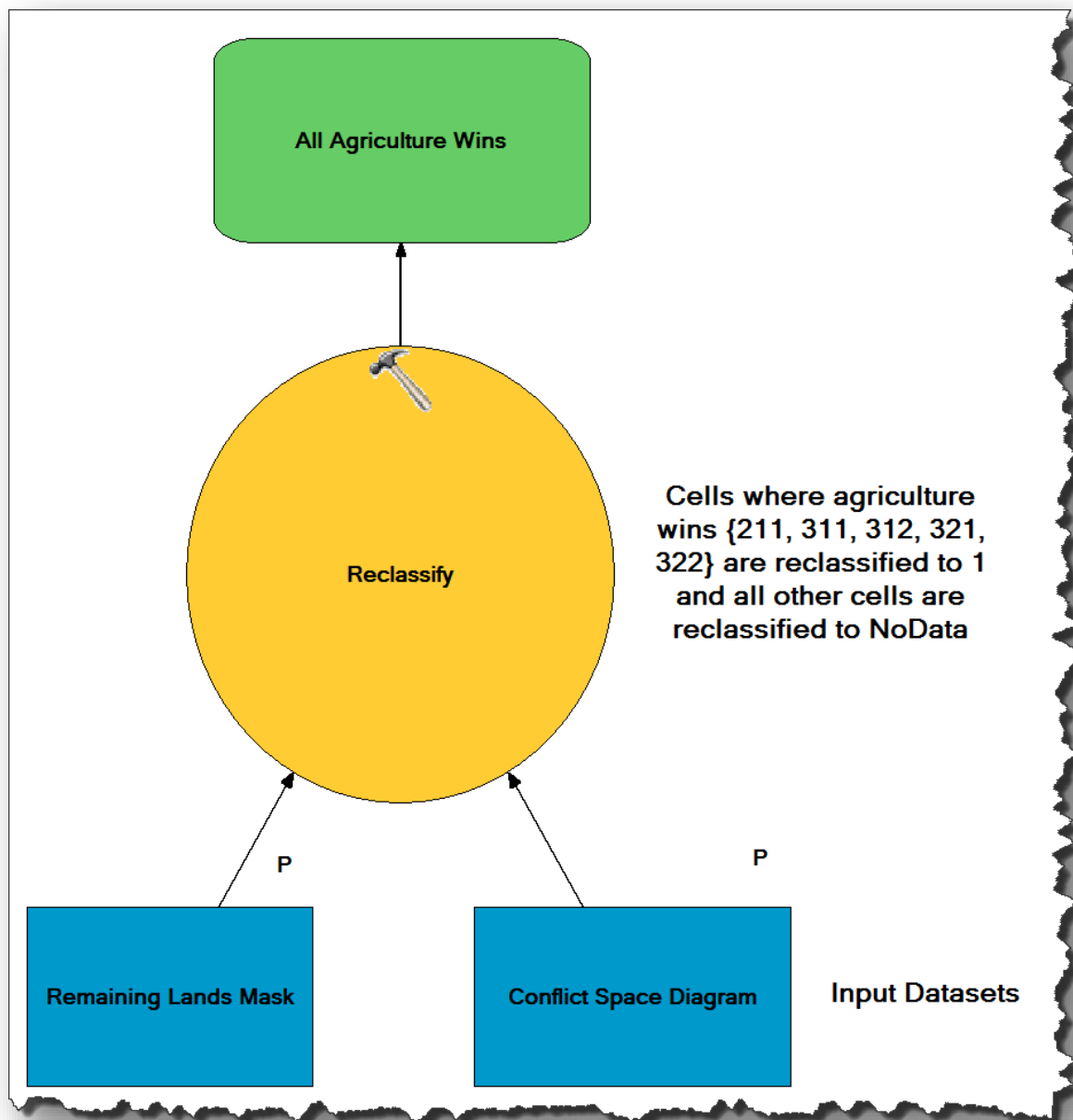


Figure 40: Model for the allocation of cells where agriculture wins

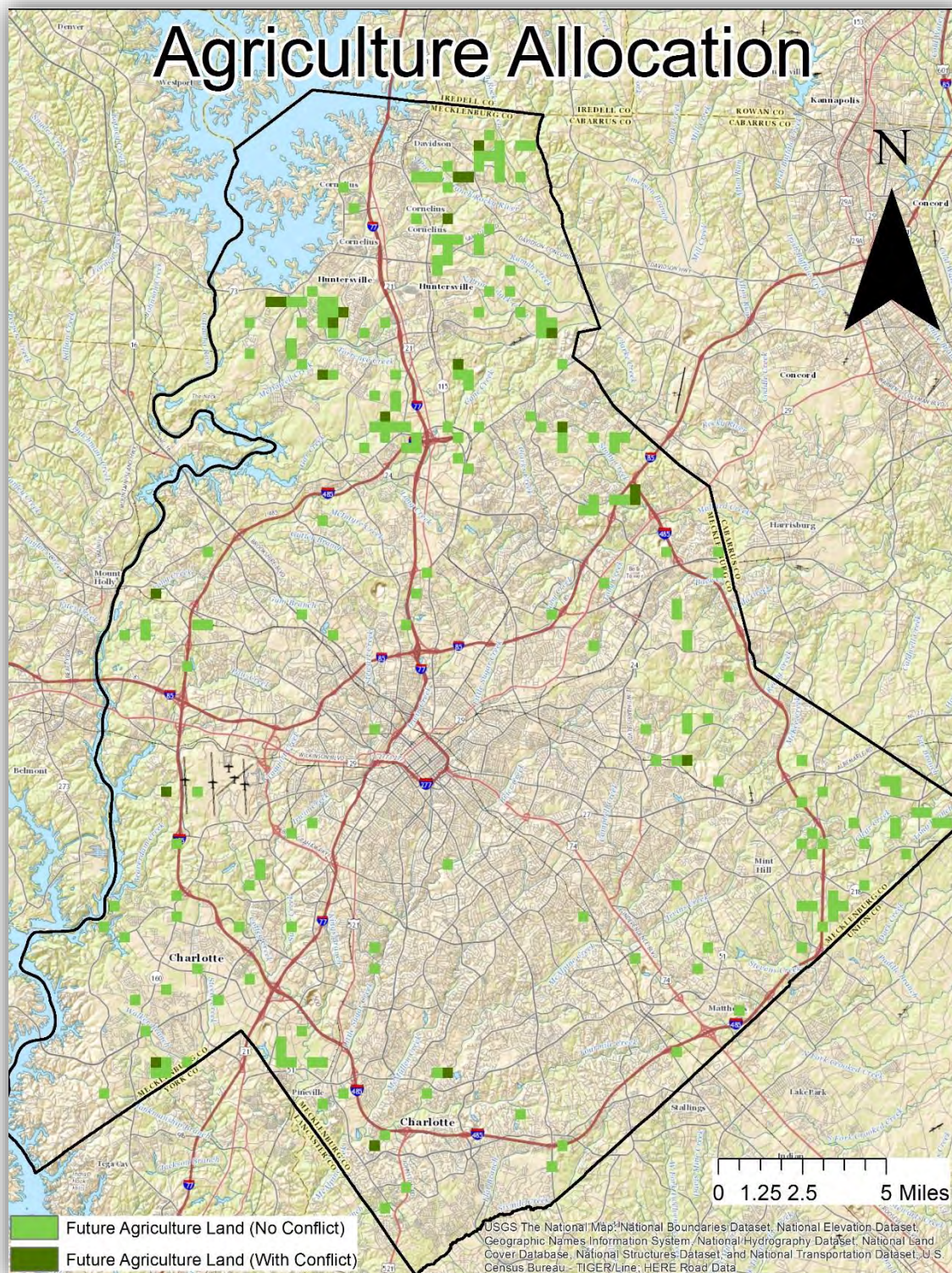


Figure 41: Land allocated to agriculture in the base line scenario

Similarly, acres were allocated to conservation where conservation was preferred and not in conflict with other land-uses. In addition, acres that had higher normalized conservation suitability when compared to other land-uses were also allocated to future conservation (Figures 42, 43, and 44).

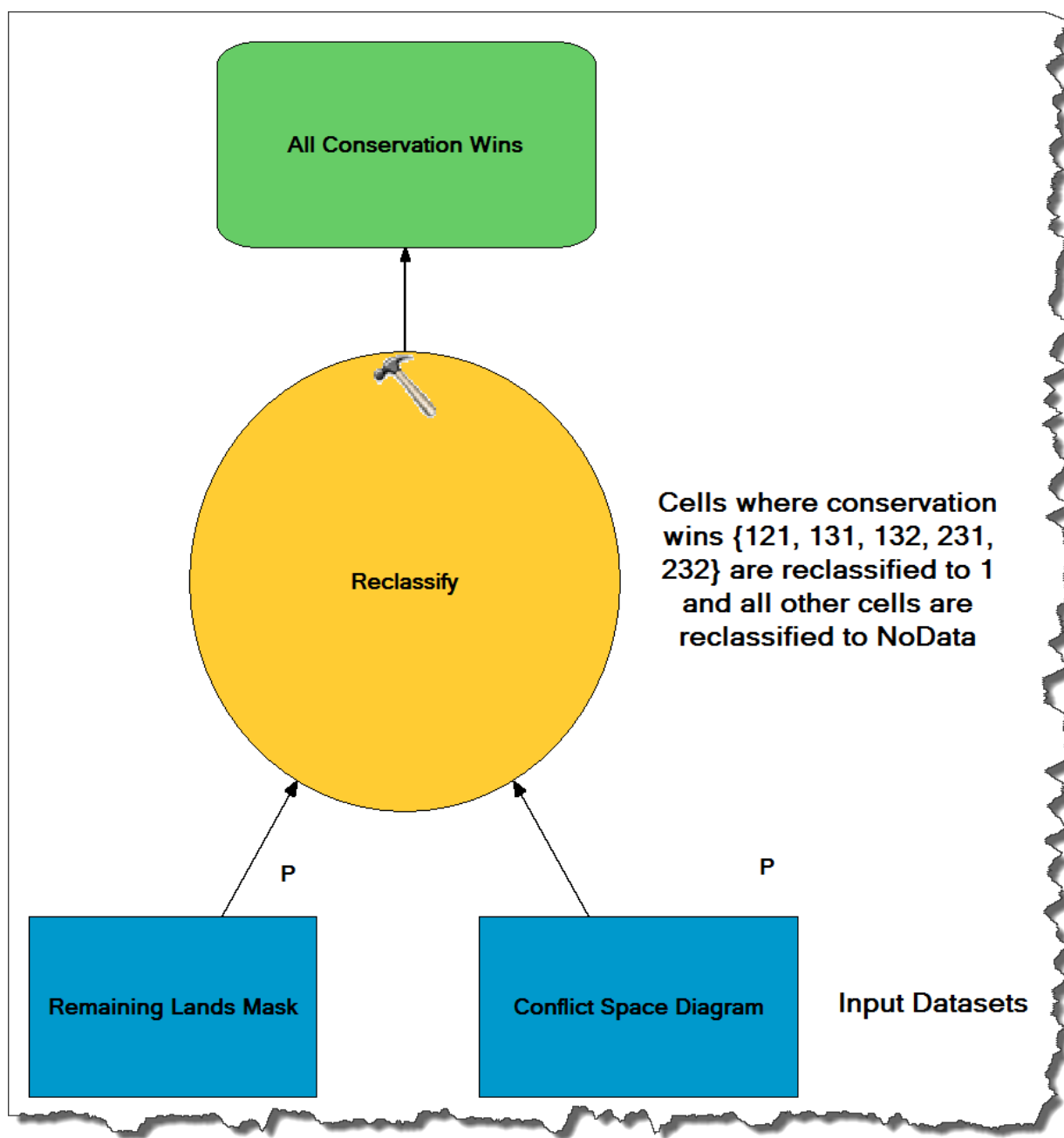


Figure 42: Model for the allocation of cells where conservation wins

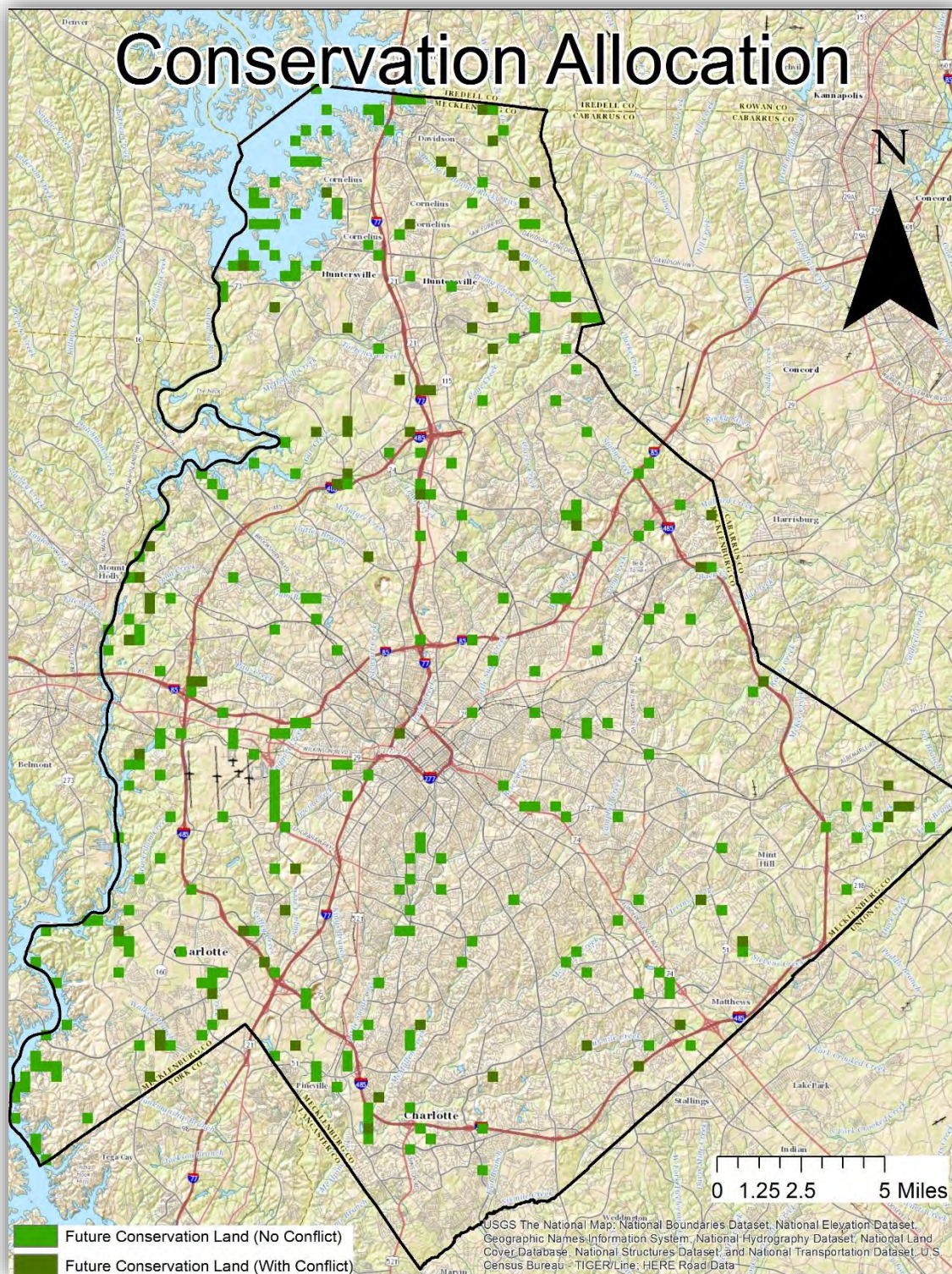


Figure 43: Land allocated to conservation in the base line scenario

As mentioned above, additional land-units were allocated to both agriculture and conservation based on conditional statements (all allocated land-units are included in Figures 41 and 43). This was achieved by first reclassifying the conflict space diagram to display agriculture and conservation conflict as 1, and all other cells as NoData, using the Reclassify tool. This reclassified surface was then used as a mask for two conditional statements that were executed using the Raster Calculator tool. These statements selected normalized suitability raster values for agriculture and conservation that were higher than each other for a given raster cell (Figure 44). The higher valued raster cells were allocated to their respective land-use class.

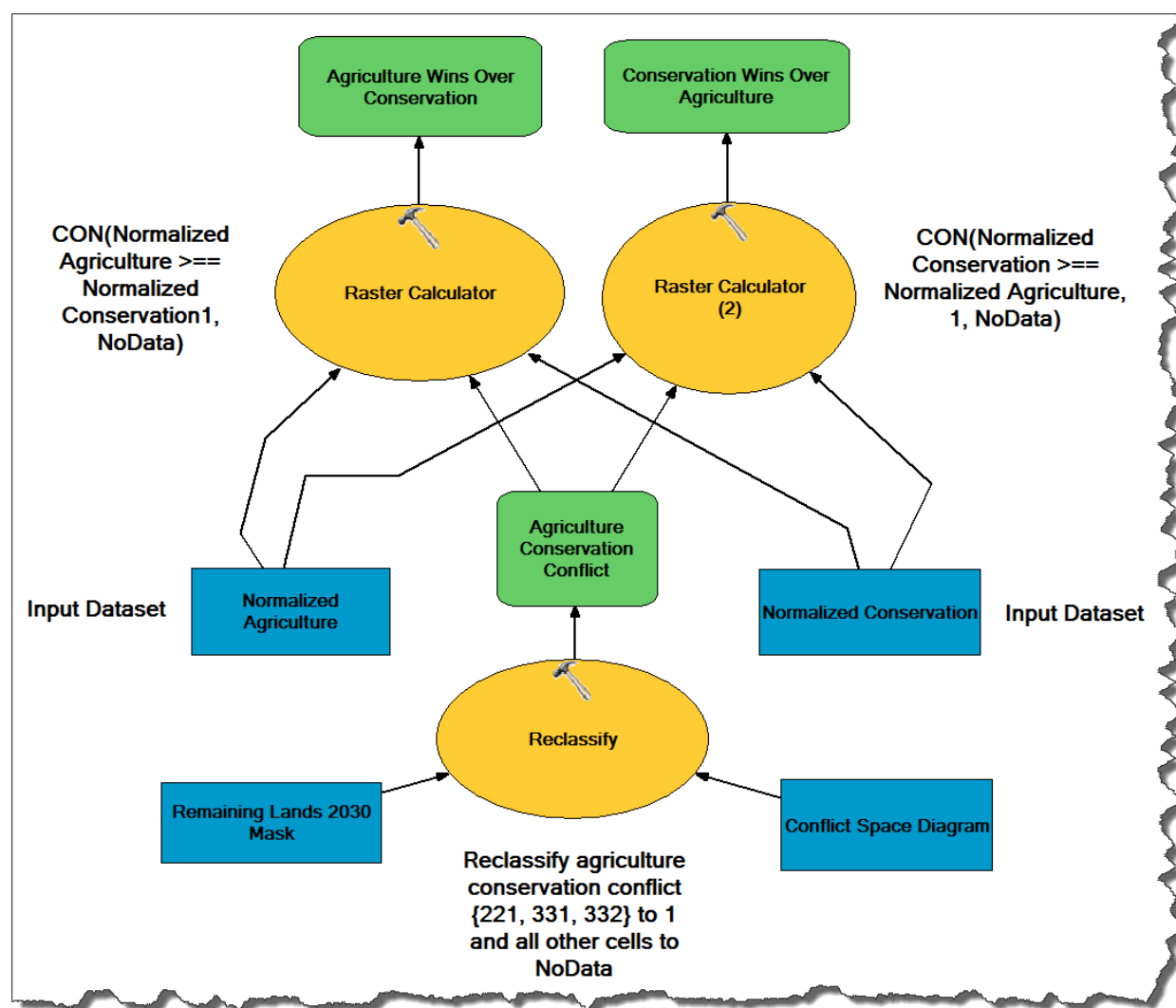


Figure 44: Model for allocation of agriculture and conservation lands that are in conflict

This modeling effort collectively yielded the baseline scenario (see Section 4.3.1). The baseline scenario was then used to derive three land-use class specific scenarios: the urban, conservation, and agriculture scenarios.

3.5.5.2 Urban, Conservation, and Agriculture Scenarios

Each land-use class specific scenario was created using the same process. Land that was allocated to a specific land-use in the baseline scenario was reevaluated manually, and reallocated according to that reevaluation. The reallocation process simply remapped raster cells that were previously allocated to one land-use to their new reevaluated land-use designation. The acreage was then recalculated and documented in that scenario's results.

The future urban land-use scenario was the first of three alternative future scenarios that was built from the baseline results. This scenario used the established trend of urban land consuming agriculture land for future expansion as the driver for acreage revaluation and reallocation. Acreage previously allocated to agriculture with and without conflict was reallocated to urban.

The conservation land-use scenario reallocated land previously allocated to agriculture with conflict to conservation. The scenario also reallocated acreage of developable land previously in major conflict, and urban with moderate conflict to conservation. This was achieved by taking all conservation lands that were in moderate conflict with urban lands, and allocating them to conservation.

In the most unlikely of the scenarios, the agriculture land-use scenario reallocated land previously allocated to conservation with conflict to agriculture. This scenario also reallocated acreage of developable land previously in major conflict, and urban with moderate conflict to agriculture. This was achieved by taking all agriculture lands that were in moderate conflict with urban lands, and allocating them to agriculture.

CHAPTER 4: RESULTS

This chapter presents the results of applying an adaptation of the LUCIS model to Mecklenburg County, North Carolina. The results are broken down into three categories; (1) preliminary land-use suitability, (2) isolation and quantification of potential future land-use conflict, and (3) future land-use scenarios. Maps, tables, charts, and graphs within each sub-section facilitate the visualization of results, and expose patterns and trends that can guide stakeholders in making critical decisions about the future of their communities.

4.1 Preliminary Land-Use Suitability

The model developed for this study derived three preliminary land-use suitability surfaces, one for each land-use class, by combining each of the land-use category goals using their pairwise comparison weights (see Section 3.5.3). Each surface (Figures 45, 46, and 47) represents the culminating product of that modeling effort. The color ramp used in each surface map depicts a range of suitability scores from high-to-low (green to red) for every land-unit in the study area (Tables 10, 11, and 12).

Table 10: Preliminary urban land-use suitability data ranges and scores

<i>Data Range</i>	<i>Score</i>
7-9	High
4-6	Moderate
1-3	Low

The urban suitability surface exposed the majority of the study area as suitable for urban development. Areas in proximity to current urban areas were found most suitable for urban development. This pattern is consistent with previous studies that have observed a correlation between new urban development suitability and the policies that produced existing urban development. Only areas of existing open water and conservation were found to have low suitability.

Table 11: Preliminary agriculture land-use suitability data ranges and scores

<i>Data Range</i>	<i>Score</i>
7-9	High
4-6	Moderate
1-3	Low

The agricultural suitability surface revealed a much different story. The western border of the county presented very low suitability due to existing open water and land in conservation, whereas the majority of the remaining areas in the county had moderate to low suitability because of the existing metropolitan landscape. Areas north and southeast of Charlotte, such as Huntersville and Mint Hill, had the only large collection of lands highly suited for agriculture.

Table 12: Preliminary conservation land-use suitability data ranges and scores

<i>Data Range</i>	<i>Score</i>
7-9	High
4-6	Moderate
1-3	Low

The conservation suitability surface differed greatly from the other land-use class surfaces. As a whole, the surface represented primarily suitable or unsuitable conservation land, with little-to-no moderately suitable conservation land-units. In fact, conservation suitability was at its highest in areas where urban suitability was at its lowest due to existing bodies of water and wetlands that are not suited for development. Areas surrounding Lake Norman and Lake Wylie (both along the western border of the county) were predominantly suitable for conservation because of high concentrations of biodiversity. This was also the case for the number of stream beds that pass through the county, which create a network of interconnected areas suited for conservation.

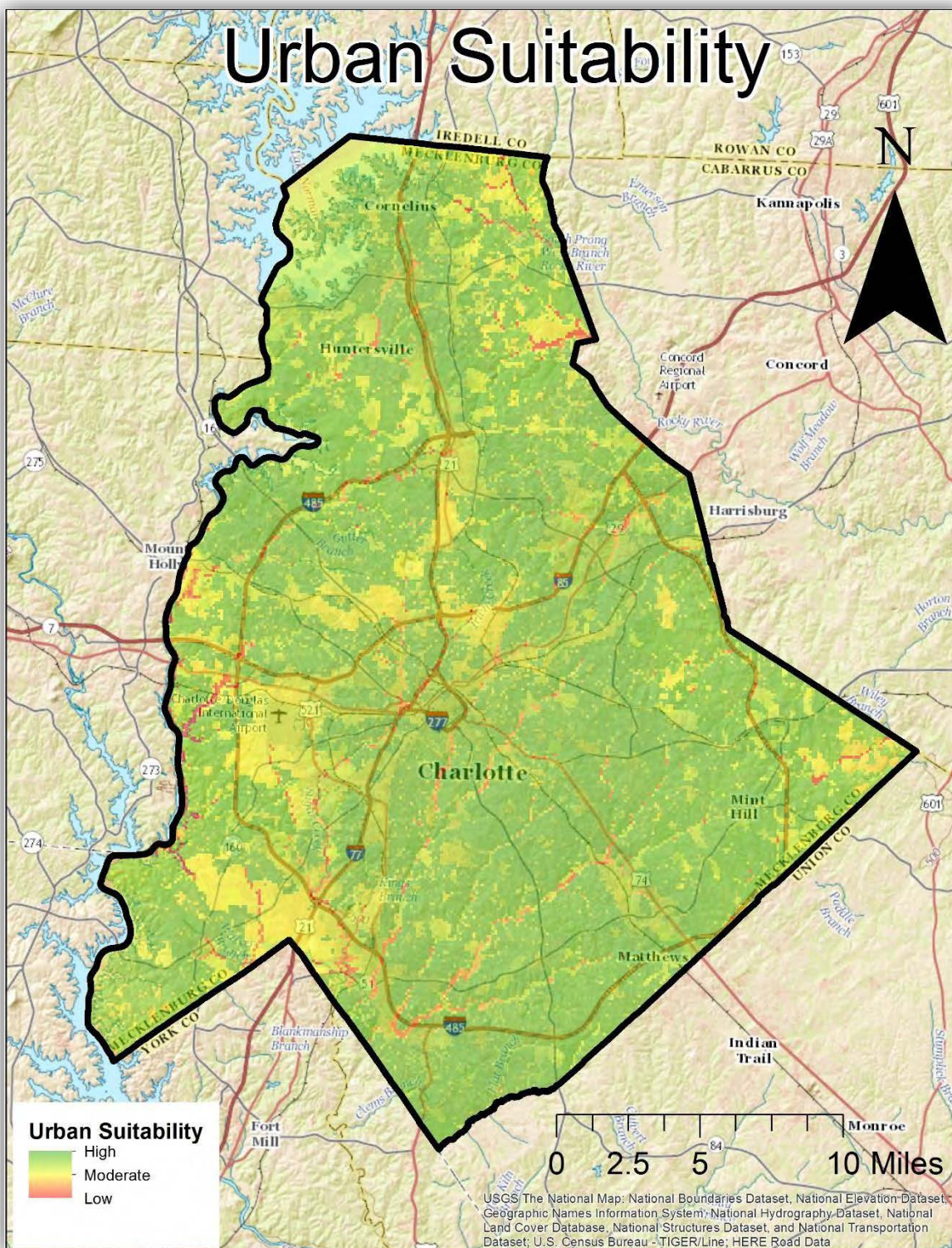


Figure 45: Urban suitability results for the study area

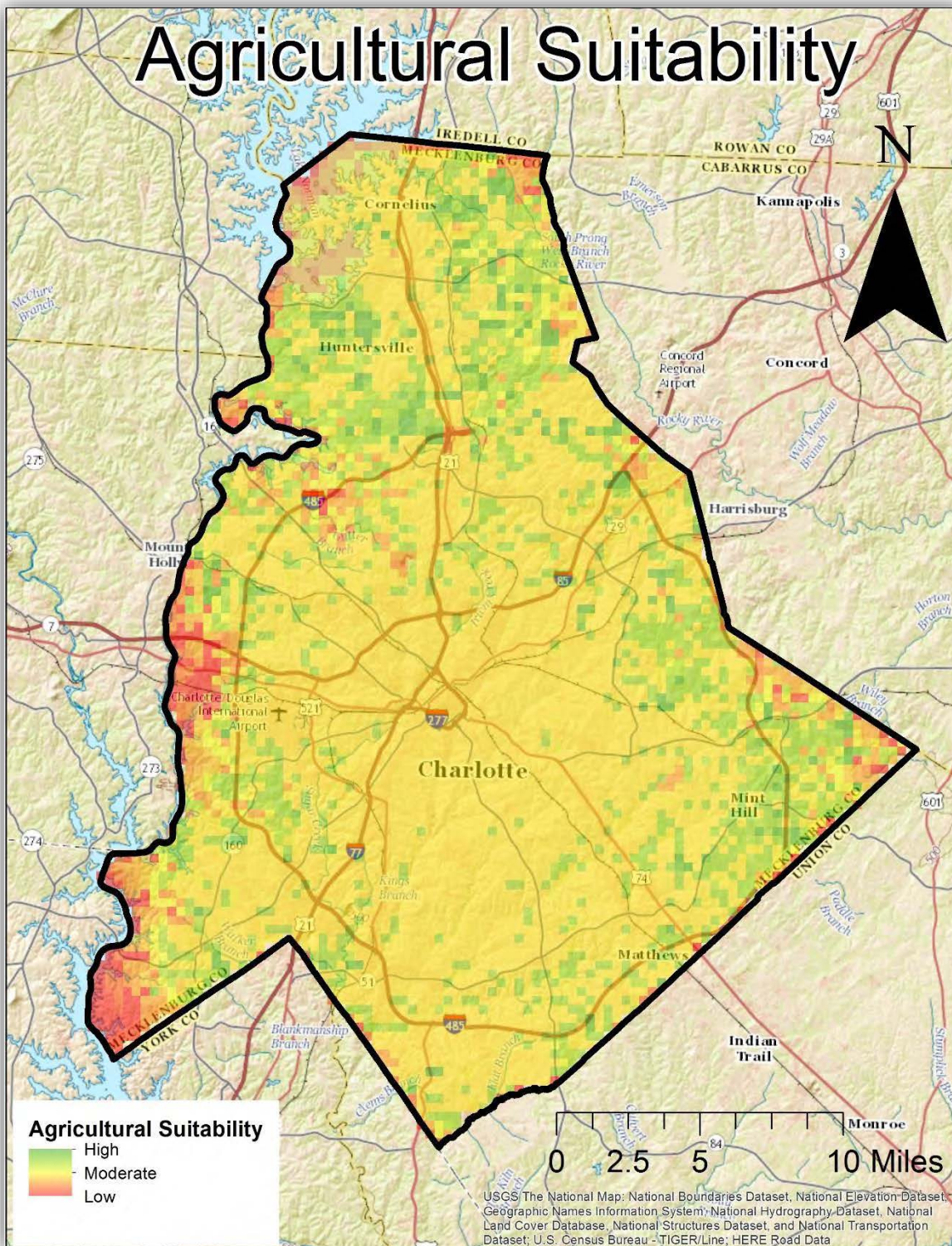


Figure 46: Agriculture suitability results for the study area

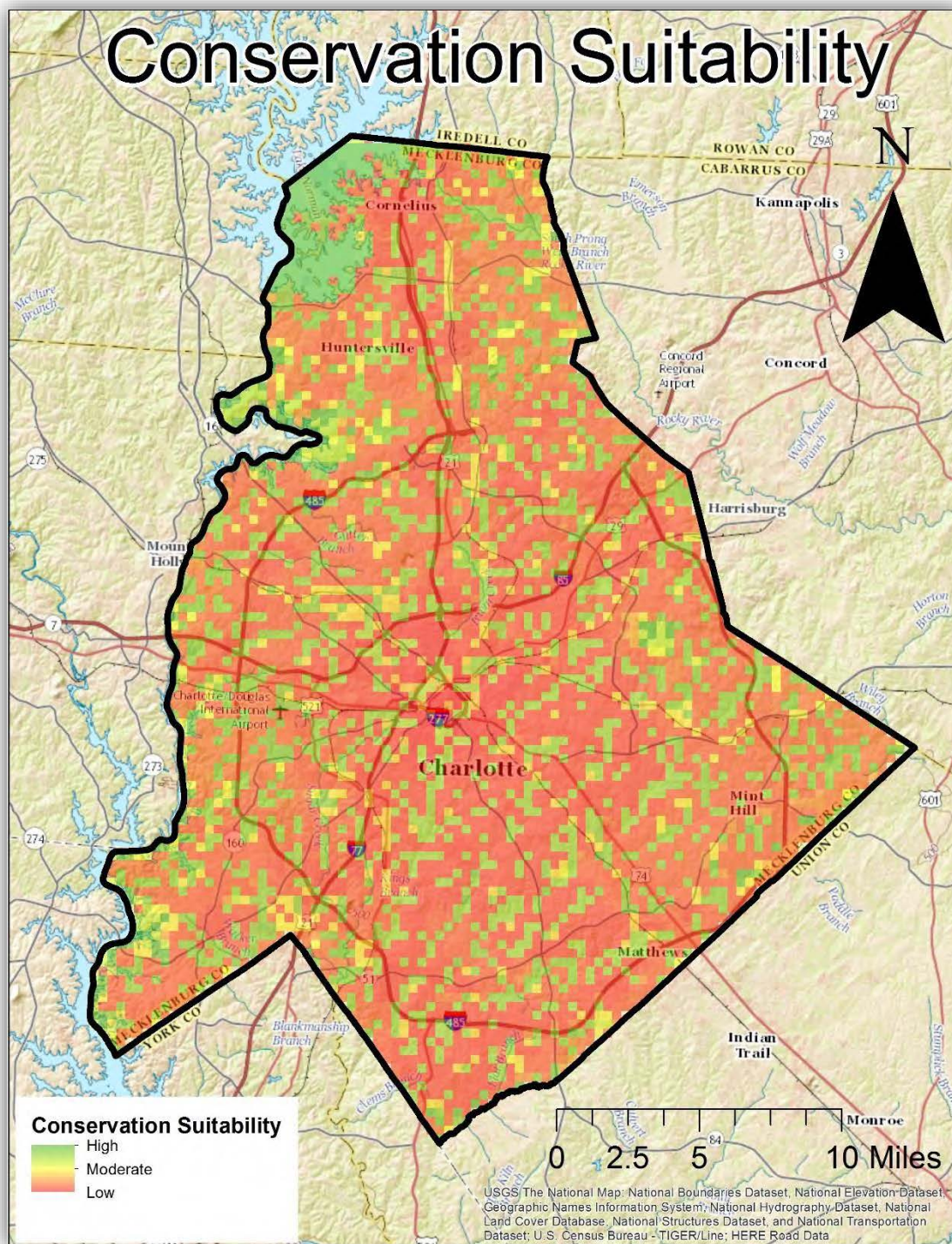


Figure 47: Conservation suitability results for the study area

4.2 Isolation and Quantification of Potential Future Land-Use Conflict

As discussed in Section 3.5.4, there were three main tasks that were required to isolate and quantify potential land-use conflict: (1) remove land within the study area whose use will not change, (2) normalize and collapse suitability results, and (3) combine the normalized and collapsed suitability results to identify and measure areas of conflict. The results of successfully accomplishing steps 2 and 3 can be seen in the following sub-sections.

4.2.1 Isolation of Potential Future Land-Use Conflict

In order to isolate, quantify, and visualize potential future land-use conflict, the three class-specific suitability surfaces were normalized, combined, and collapsed. The strength of mapping collapsed suitability is that suitable values may be easily combined to show different relationships among the three categories (Carr and Zwick 2007). Collapsed suitability surfaces (Figures 48, 49, and 50) were limited to the developable lands mask and mapped to represent each land-use classification. The color ramp used in each surface map depicts the range of collapsed suitability scores from high-to-low (green to red) for every land-unit in the study area (Table 13, 14, and 15).

Table 13: Collapsed agricultural suitability data ranges and scores

<i>Data Range</i>	<i>Score</i>
3	High
2	Moderate
1	Low

While the resulting surfaces did not differ greatly from before they were normalized, collapsed, and limited in size, a more refined picture of where land-use classes were suitable and at what magnitude emerged. The collapsed agricultural suitability surface validated previous notions that current agricultural land holdings exist mostly north of Charlotte toward the Mecklenburg and Iredell County border. These concentrations of highly suitable agricultural

lands are located on either side of the Huntersville-Cornelius-Davidson corridor that runs directly down the center of the study area.

Table 14: Collapsed conservation suitability data ranges and scores

<i>Data Range</i>	<i>Score</i>
3	High
2	Moderate
1	Low

The collapsed conservation suitability surface highlighted predominately low suitability throughout the study area. Areas in proximity to Lake Norman (northwest border), Lake Wylie (southwest border), existing conservation lands and parks, as well as local streams held the highest suitability for future conservation. Another pattern was also emerging. There was an overlap of agricultural and conservation suitable lands in a number of northern Mecklenburg County towns like Huntersville and Davidson. Some conflict will exist between the two land-use categories.

Table 15: Collapsed urban suitability data ranges and scores

<i>Data Range</i>	<i>Score</i>
3	High
2	Moderate
1	Low

The urban collapsed suitability surface showed the effects of a large, existing urban landscape. Of the developable land, very little was unsuitable for future urban development. Dense high suitability can be seen in proximity to major highways and interstates, a traditional early indicator of sprawl (Carr and Zwick 2007). Lands within immediate proximity to center city possessed high urban land-use suitability.

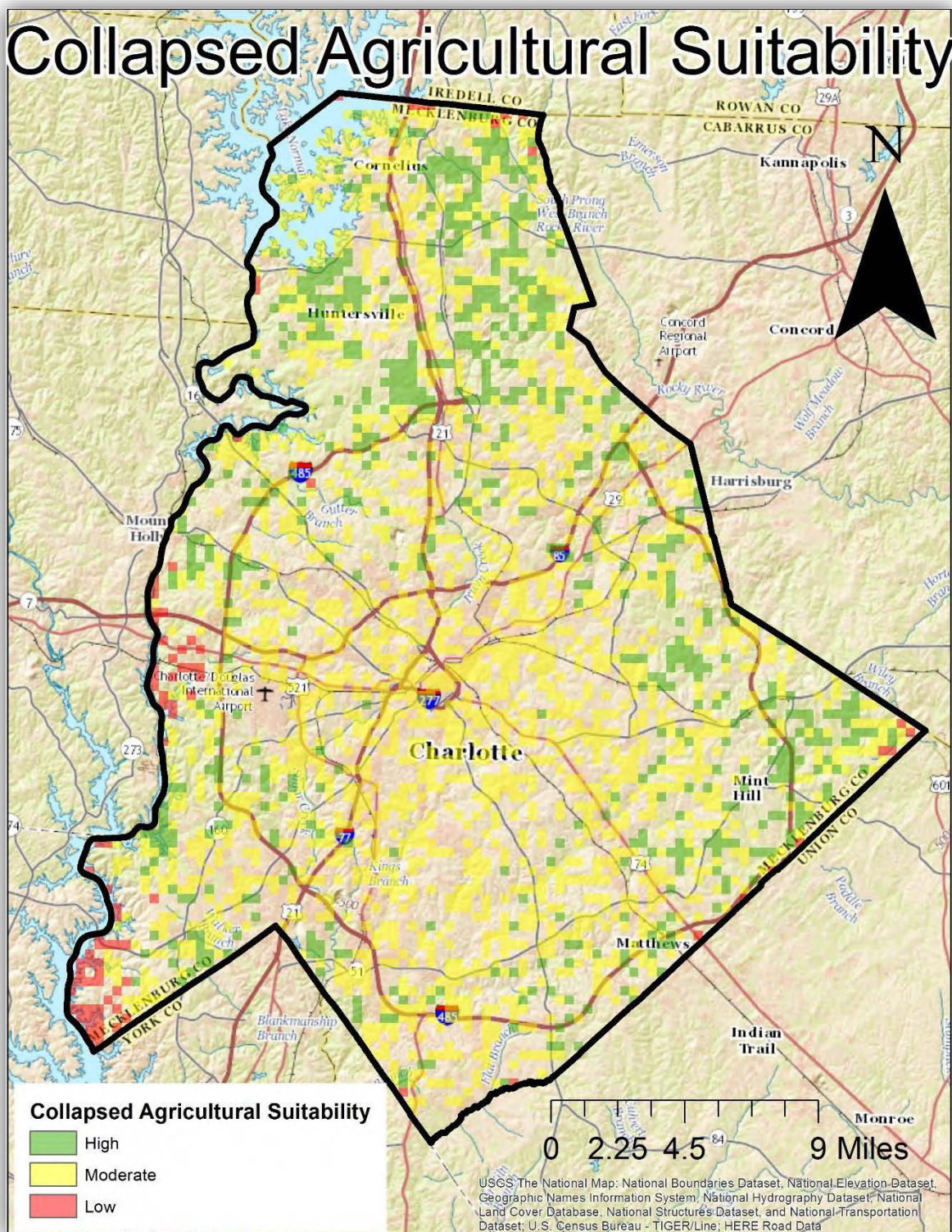


Figure 48: Collapsed agricultural suitability limited to developable lands

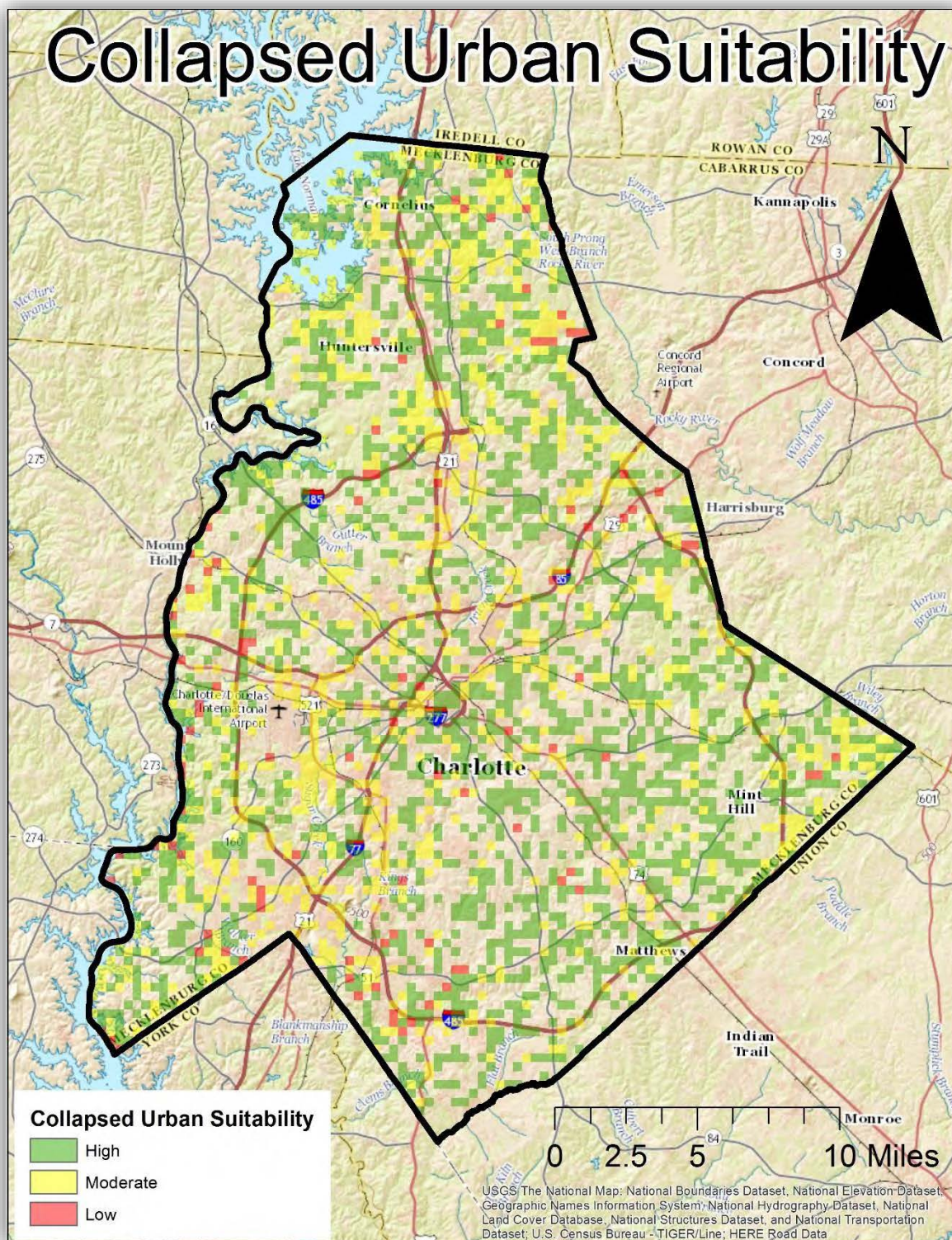


Figure 50: Collapsed urban suitability limited to developable lands

The collapsed suitability surfaces were reclassified from high (3), moderate (2), and low (1), into three categories that could be easily combined to create the conflict space diagram (CSD) described in Section 5.4.2. The CSD exposed 27 unique conflict categories that were analyzed and mapped to visualize the distribution of land-use conflict and preference. The simple conflict map, in Figure 52, aggregated all of the areas of conflict and no conflict into two separate categories (no conflict and conflict), to provide a high level understanding of these phenomena.

An examination of the acreage of each conflict category (Figure 51) revealed a few patterns, particularly the following:

- 65,162 acres, or 41%, of future developable land were in potential conflict (Figure 52).
- 62,806 acres, or 40%, of future developable land were urban suitability dominant.
- 41,540 acres, or 64%, of future developable land in conflict (26% of total future developable land) was in moderate or major conflict between agriculture and urban suitabilities. This shows that more often than not, when land-uses were in conflict, that conflict was shared by agriculture and urban suitabilities.

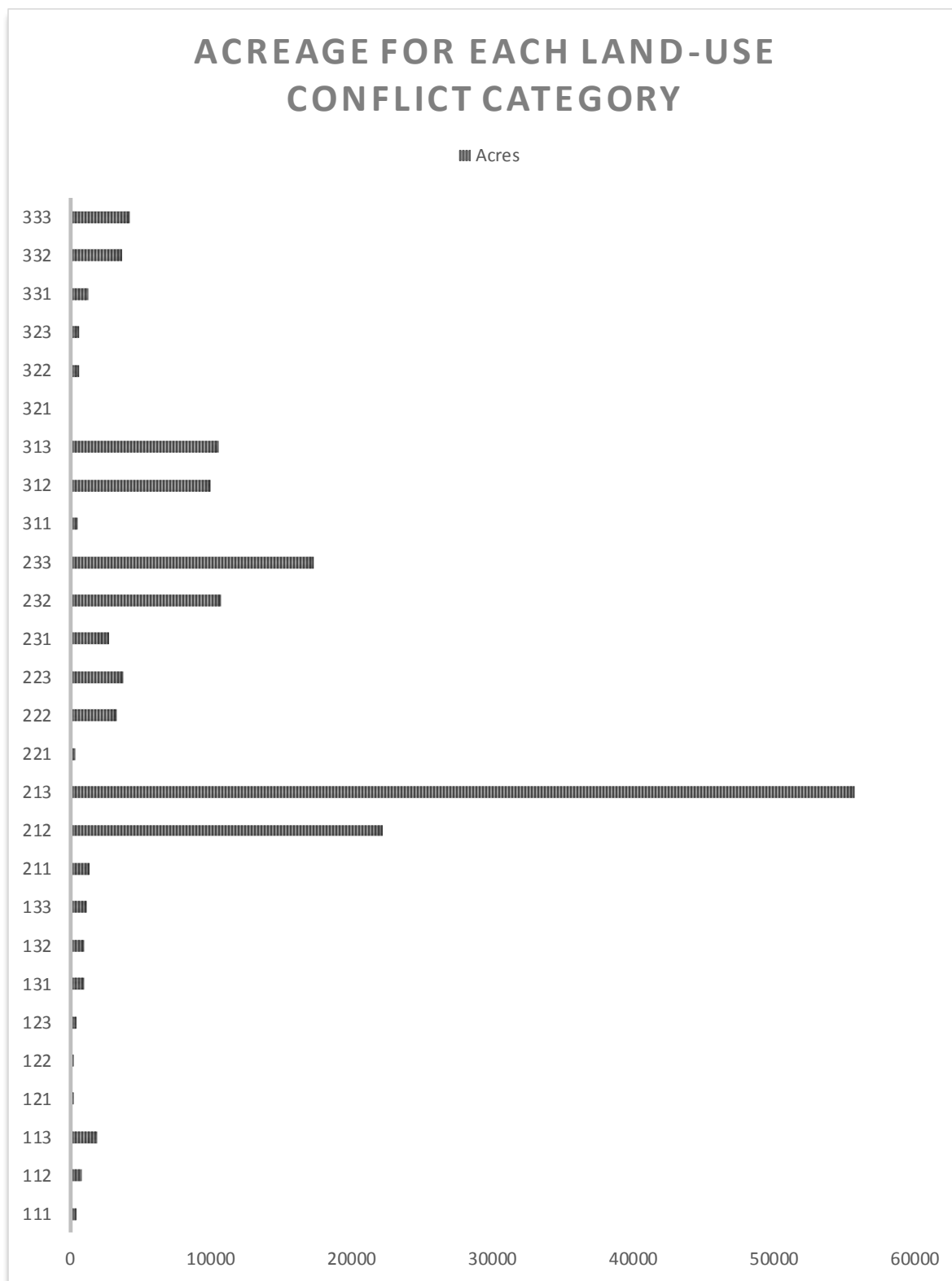


Figure 51: A bar graph showing the distribution of acreage over each land-use conflict category

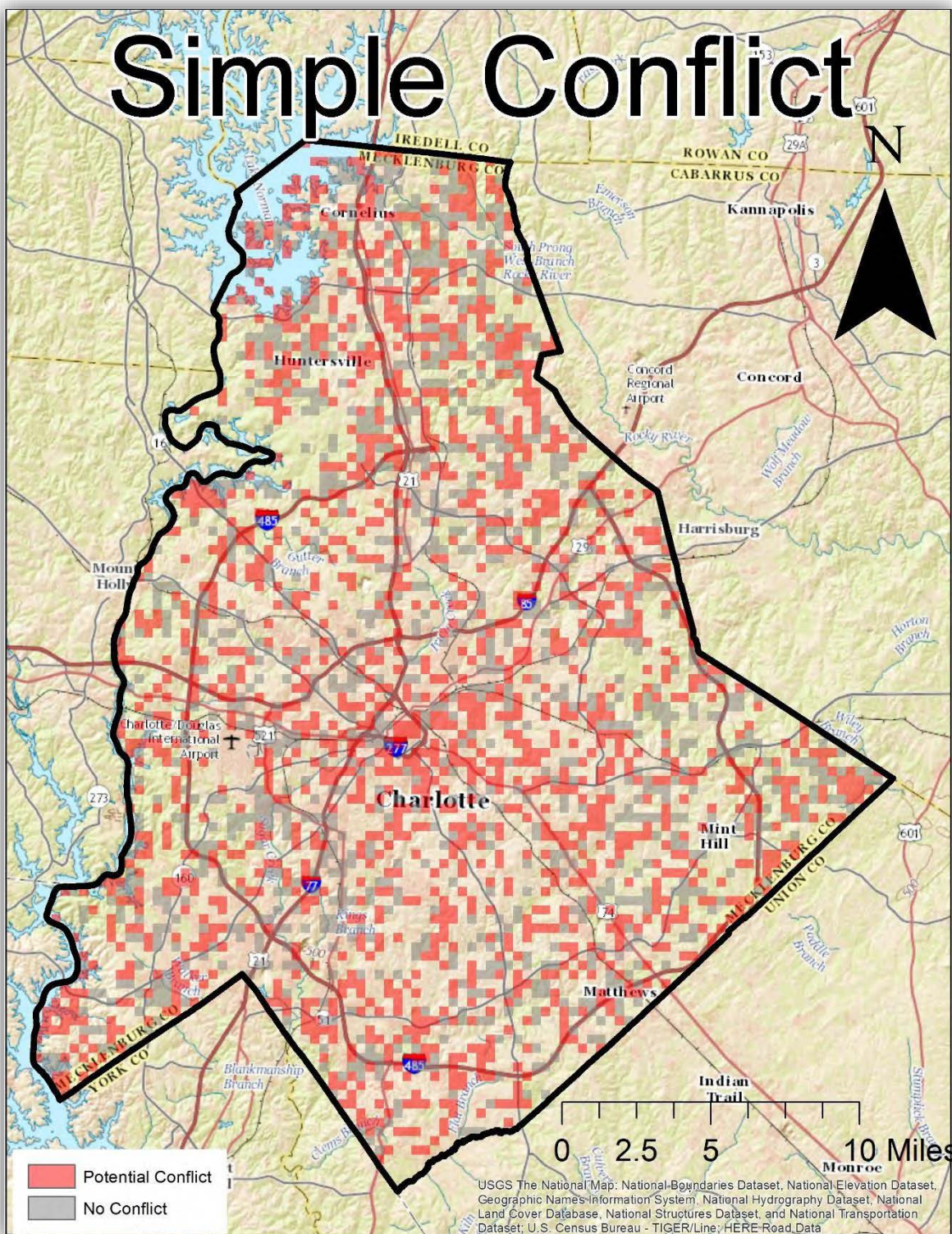


Figure 52: Future developable land having potential conflict or possessing no potential conflict

4.2.2 Quantification of Potential Land-Use Conflict

A more detailed view of the location and magnitude of future land-use conflict can be seen in Table 16 and Figure 53. Four categories of potential conflict and three categories of dominant suitability, or preference, were derived from the 27 unique conflict categories. Each category was described in terms of acres of conflict and the percentage of total developable land that those acres may consume. It became more evident that urban suitability dominates the landscape when compared to the other aggregated conflict categories. This can be observed in the next largest category in acres being agriculture/urban conflict, exposing that not only was the majority of land suitable for potential urban development, but that the majority of land that may be suitable for agriculture also possess high urban suitability. This also has an effect on the amount of land that was agriculture preference dominant. If most of the suitable agriculture land was in conflict with urban land, then agriculture preference dominant land would be expected to be limited. The smallest portions of acreage in conflict belonged to agriculture/conservation, major conflict, and agriculture preference. Currently there is a small amount of land in conservation within this study area making a lack of both agriculture/conservation conflict and major conflict predictable. Without sizeable amounts of land suitable for conservation it was highly unlikely that conflict between conservation and the other land-uses would occur.

As seen in Figure 54, areas of conflict were evenly distributed across the study area, with the exception of dense conservation/urban conflict near the northern county boundary. This area near Lake Norman has seen significant residential growth in recent years as affluent families from Charlotte and other surrounding areas have moved to lakeside homes with larger lot sizes. This area of the county may continue to experience high volumes of land contention in the coming years amongst differing conservation and development groups.

In Figure 55, it can be observed that the majority of the study area holds urban preference. This was especially true along major highways and interstates, like the Huntersville-Cornelius-Davidson corridor, and in Uptown Charlotte where the largest concentration of existing urban land is located within the county (i.e. center of study area). But around the outer ring of this space some intermittent conservation and agriculture land was preferred. This may be

because of the location of streams and surrounding greenways, transportation corridors (i.e. railroads), and existing open or wooded land.

Table 16: Areas of potential future land-use conflict, described in acres and percentage of total developable land

<i>Conflict or Preference Type</i>	Acres of Conflict or Preference	Percentage of Total Developable Land
<i>Agriculture/Urban Conflict (Conflict Codes: 212, 313, and 323)</i>	33418	21%
<i>Agriculture/Conservation Conflict (Conflict Codes: 221, 331, and 332)</i>	5332	3%
<i>Conservation/Urban Conflict (Conflict Codes: 122, 133, and 233)</i>	19964	13%
<i>Major Conflict (Conflict Codes: 111, 222, and 333)</i>	8122	5%
<i>Agriculture Preference (Conflict Codes: 311, 312, 321, 322, and 211)</i>	12586	8%
<i>Conservation Preference (Conflict Codes: 121, 131, 132, 231, and 232)</i>	15810	10%
<i>Urban Preference (Conflict Codes: 112, 113, 123, 213, and 223)</i>	62806	40%

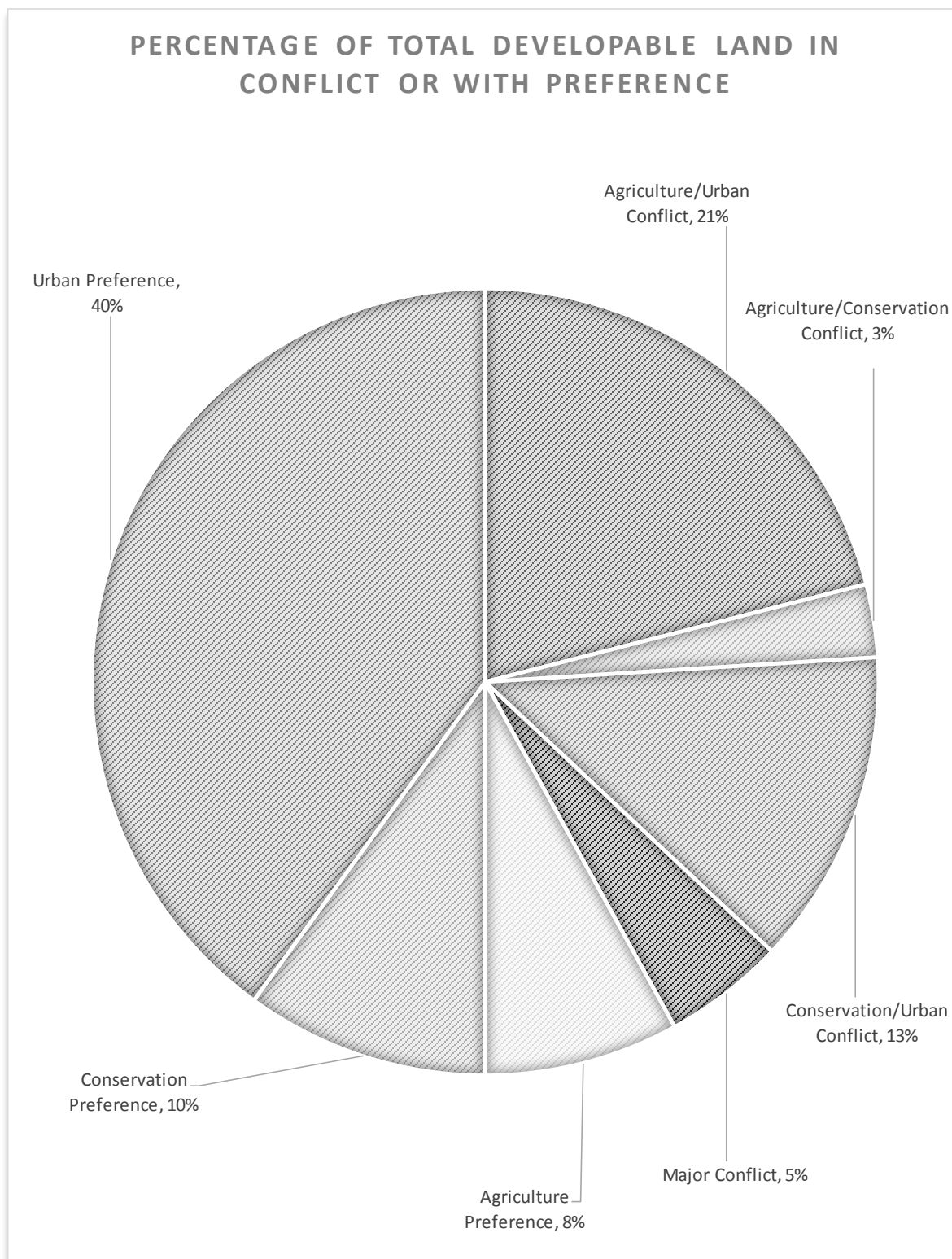


Figure 53: Percentage of developable land in conflict by category

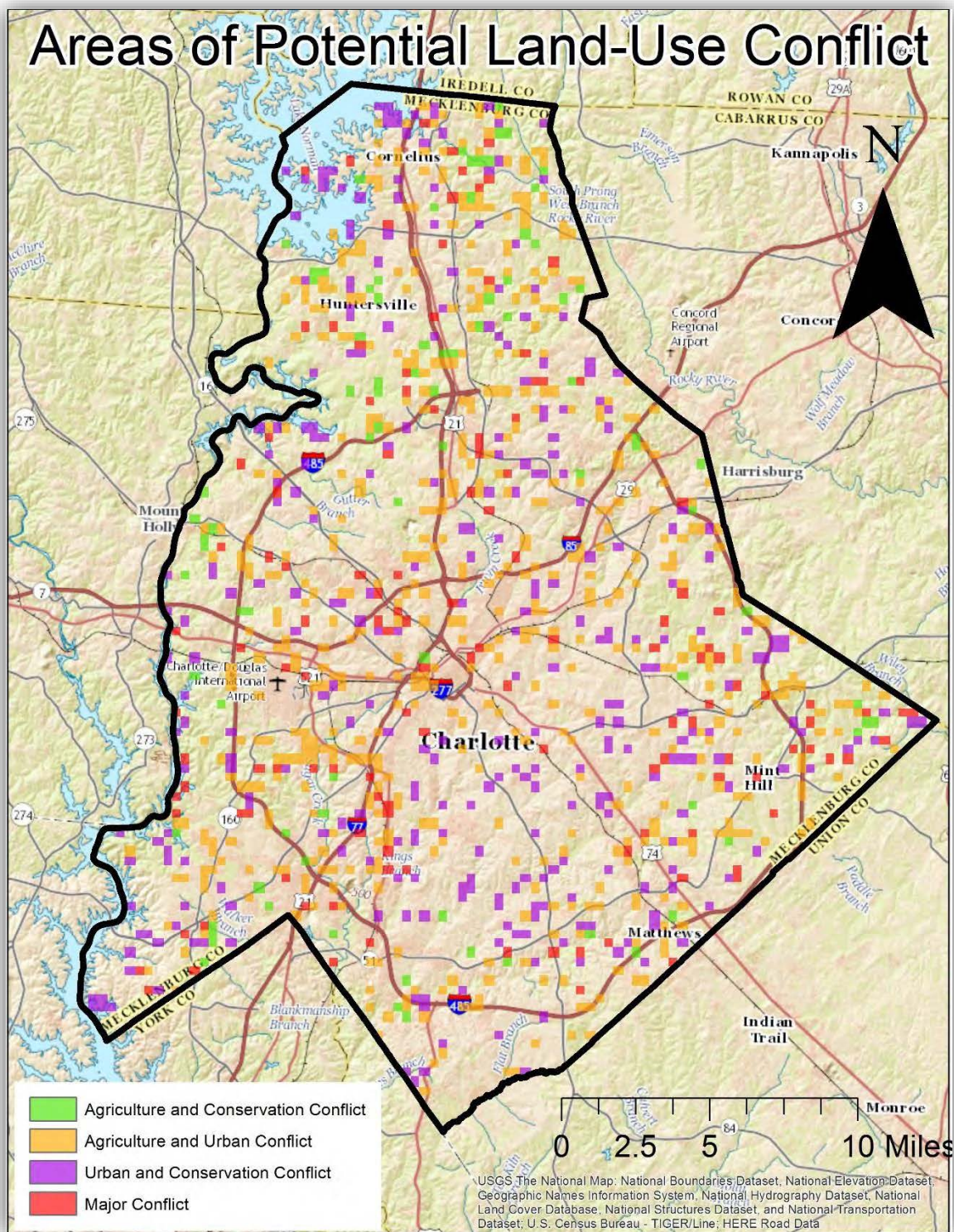


Figure 54: Areas of potential land-use conflict, specifically major conflict and conflict among the three land-use categories

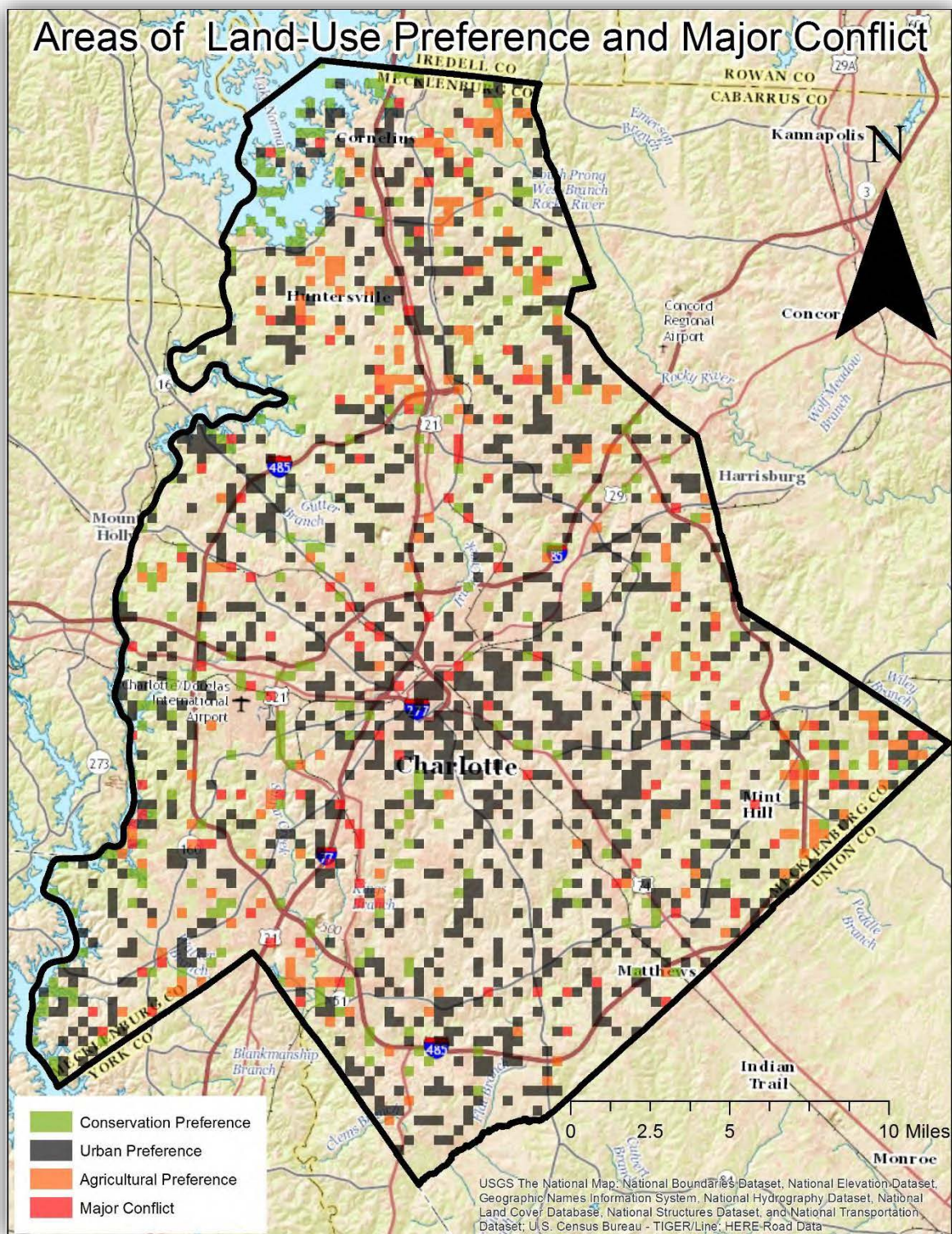


Figure 55: Areas of potential major conflict and areas of land-use preference

4.3 Future Land-Use Scenarios

Thus far this study has isolated and quantified potential future land-use conflict. The resulting conflict surfaces from the previous section were used to create future land-use scenarios that can assist local stakeholders in smart growth and planning. To accomplish this task a baseline scenario was developed to demonstrate how land-use may be allocated based on status quo land-use policies and the existing gross urban density (Carr and Zwick 2007).

4.3.1 Baseline Land-Use Scenario

With 456,813 projected new citizens and a current gross population density of approximately three people per acre, Mecklenburg County will need 152,271 additional urban acres to support the estimated population of the year 2030. That is approximately 96% of the 158,038 acres of future developable land. 123,132 acres (78%) of that developable land was allocated to urban land, leaving a need of an additional 29,139 acres of urban land to fully support the projected future population for the year 2030.

For the baseline scenario these acres were not reallocated from other land-uses to meet the needs of the future population, instead an adjustment to gross population density was calculated. For Mecklenburg County alone (this study does not account for urban acreage expanding outside of the county) to support the projected future population with 123,132 additional urban acres the population density would need to increase by 0.7 people per acre to 3.7 people per acre.

The remaining future developable land amounts to 34,906 acres (22%). The majority of that land lies in the Huntersville-Cornelius-Davidson corridor north of Charlotte. From the available remaining land, acres were allocated to agriculture where agriculture was preferred and not in conflict with other land-uses. 13,888 acres in total were allocated to agriculture, amounting to 9% of all developable land. The majority of future agriculture allocation was located just east of Mint Hill and along the Huntersville-Cornelius-Davidson corridor.

Similarly, acres were allocated to conservation where conservation was preferred and not in conflict with other land-uses. 19,840 acres in total were allocated to conservation, amounting

to 13% of all developable land. The majority of future conservation allocation was along the shores of Lake Norman and to the southwestern regions of the county toward Lake Wylie.

This scenario is one of many possible future outcomes for Mecklenburg County. Through the LUCIS process this study isolated and quantified potential future land-use conflict, and subsequently used those results to create a baseline future land-use scenario (Figure 56). In this scenario, conservation was allocated nearly 20,000 acres (13%) of future developable land. Agriculture was the least preferred and allocated land-use class, holding only 1% (1,302 acres) of allocated land that was in conflict (Table 17). While unsurprising, this pattern highlights the fact that much of the newly allocated urban land was almost entirely comprised of acreage that was in conflict with agriculture. Agricultural land is more often than not consumed to accommodate the need for further urban development and expansion.

Even with the large amount of land allocated to urban land-use, there was still a clear disparity in this scenario between the needs of the future projected population, gross population density, and available developable land. This poses the question, to what end is additional land developed to accommodate urban expansion? How much conservation or agricultural land is the community willing to part with to make room for more urban land? To answer this question, alternative future scenarios were created to reevaluate land-use allocation to visualize the effects of weighting specific land-uses heavier than each of the others.

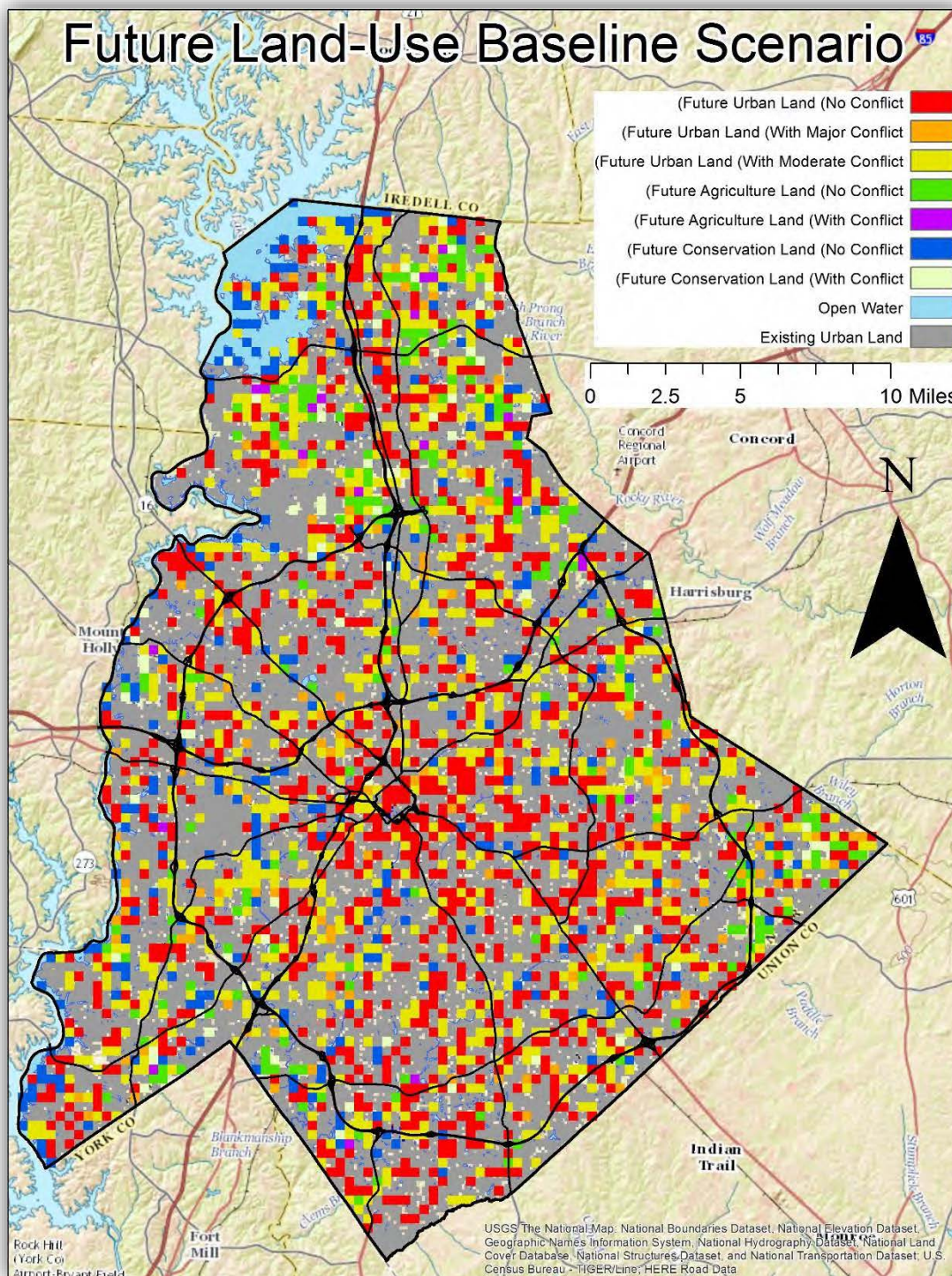


Figure 56: Future Land-Use Baseline Scenario

Table 17: Tabulation of future land-use allocation results for the base line scenario

Future Land-Use Baseline Scenario: Land-Use Allocation

<i>Allocation Type</i>	<i>Acres</i>	<i>Percentage of Developable Land</i>
<i>Agriculture Allocation</i>		
<i>Future Agriculture Land (No Conflict)</i>	12586	8%
<i>Future Agricultural Land (With Conflict)</i>	1302	1%
<i>Agriculture Subtotals</i>	13888	9%
<i>Conservation Allocation</i>		
<i>Future Conservation Land (No Conflict)</i>	15810	10%
<i>Future Conservation Land (With Conflict)</i>	4030	3%
<i>Conservation Subtotals</i>	19840	13%
<i>Urban Allocation</i>		
<i>Future Urban Land (No Conflict)</i>	62806	40%
<i>Future Urban Land (With Major Conflict)</i>	8122	5%
<i>Future Urban Land (With Moderate Conflict)</i>	52204	33%
<i>Urban Subtotals</i>	123132	78%
<i>Totals</i>	156860	100%

*Note: Acreage allocation error of 1178 acres not allocated during baseline scenario analysis due to resampling.

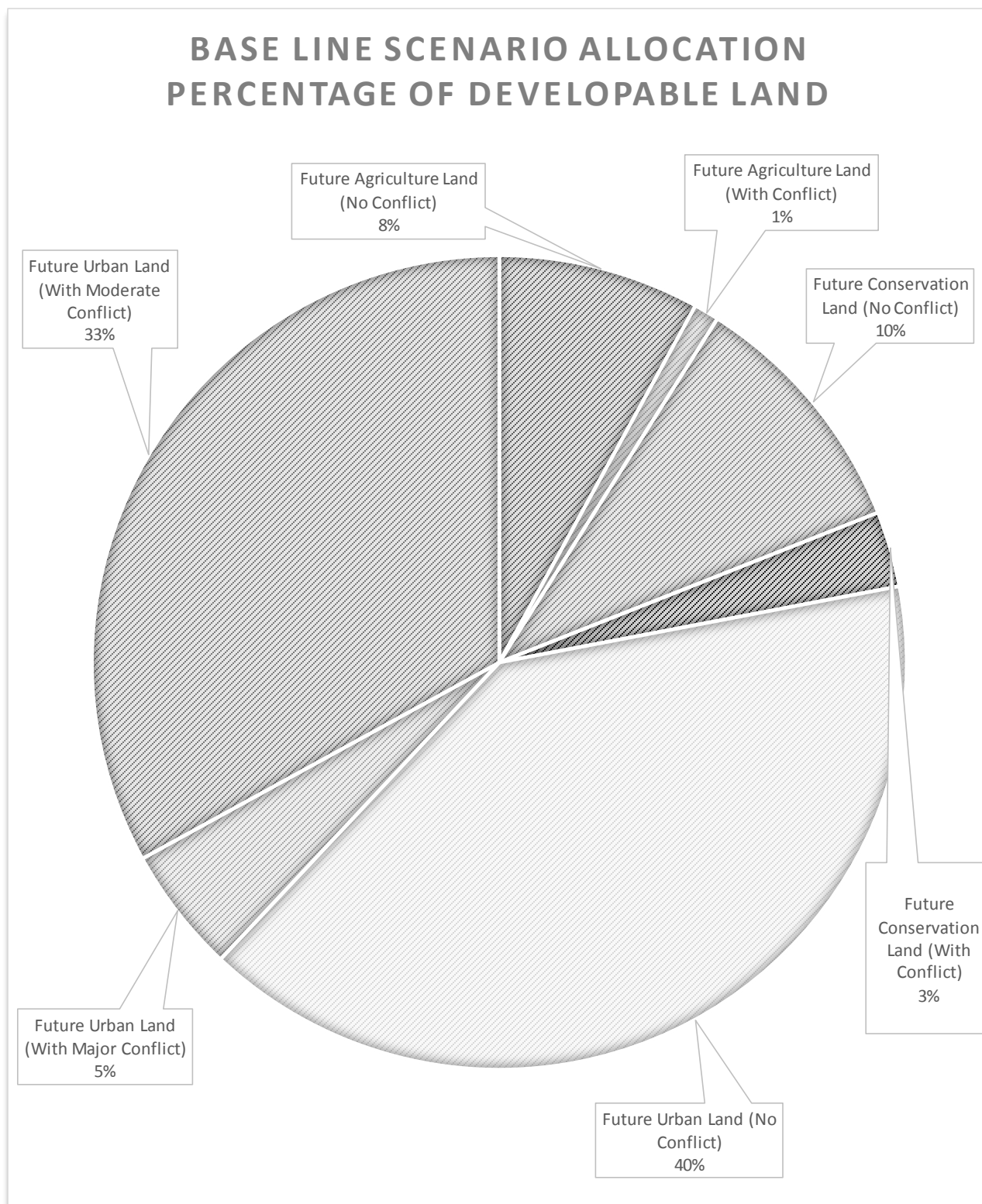


Figure 57: Allocation percentage of developable land for the base line scenario

4.3.2 Urban Land-Use Scenario

The future urban land-use scenario was the first of three alternative future scenarios that was built from the base line results. This scenario (Table 18 and Figures 58 & 59) used the established trend of urban land consuming agriculture land for future expansion as the driver for acreage revaluation and reallocation. Acreage previously allocated to agriculture with and without conflict were reallocated to urban, adding an additional 13,888 acres of developable land to urban use. In doing so, future urban land in this scenario topped out at 137,020 acres (87%) of developable land, falling just short of the 152,271 additional urban acres needed to support the projected population for the year 2030. To reach the required acreage, 15,251 acres of urban land would still be needed. For Mecklenburg County to support the projected future population with 137,020 additional urban acres the population density would need to increase by 0.5 people per acre to 3.5 people per acre.

This scenario revealed a surge of urban development spreading north from Charlotte into the Huntersville-Cornelius-Davidson corridor. Land in these northern towns are highly coveted by real estate developers due to their proximity to Lake Norman and Charlotte. This trend could potentially raise land prices and theoretically drive agricultural practices out of the area.

Table 18: Tabulation of future land-use allocation results for the urban scenario

Future Land-Use Urban Scenario: Land-Use Allocation

<i>Allocation Type</i>	<i>Acres</i>	<i>Percentage of Developable Land</i>	<i>Acreage Change from Base Line Scenario</i>
<i>Agriculture Allocation</i>			
<i>Future Agriculture Land (No Conflict)</i>	0	0%	- 12586
<i>Future Agricultural Land (With Conflict)</i>	0	0%	- 1302
<i>Agriculture Subtotals</i>	0	0%	- 13888

Conservation Allocation

<i>Future Conservation Land (No Conflict)</i>	15810	10%	0
<i>Future Conservation Land (With Conflict)</i>	4030	3%	0
<i>Conservation Subtotals</i>	19840	13%	0

Urban Allocation

<i>Future Urban Land (No Conflict)</i>	62806	40%	0
<i>Future Urban Land (With Major Conflict)</i>	8122	5%	0
<i>Future Urban Land (With Moderate Conflict)</i>	52204	33%	0
<i>Future Urban Land (Reallocated from Agriculture No Conflict)</i>	12586	8%	+ 12586
<i>Future Urban Land (Reallocated from Agriculture With Conflict)</i>	1302	1%	+ 1302
<i>Urban Subtotals</i>	137020	87%	+ 13888
<i>Totals</i>	156860	100%	

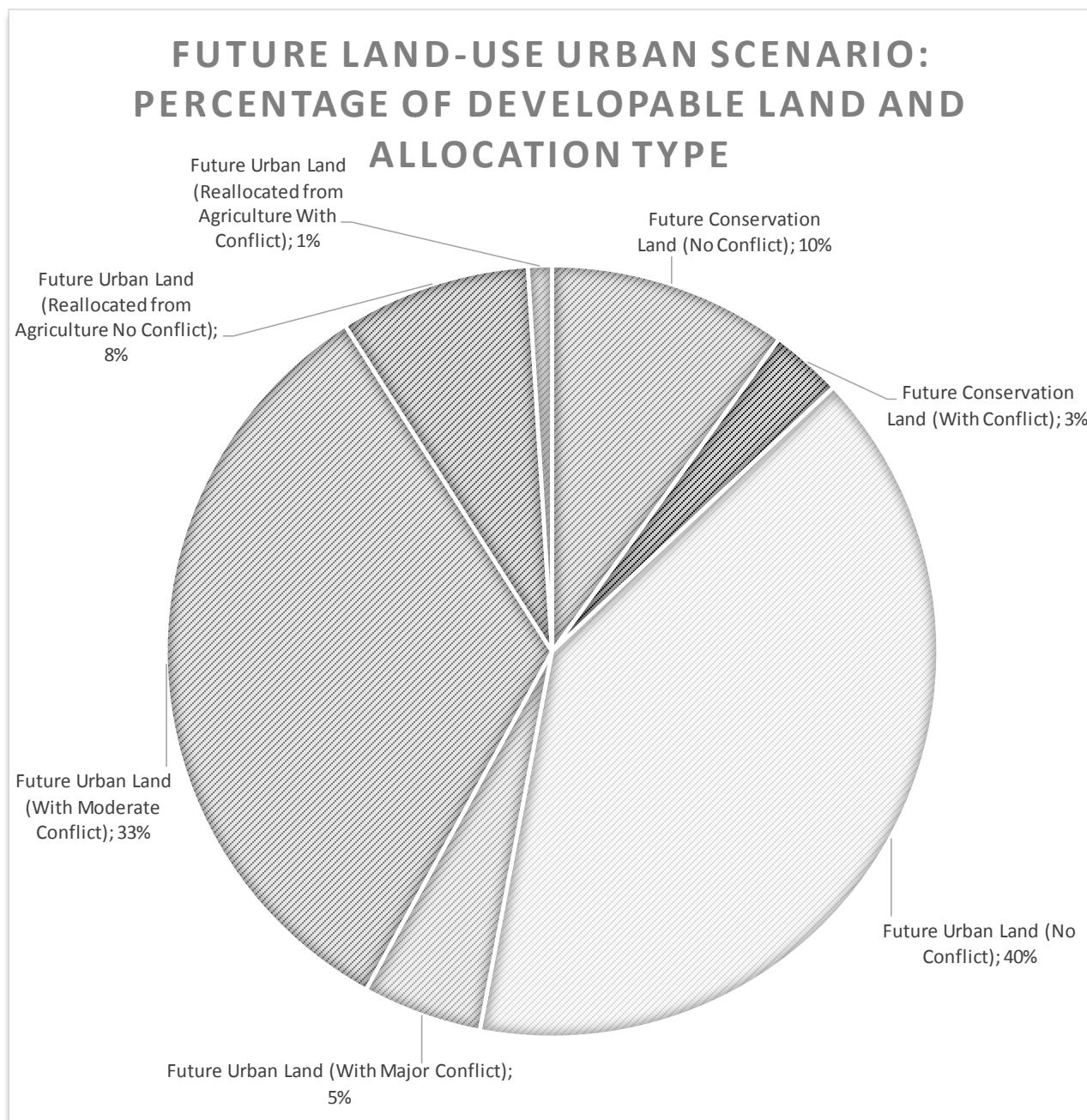


Figure 58 : Allocation percentage of developable land for the urban scenario

Land southwest and east-southeast of Charlotte also showed an expanding urban landscape. The town of Pineville, along the South Carolina border, had a cluster of newly allocated urban land. This area is not only growing into Charlotte, it is also being sandwiched from the south by Rock Hill, SC, a trend that can be explored in future work that takes a larger regional approach.

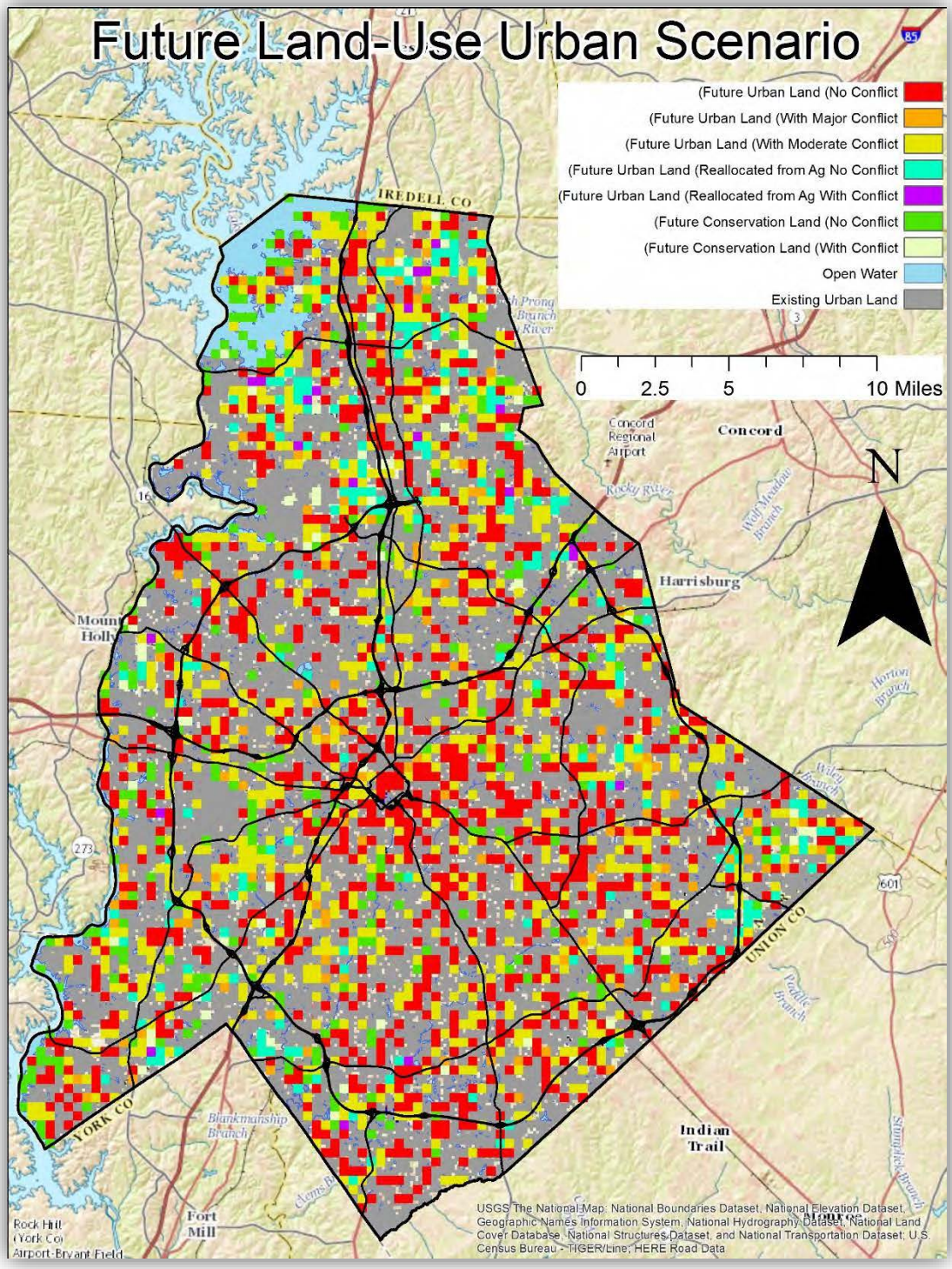


Figure 59: Future Land-Use Urban Scenario

4.3.3 Conservation Land-Use Scenario

The conservation land-use scenario (Table 19 and Figures 60 & 61) reallocated land previously allocated to agriculture with conflict, adding an additional 1,302 acres of developable land to conservation use. The scenario also reallocated 8,122 acres of developable land previously in major conflict, and 18,786 acres of developable land previously allocated to urban with moderate conflict to conservation. This was achieved by taking all conservation lands that were in moderate conflict with urban lands, and allocating them to conservation. 48,050 acres (31%) of developable land were allocated to future conservation in this scenario, an increase of 28,210 acres from base line.

Table 19: Tabulation of future land-use allocation results for the conservation scenario

Future Land-Use Conservation Scenario: Land-Use Allocation

<i>Allocation Type</i>	Acres	Percentage of Developable Land	Acreage Change from Base Line Scenario
<i>Agriculture Allocation</i>			
<i>Future Agriculture Land (No Conflict)</i>	12586	8%	0
<i>Future Agricultural Land (With Conflict)</i>	0	0%	- 1302
<i>Agriculture Subtotals</i>	12586	8%	- 1302
<i>Conservation Allocation</i>			
<i>Future Conservation Land (No Conflict)</i>	15810	10%	0
<i>Future Conservation Land (With Conflict)</i>	4030	3%	0

Conservation Allocation Cont'd

<i>Future Conservation Land (Reallocated from Agriculture With Conflict)</i>	1302	1%	+ 1302
<i>Future Conservation Land (Reallocated From Urban Major Conflict)</i>	8122	5%	+ 8122
<i>Future Conservation Land (Reallocated From Future Urban Land Moderate Conflict)</i>	18786	12%	+ 18786
<i>Conservation Subtotals</i>	48050	31%	+ 28210

Urban Allocation

<i>Future Urban Land (No Conflict)</i>	62806	40%	0
<i>Future Urban Land (With Major Conflict)</i>	0	0%	- 8122
<i>Future Urban Land (With Moderate Conflict)</i>	33418	21%	- 18786
<i>Urban Subtotals</i>	96224	61%	- 26908
<i>Totals</i>	156860	100%	

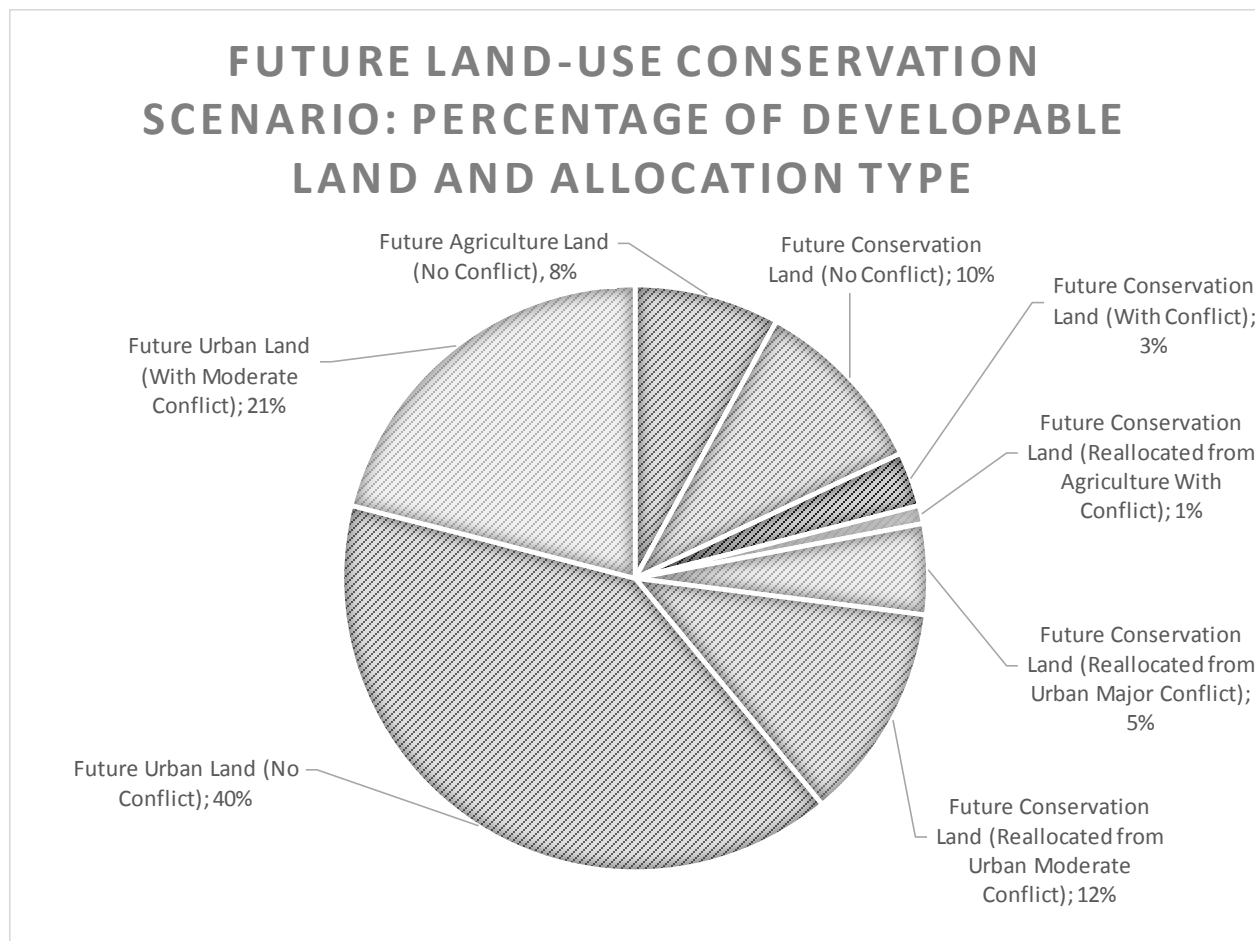


Figure 60: Allocation percentage of developable land for the conservation scenario

Future urban land in this scenario consumed 96,224 acres (61%) of developable land, falling well short of the 152,271 additional urban acres needed to support the estimated population for the year 2030. To reach the required acreage, 56,047 acres of urban land would still be needed. For Mecklenburg County to support the projected future population with 96,224 acres additional urban acres the population density would need to increase by 1.7 people per acre to 4.7 people per acre.

While the majority of land was still dominated by future urban land, the adoption of a conservative approach to the county's landscape was quite evident. Newly allocated conservation land was dispersed throughout the study area, with significant clusters in proximity to each of the area markets. The gross population density would increase in this scenario, but larger amounts of conserved land would be enjoyed by Mecklenburg County as a whole.

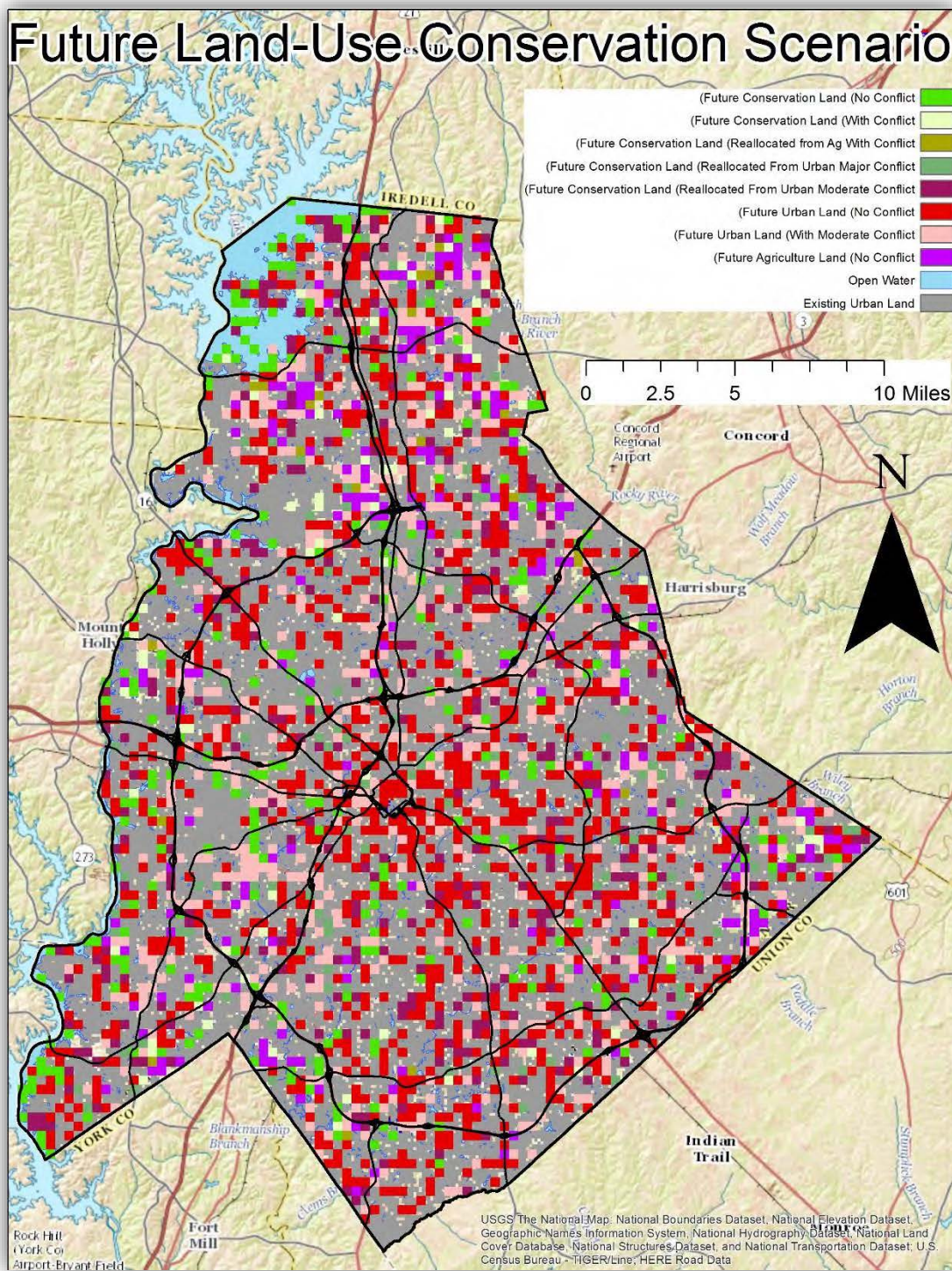


Figure 61: Future Land-Use Conservation Scenario

4.3.4 Agriculture Land-Use Scenario

In the most unlikely of the scenarios, the agriculture land-use scenario (Table 20 and Figures 63 & 62) reallocated land previously allocated to conservation with conflict, adding an additional 4,030 acres of developable land to agricultural use. The scenario also reallocated 8,122 acres of developable land previously in major conflict, and 33,418 acres of developable land previously allocated to urban with moderate conflict to agriculture. This was achieved by taking all agriculture lands that were in moderate conflict with urban lands, and allocated them to agriculture. 59,458 acres (38%) of developable land were allocated to future agriculture in this scenario, an increase of 45,570 acres from baseline.

Table 20: Tabulation of future land-use allocation results for the agriculture scenario

Future Land-Use Agriculture Scenario: Land-Use Allocation

<i>Allocation Type</i>	<i>Acres</i>	<i>Percentage of Developable Land</i>	<i>Acreage Change from Base Line Scenario</i>
<i>Agriculture Allocation</i>			
<i>Future Agriculture Land (No Conflict)</i>	12586	8%	0
<i>Future Agricultural Land (With Conflict)</i>	1302	1%	0
<i>Future Agriculture Land (Reallocated From Conservation With Conflict)</i>	4030	3%	+ 4030
<i>Future Agriculture Land (Reallocated From Urban Major Conflict)</i>	8122	5%	+ 8122

Agriculture Allocation

<i>Future Agriculture Land (Reallocated From Urban Moderate Conflict)</i>	33418	21%	+ 33418
<i>Agriculture Subtotals</i>	59458	38%	+ 45570

Conservation Allocation

<i>Future Conservation Land (No Conflict)</i>	15810	10%	0
<i>Future Conservation Land (With Conflict)</i>	0	0%	- 4030
<i>Conservation Subtotals</i>	15810	10%	- 4030

Urban Allocation

<i>Future Urban Land (No Conflict)</i>	62806	40%	0
<i>Future Urban Land (With Major Conflict)</i>	0	0%	- 8122
<i>Future Urban Land (With Moderate Conflict)</i>	18786	12%	- 33418
<i>Urban Subtotals</i>	81592	52%	- 41540
<i>Totals</i>	156860	100%	

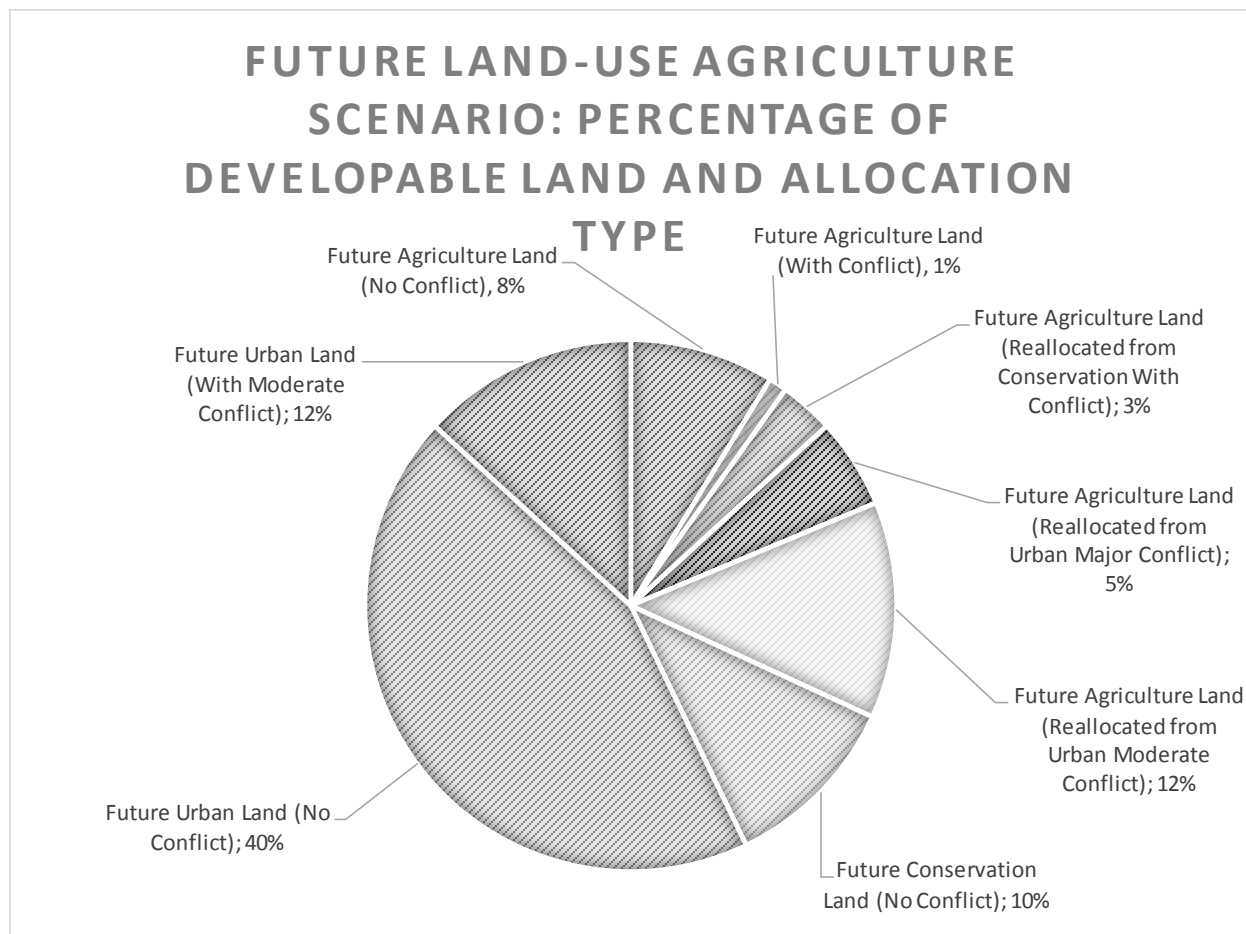


Figure 62: Allocation percentage of developable land for the agriculture scenario

Future urban land in this scenario was 81,592 acres (52%) of developable land, a figure that failed to meet the 152,271 additional urban acres needed to support the estimated population for the year 2030. To reach the required acreage, 70,679 acres of urban land would still be needed. For Mecklenburg County to support the projected future population with 81,592 acres additional urban acres the population density would need to increase by 3.4 people per acre to 6.4 people per acre.

The contentious Huntersville-Cornelius-Davidson corridor was mainly allocated to agriculture in this scenario. This would be an agricultural revival for one of the areas of the county that was once driven economically by agriculture. Lands east of Mint Hill also saw an increase in agricultural land. With Union County, a rural community in close proximity, this area would potentially see that influence along the border.

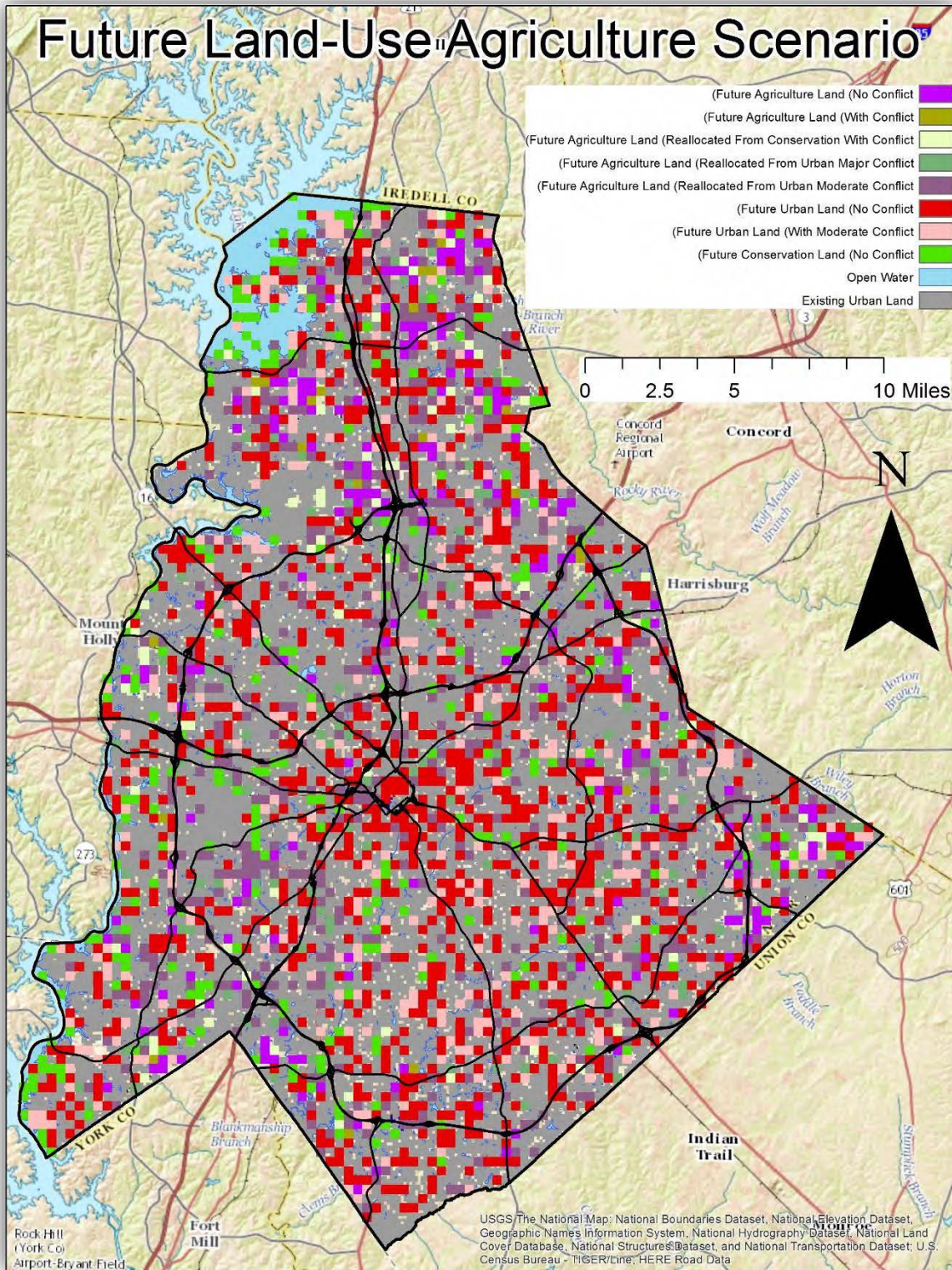


Figure 63: Future Land-Use Agriculture Scenario

4.3.5 Population Density, Projected Future Population, and Required Acreage

Resulting scenario data (Figures 64, 65, and 66) was charted to better understand the population density changes and required acreage to support the estimated future population for 2030. The necessary gross population density for each scenario was quite varied in regards to the respective acreage each had allocated to accommodate the population increase. The baseline and urban scenarios share similar results requiring only a 0.7 and 0.5 persons per acre increase to 3.7 and 3.5 people per acre density. This was in contrast to the conservation and agriculture scenarios that required more dense areas of human settlement with 1.7 and 3.4 persons per acre increases to 4.7 and 6.4 people per acre respectively.

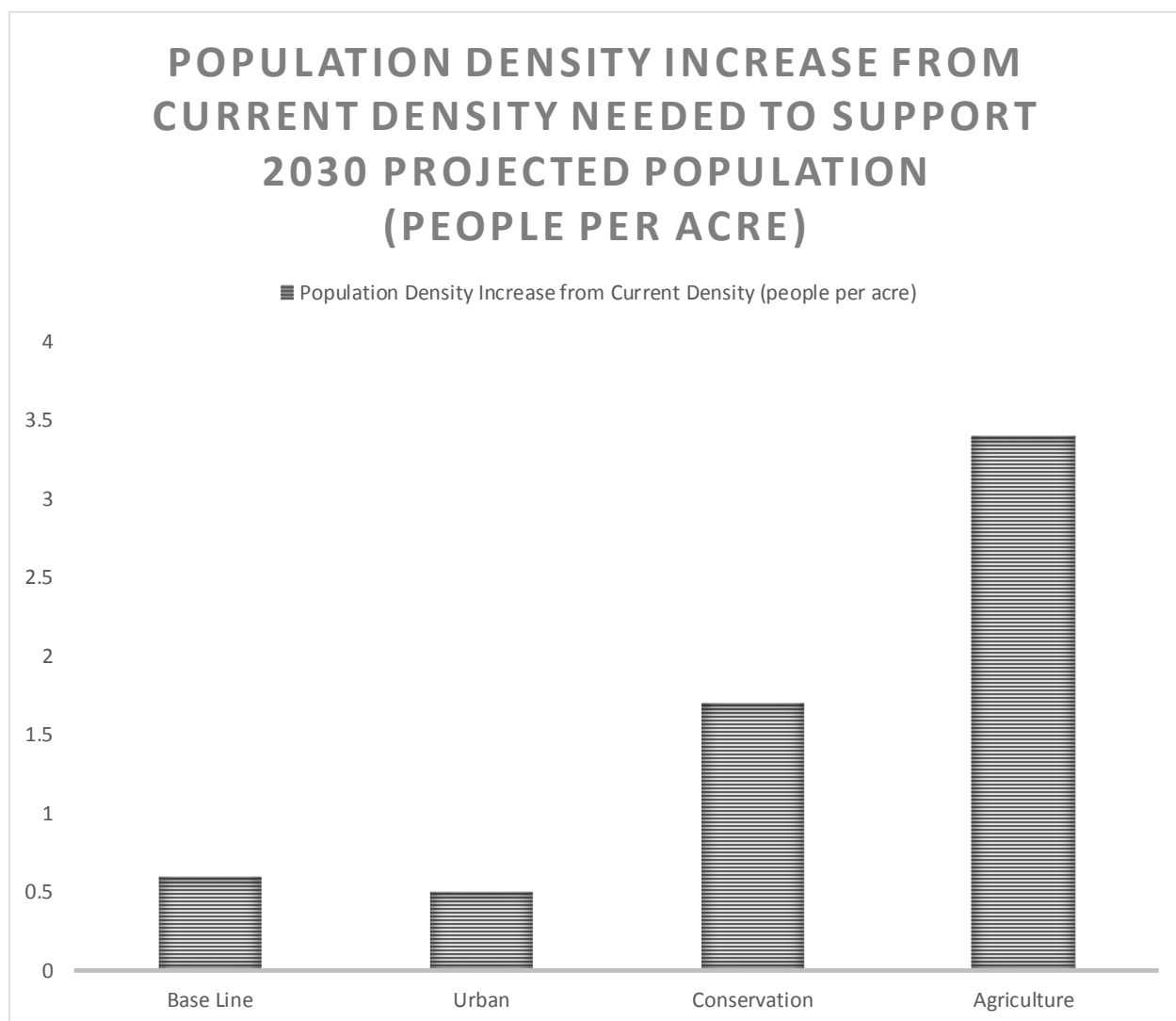


Figure 64: Population density increase from current density needed to support 2030 projected population

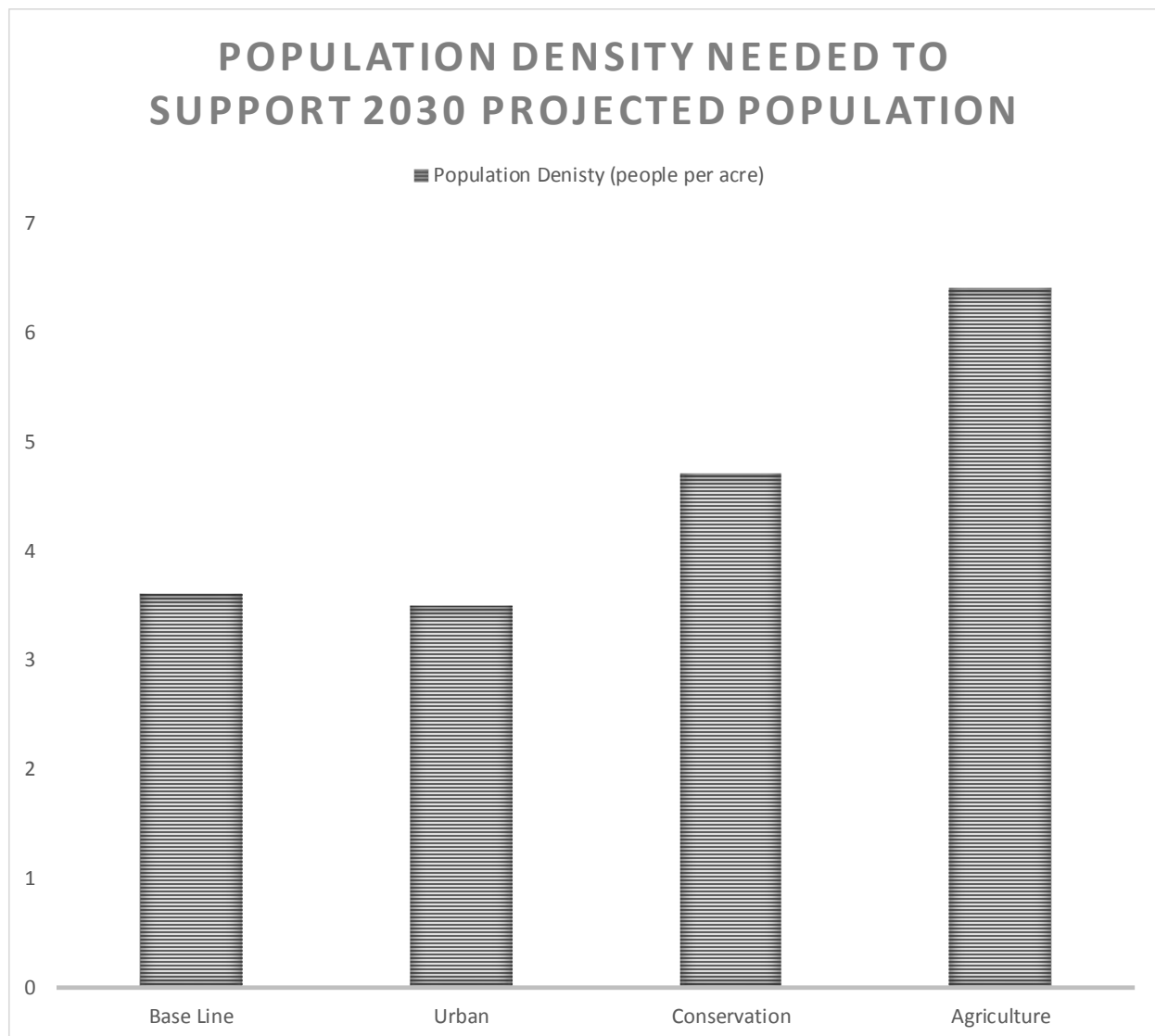


Figure 65: Population Density Needed to Support 2030 Projected Population

The baseline and urban scenarios represented futures that threaten to become expansive, low-density sprawl over time, lending themselves to the prioritization of urban development to accommodate the ever-growing population. Differing from these future scenarios, both the conservation and agriculture scenarios tended to be higher-density urban core focused alternatives with land-use specific visions for the county's peripheral lands. In the case of conservation, focus was placed on the conservation of lands with high levels of native biodiversity and recreation potential, whereas the agriculture scenario prioritized feeding the large local market with more local food.

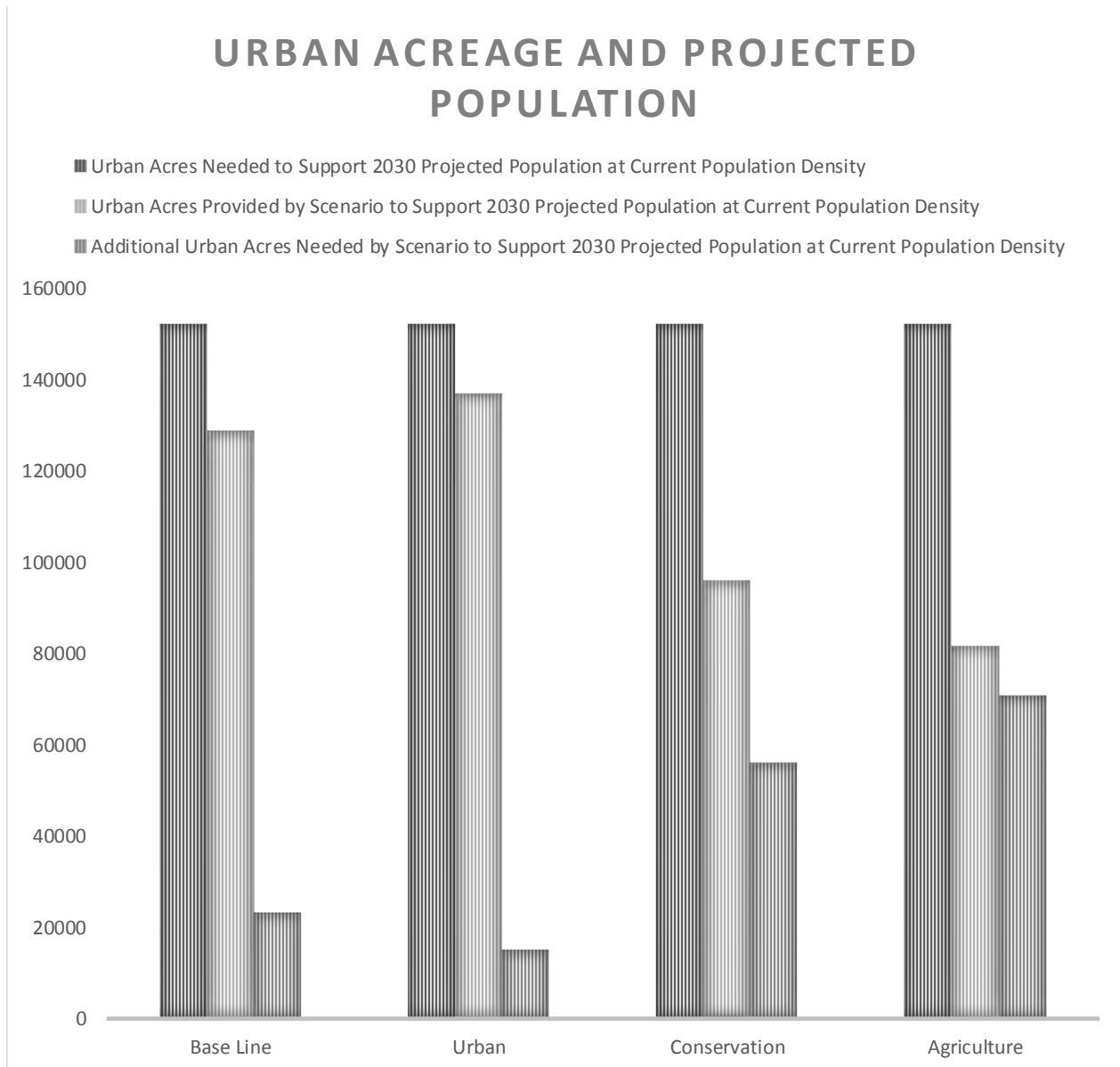


Figure 66: Urban acreage and projected population

In a complementary trend, urban acreage necessary to support the estimated population of 2030 at current gross population density was a constant of 152,271 acres of future developable land. The urban and baseline scenarios provided more acres to accommodate the future need with 152,271 and 123,132 acres each, while conservation and agriculture provided successively less acreage with 96,224 and 81,592 apiece.

CHAPTER 5: CONCLUSIONS

This chapter summarizes insights gained from the study, and suggests future work that could potentially improve upon the study's overall process and results.

5.1 Conclusions

As mentioned in chapter 1, Mecklenburg county's population has grown by 32 percent since the year 2000, and is estimated to grow an additional 71 percent by the year 2030 (Chesser 2012 and 2014). As a result, this region is faced with the threat of rapid land-use change. This study implemented an adaptation of Carr and Zwick's LUCIS model in response, to better assist community members and stakeholders identify, quantify, and visualize the location and magnitude of potential future land-use conflict. The model's results were then used to derive multiple potential future land-use scenarios. A resulting baseline scenario featured the spatial significance of status quo land-use decisions, and each of the remaining three scenarios highlighted the comparative effects of potential agriculture, conservation, or urban centric land-use decisions.

5.1.1 Structural Framework and Assumptions of Research

The LUCIS model employs a classification system that is an intentional oversimplification of reality. Based on concepts developed by Odum in the late 1960's, the broad land-use categories used in this study are purposefully designed to be applied at local and regional scales. With that said, to implement such a broad classification system involves a liberal land-use designation process that is less than systematic. As a whole the model is quite flexible and modifiable, but to fully consider the results of this study, land-use designations must be taken into full consideration.

For example, open water sources such as lakes, ponds, and streams are designated as future conservation areas within the parameters of this study and provide additional acreage to the conservation land-use category that may not have been considered by the county's parcel fabric. In this case the designation process may skew acreage from parcel specific calculations, but ultimately assists in curating an executable and repeatable model.

In addition to land-use designations, other assumptions have also contributed to the holistic framework of this study. As mentioned in chapter 3, the weighting of CMUA's to derive penultimate suitability surfaces was achieved through the application of equal suitability weights with the exception of the urban residential land goal. This suitability goal was weighted higher to accommodate the growing need to house existing and projected citizens, and assumes that the desire for urban residential land logically outweighs the desire for alternative urban land, such as urban industrial. Because weights are used determine which goals are valued more than others within a specific land-use type, the preference of urban residential land over other forms of urban land only affects the urban land-use classification. This aspect of the study diverges furthest from the original LUCIS model. Typically the AHP is used to generate the weights used to create final land-use suitability surfaces, but due to a lack of resources and access to stakeholder rationale, the weights were simulated.

Each of these assumptions solidifies the notion that the scenarios created in this study are intended to be utilized as a guide in shaping future land-use decisions, and as a visualization tool that allows community members and stakeholders to envision differing paths for the future of their region. In doing so, community members and stakeholders can actively educate themselves and participate in the land-use decisions that mold their county, city, town, or neighborhood.

5.1.2 Visualizations

Integral to this study is the ability to identify, quantify, and visualize the location and magnitude of future land-use conflict with the intention of deriving future land-use development scenarios. In chapter 4 an acreage breakdown for each scenario was provided, giving community members and stakeholders multiple views of how the county's developable land may be effected by growth. For comparison purposes a breakdown of Mecklenburg County's current land-use acreage, as it stands today, is provided below in Table 21.

Table 21: Mecklenburg County's current land-use acreage breakdown

<i>Current Land-Use</i>	Acres of Land	Percentage of Total Land
<i>Urban</i>	837,086	93%
<i>Agriculture</i>	15,827	2%
<i>Conservation</i>	9,315	1%
<i>Unassigned</i>	33,106	4%
	Total	Total
	895,334	100%

Each of these categories was subject to the previously discussed designation methodology. Any parcel that did not have a clear land-use was given an unassigned designation. The unassigned category was systematically distributed amongst the land-uses during the various allocation processes, with an unsurprising pull towards future urban use. Other land that was deemed developable either changed land-uses or was reassigned to its current land-use. To view full breakdowns of developable land in regards to each land-use development scenarios revisit chapter 4.

There is of course no guarantee that land-uses will fall into conflict in this manner or that development will follow these specific patterns, but from each scenario a variety of insights can be gleaned. Both the baseline and urban land-use development scenarios are most likely to occur due to their ability to provide developable acreage to the growing population. However in reality, even more land-use conversion to urban could occur depending on local initiatives. The conservation and agriculture scenarios on the other hand are both quite optimistic, highlighting the adoption of necessary policies to achieve such an aggressive swing in development.

Overall, agriculture is positioned to lose the most acreage going forward. Noted earlier is the patterns and trends that expose themselves north of Charlotte in the Huntersville-Cornelius-Davidson corridor along the I-77 and southeast in proximity to Mint Hill. In both of these sub-regions contention amongst land-use groups were extremely likely. The I-77 corridor will predictably garner interest from developers, but with Mint Hill's proximity to Union County (a predominately agricultural community), one can assume that agricultural production will not completely fizzle out.

5.2 Future Work

Going forward this study has the ability to improve upon itself in a number of ways. Because stakeholder feedback was not used in this study, engaging community members and critical stakeholders directly, during the land-use goal weighting process would ensure that the Analytical Hierarchy Process (AHP) is executed properly. In doing so, a more accurate view of community priorities and desires would be achieved, allowing planners and legislators to better meet the needs of their respective constituents. The results of this model currently provide a balanced, yet simulated view of community priorities, which ultimately yield approximated, theoretical scenarios. Instead, this study could potentially arm Mecklenburg County's upper level decision makers with actionable information products that drive successful planning efforts with the help of a working group of community members.

Expanding the study area to include surrounding counties could also improve this study's scope and potential outcomes. The migration and growth of urban areas and their associated future population in counties that are intimately linked to the current study area geographically, are not taken into consideration when limiting the study area to a predominately urban county. Regional land-use conflict and development scenarios can be identified, quantified, and visualized as an extension of the products of this study. A regional modeling effort would more effectively consider the flow of development and population. To achieve this endeavor, data and analysis would be required for counties such as Union, Gaston, Iredell, and York.

Finally, Dr. Zwick and his colleagues are in the process of publishing an updated version of the LUCIS model known as LUCIS plus. This newest iteration will provide users with a more robust toolset for modeling and allocating future population to specific land-use classifications. Access to the A4 tools created by Arafat (Chapter 2), as well as more refined land-use designation methodologies could be opened to those with access to the model. In addition, the updated model could allow for more accurate examination and development of land-use scenarios by equipping implementation groups with a more complete framework and a larger catalog of use cases to guide them through the process (Zwick 2014).

Each of these suggestions to future work provide a higher degree of alignment with Steinitz's geodesign framework, and collectively comprise a more educated and focused

approach to land-use planning. Producing land-use scenarios periodically will be an essential practice moving forward. As the community and its stakeholders observe unwanted changes they can mold their policies to accommodate their true desired future. By not focusing on geodesign, alternative futures analysis, and scenario planning the community may experience changes that were undesired, completely diminishing their future options for change.

The analytical products of this study can now provide the community with insight into potential future land-use conflict, and the derived future land-use scenarios can offer a mechanism for collaboration between stakeholders, government entities, and development groups. The results can be potentially utilized in planning events as an aid to reach consensus on critical decisions that affect land-use change or during envisioning sessions that give stakeholders the ability to interactively choose where they would like to see future development. Efforts such as these may even yield value-based trends that can then be used to create new, more community reflective future land-use scenarios.

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APPENDIX A

This appendix provides a description of each suitability surface and results for agriculture, conservation, and urban sub-objectives, objectives, and goals referenced throughout the text.

*(*Content begins on the next page.)*

Land-Use: Agriculture

Goal 1: Identify lands suitable for cropland

Objective 1.1: Identify lands physically suitable for cropland

Sub-objective 1.1.1: Identify soils most suitable for cropland

Input: Agricultural Assessment – NC Dept. of Environment and Natural Resources

Rationale: The higher the crop yield, the higher the suitability.

Output: Crop Yield SUA (AG1O11SO111)

Criteria for Utility Assignment: Cells with crop yields were assigned values from 2–9, based on an equal interval classification of crop yield score. All cells without crop yield were assigned the value of 1.

Table 22: Crop yield sub-objective data range and UA value

<i>Data Range</i>	<i>Utility Assignment</i>
<i>NoData</i>	1
<i>22-24.88</i>	2
<i>24.89-27.75</i>	3
<i>27.76-30.63</i>	4
<i>30.64-33.50</i>	5
<i>33.51-36.38</i>	6
<i>36.39-39.25</i>	7
<i>39.26-42.13</i>	8
<i>42.14-45</i>	9

AG1011S0111

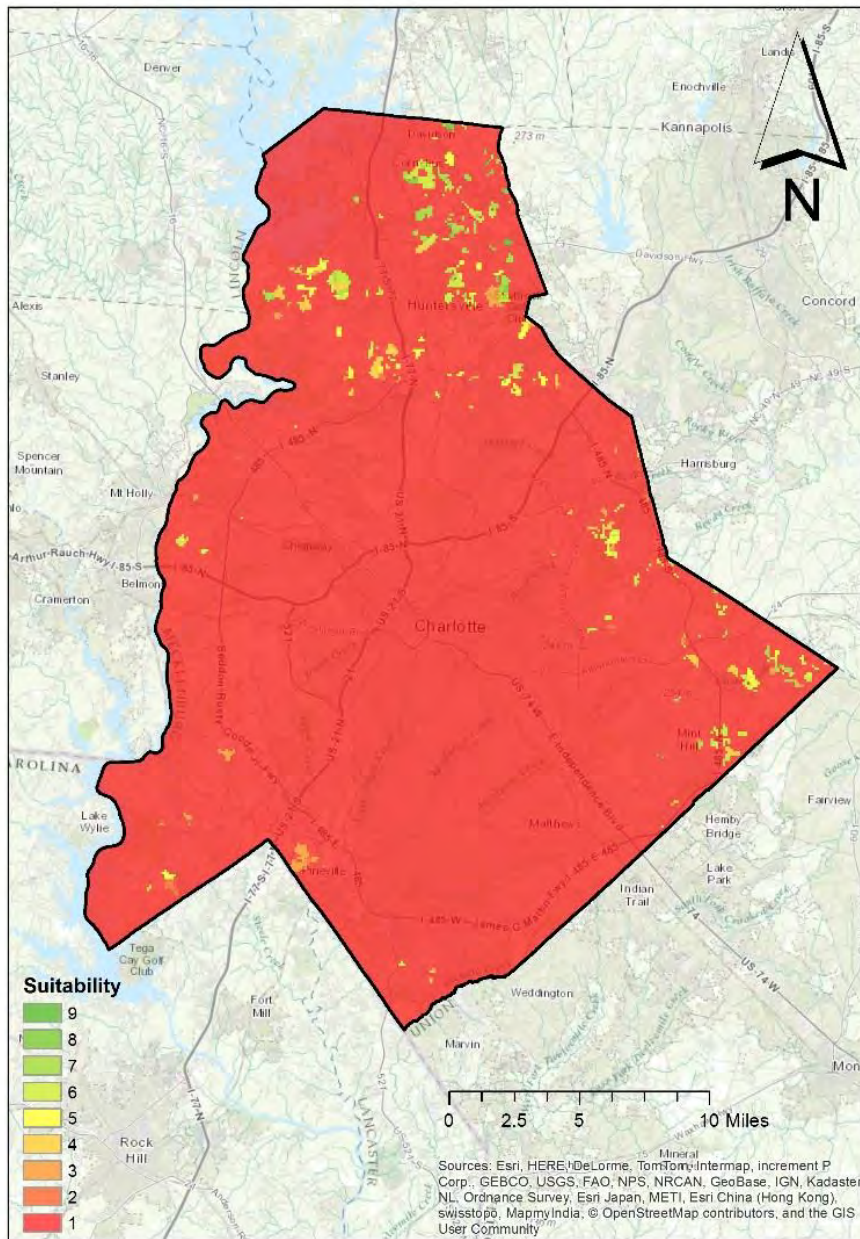


Figure 67: AG1011S0111

Land use: Agriculture**Goal 1:** Identify lands suitable for cropland**Objective 1.1:** Identify lands physically suitable for cropland**Sub-objective 1.1.2:** Identify current cropland as suitable**Input:** Agricultural Assessment – NC Dept. of Environment and Natural Resources**Rationale:** If it is currently cropland, it is physically suitable.**Output:** Existing Cropland SUA (AG1O11SO112)**Criteria for Utility Assignment:** Areas of existing croplands were assigned a value of 9; all other areas were assigned a value of 1.*Table 23: Existing cropland sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>NoData</i>	1
<i>Cropland</i>	9

AG1011S0112

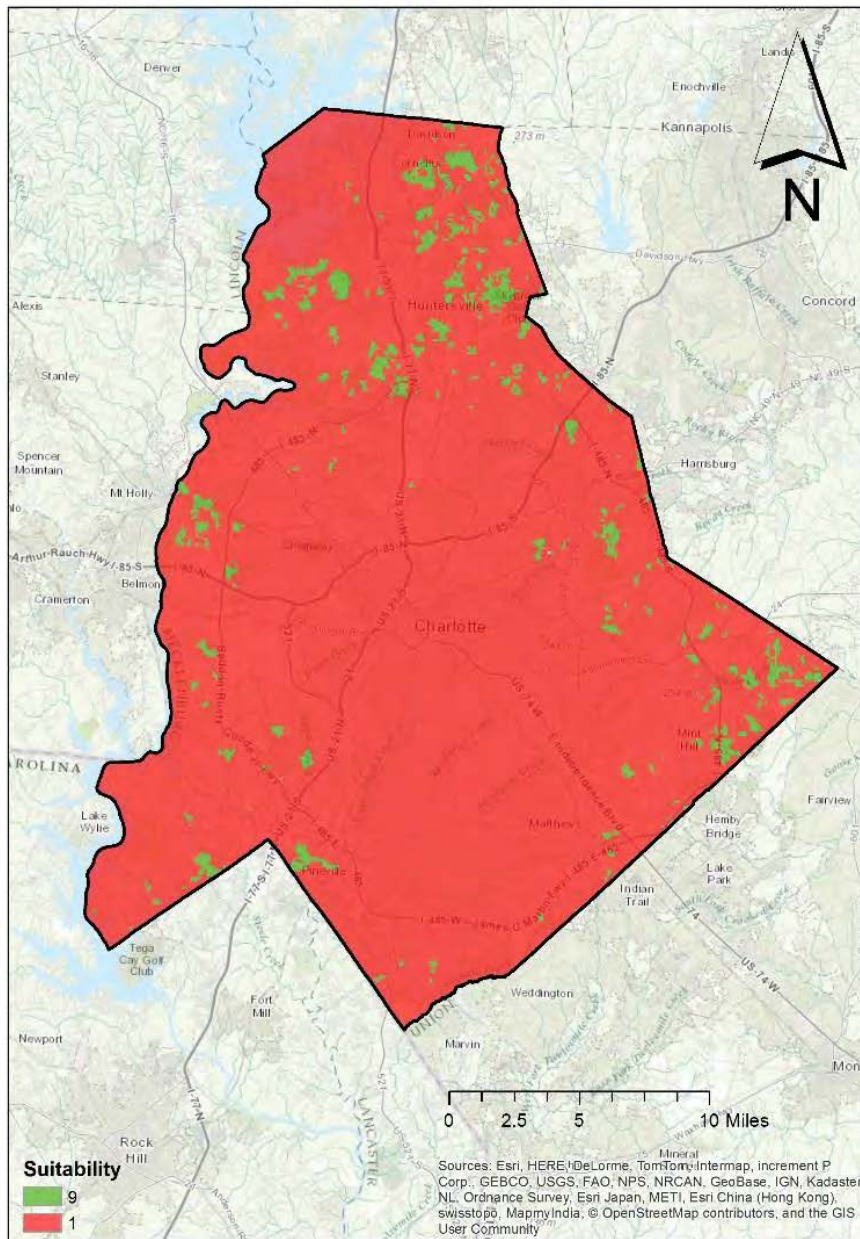


Figure 68: AG1011S0112

Land use: Agriculture

Goal 1: Identify lands suitable for cropland

Objective 1.1: Identify lands physically suitable for cropland

Inputs: Crop Yield SUA (AG1O11SO111), Existing Cropland SUA (AG1O11SO112)

Rationale: If land is currently used for crops, then the suitability is high; for all other land, crop yield is used to determine suitability.

Output: Cropland Physical Suitability MUA (AG1O11)

Criteria for Utility Assignment: The inputs were combined using the Raster Calculator tool's conditional statement function. Cells currently used for crops were given a value of 9; for all other cells, the Crop Yield value was used.

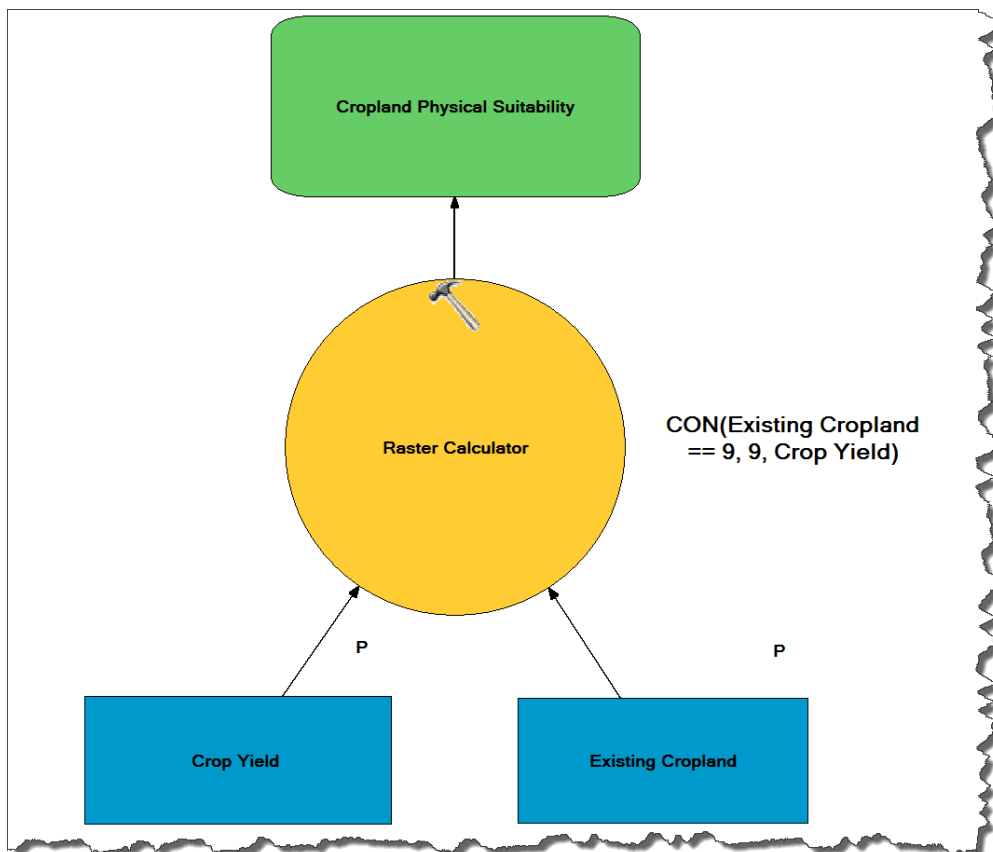


Figure 69: Cropland physical suitability model

AG1011

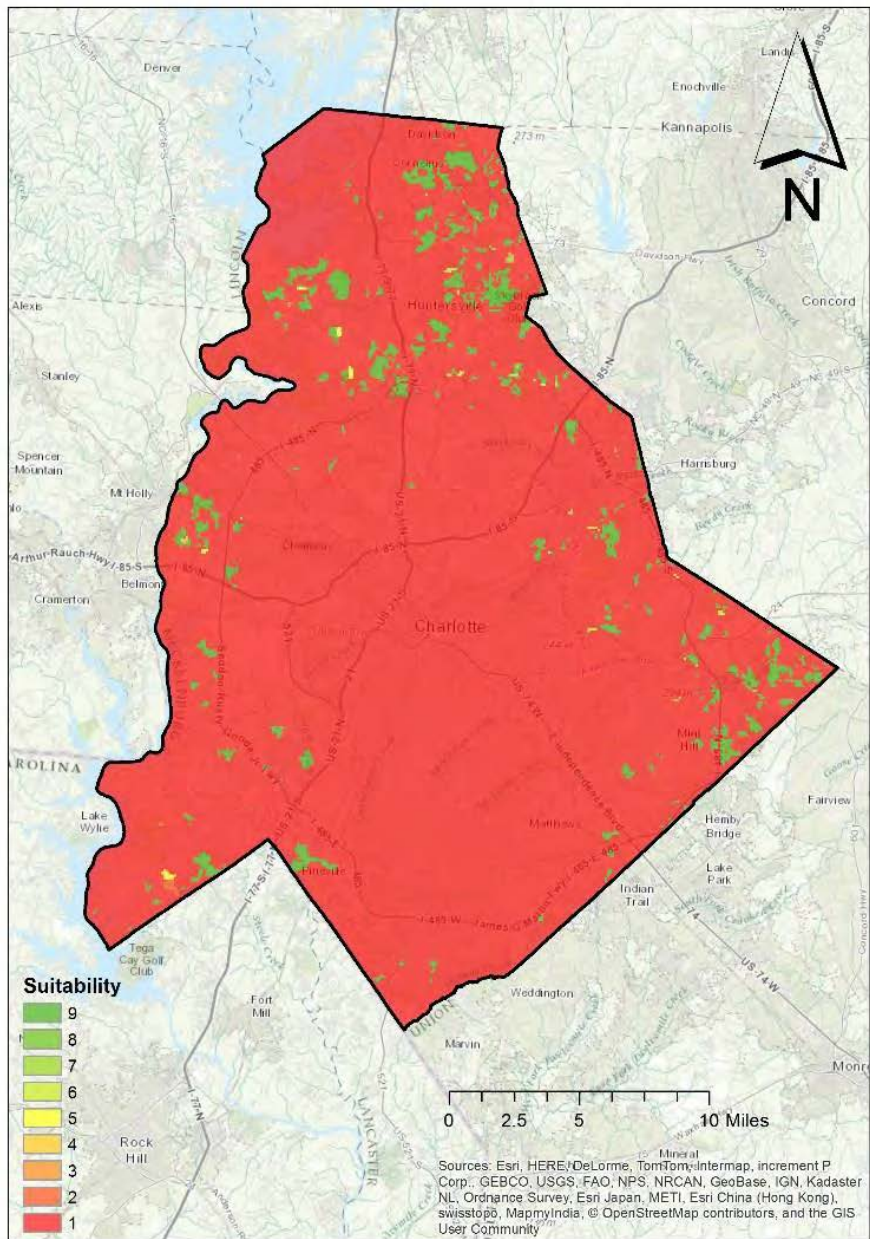


Figure 70: AG1011

Land use: Agriculture**Goal 1:** Identify lands suitable for cropland**Objective 1.2:** Determine lands economically suitable for cropland**Input:** City and Town Limits**Rationale:** The closer to markets for row crops the better.**Output:** Proximity to Cropland Markets SUA (AG1012)**Criteria for Utility Assignment:** Euclidean distance was run against City and Town Limits.

Zonal statistics were then run on the Euclidean Distance from City and Town Limits to determine the mean and standard deviation. Cells with a Euclidean distance less than or equal to the mean were assigned a value of 9 (0-662 ft.); cells within the next quarter standard deviation were assigned a value of 8, and so on, until 2. All the remaining cells were assigned a value of 1.

Table 24: Proximity to cropland markets objective data ranges and values

<i>Data Range (in feet)</i>	<i>Utility Assignment</i>
0-662	9
663-2208	8
2209-3753	7
3754-5298	6
5299-6843	5
6844-8388	4
8389-9933	3
9934-11478	2
11479-(All other distances)	1

AG1012

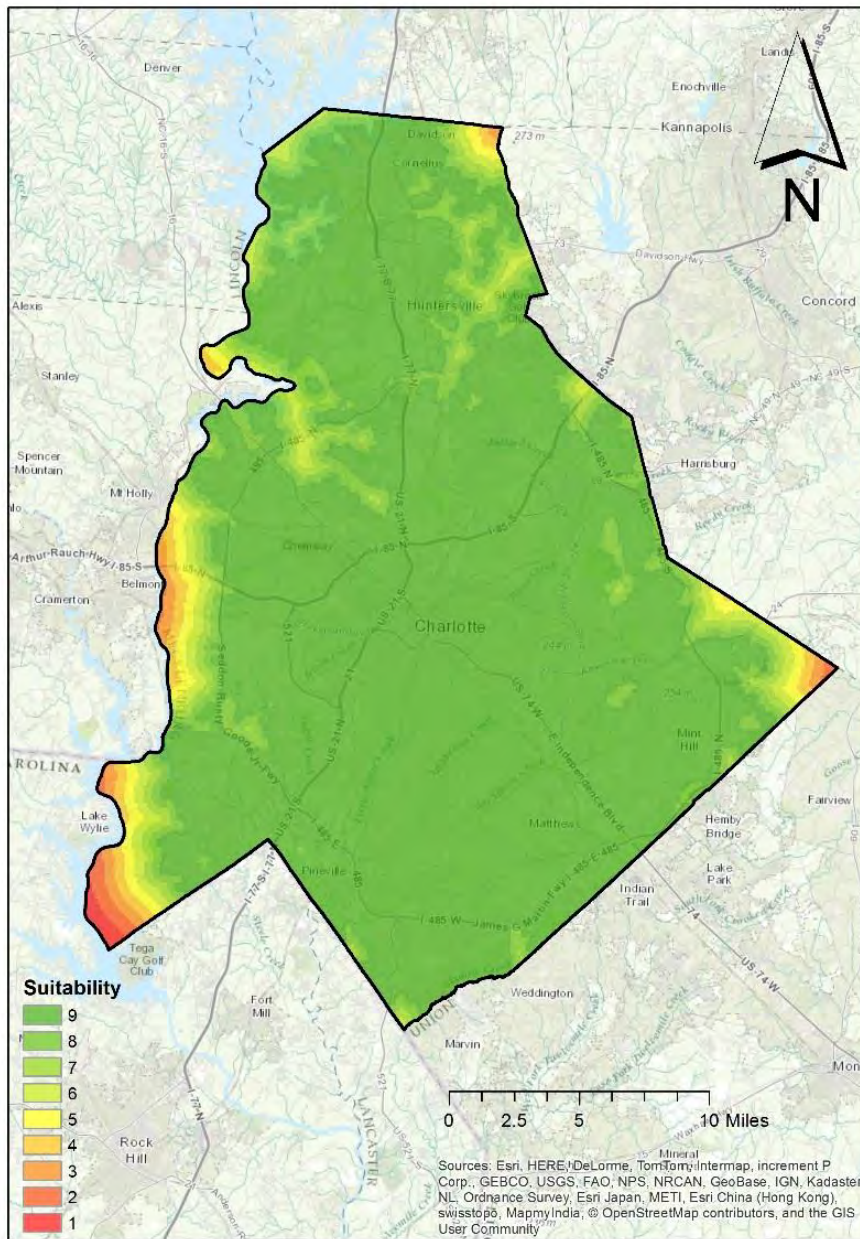


Figure 71: AG1012

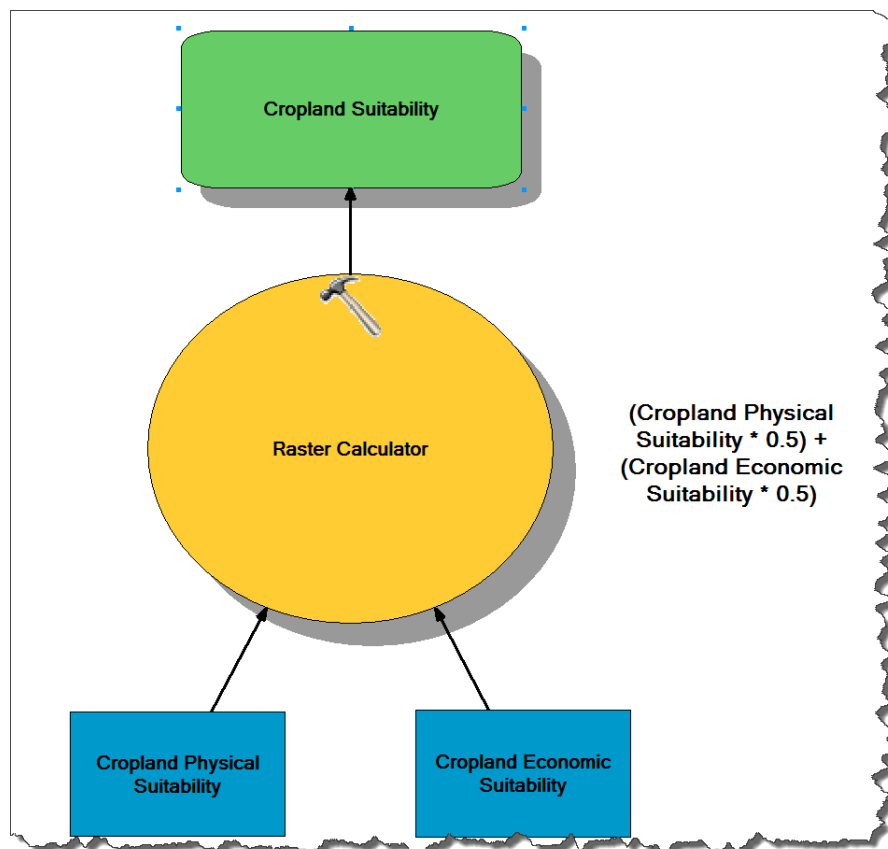
Land use: Agriculture**Goal 1:** Identify lands suitable for cropland**Inputs:** Cropland Physical Suitability MUA, Cropland Economic Suitability MUA**Rationale:** Physical and economic suitability are equally important in determining agricultural suitability.**Output:** Cropland Suitability MUA (AG1)**Criteria for Utility Assignment:** The MUAs were weighted and combined using the Raster Calculator. Physical suitability was weighted 50 percent, and economic suitability was weighted 50 percent.

Figure 72: Cropland suitability model

AG1

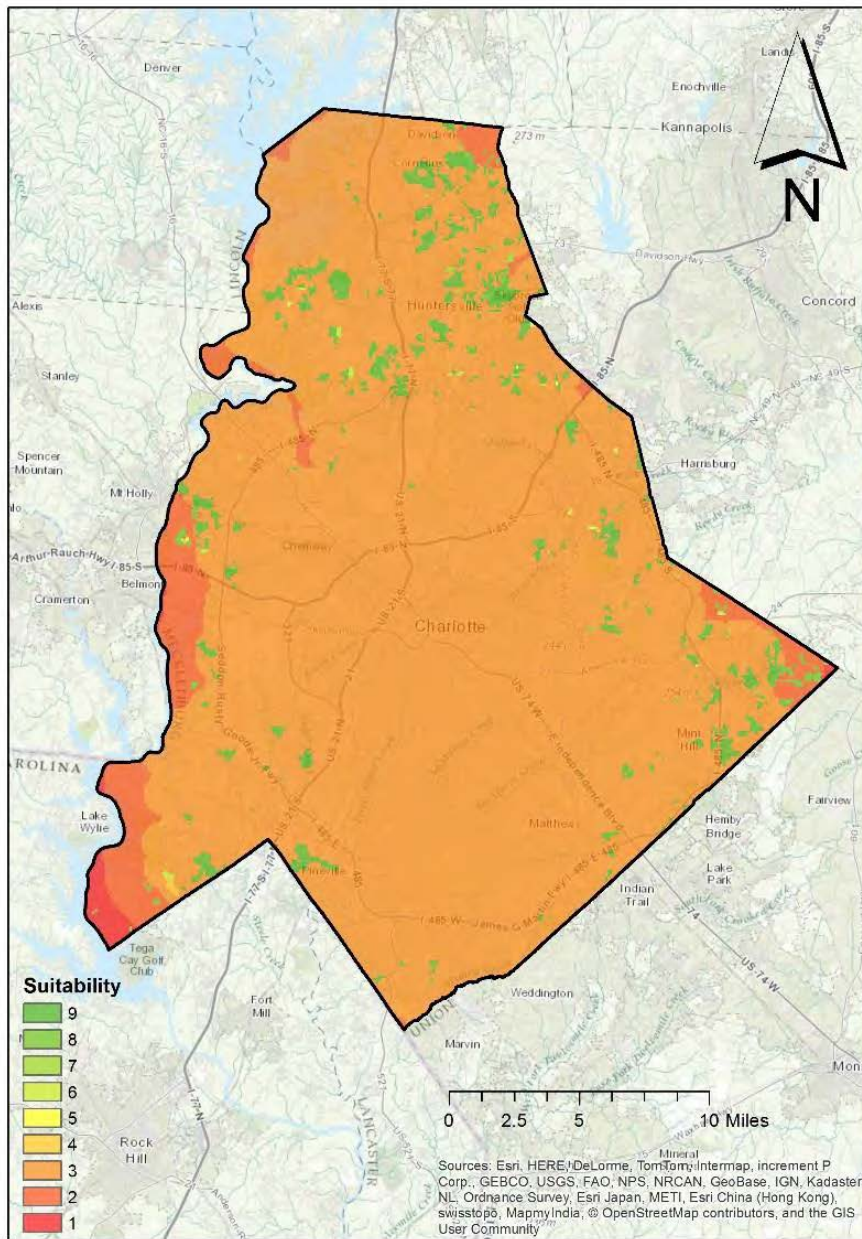


Figure 73: AG1

Land use: Agriculture

Goal 3: Determine lands suitable for livestock activities

Objective 3.1: Identify lands physically suitable for livestock activities

Input: Land Cover

Rationale: If it is currently used for livestock, it is physically suitable.

Output: Existing Livestock Areas SUA (AG3O31)

Criteria for Utility Assignment: Areas of existing livestock production were assigned a value of 9; all other areas were assigned a value of 1.

Table 25: Existing livestock areas objective data ranges and UA values

<i>Data Range</i>	<i>Utility Assignment</i>
<i>NoData</i>	1
<i>Pasture/Hay</i>	9

AG3031

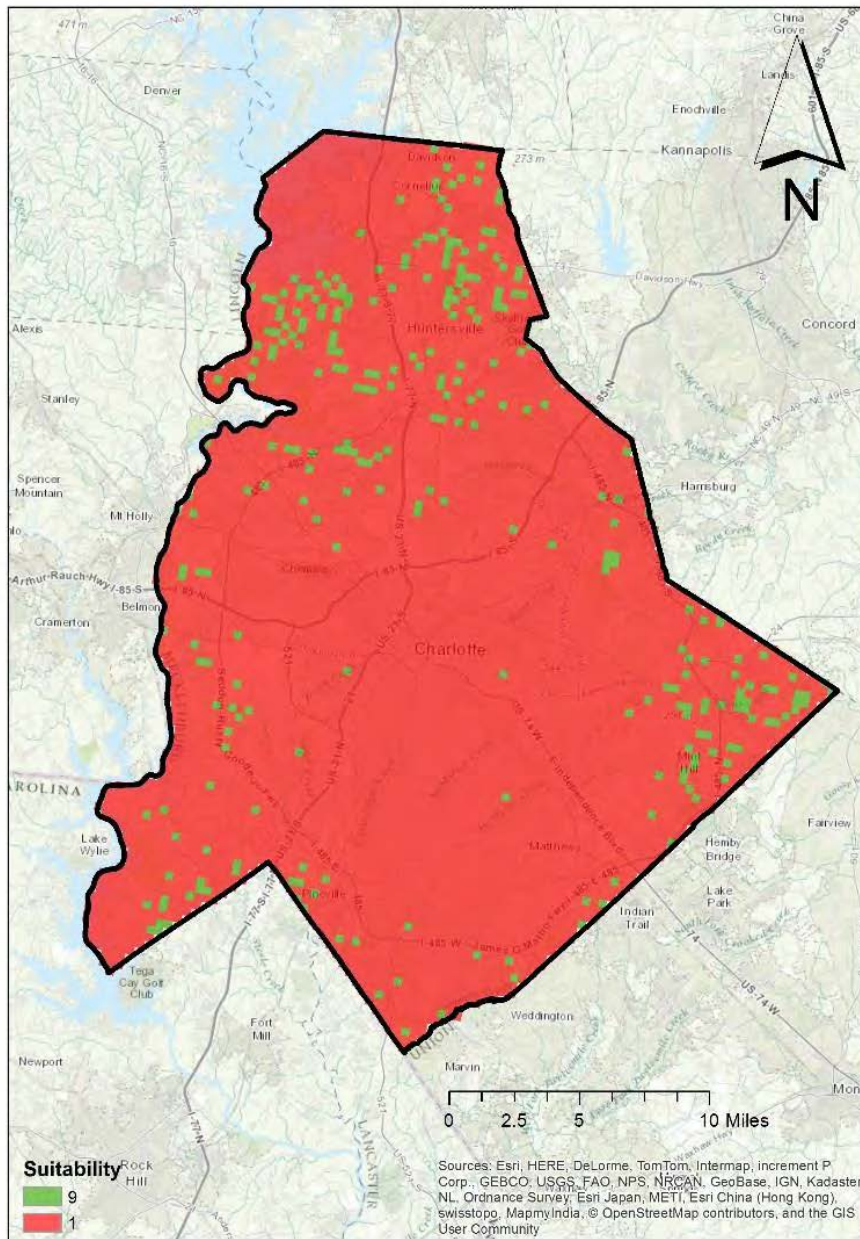


Figure 74: AG3031

Land use: Agriculture

Goal 3: Determine lands suitable for livestock activities

Objective 3.2: Determine lands economically suitable for livestock activities

Sub-objective 3.2.1: Identify lands proximal to markets for livestock

Inputs: City and Town Limits

Rationale: The closer to markets the better, based on the proximity of existing livestock areas to markets.

Output: Livestock Economic Suitability SUA (AG3O32SO321)

Criteria for Utility Assignment: Euclidean distance was run for City and Town Limits. Zonal statistics were run on the Euclidean Distance from City and Town Limits to determine the mean and standard deviation. Cells with a Euclidean distance less than or equal to the mean were assigned a value of 9 (0-662 ft.); cells within the next quarter standard deviation were assigned a value of 8, and so on, until 2. All the remaining cells were assigned a value of 1.

Table 26: Proximity to livestock markets sub-objective data ranges and values

<i>Data Range (in feet)</i>	<i>Utility Assignment</i>
0-662	9
663-2208	8
2209-3753	7
3754-5298	6
5299-6843	5
6844-8388	4
8389-9933	3
9934-11478	2
11479-(All other distances)	1

AG3032S0321

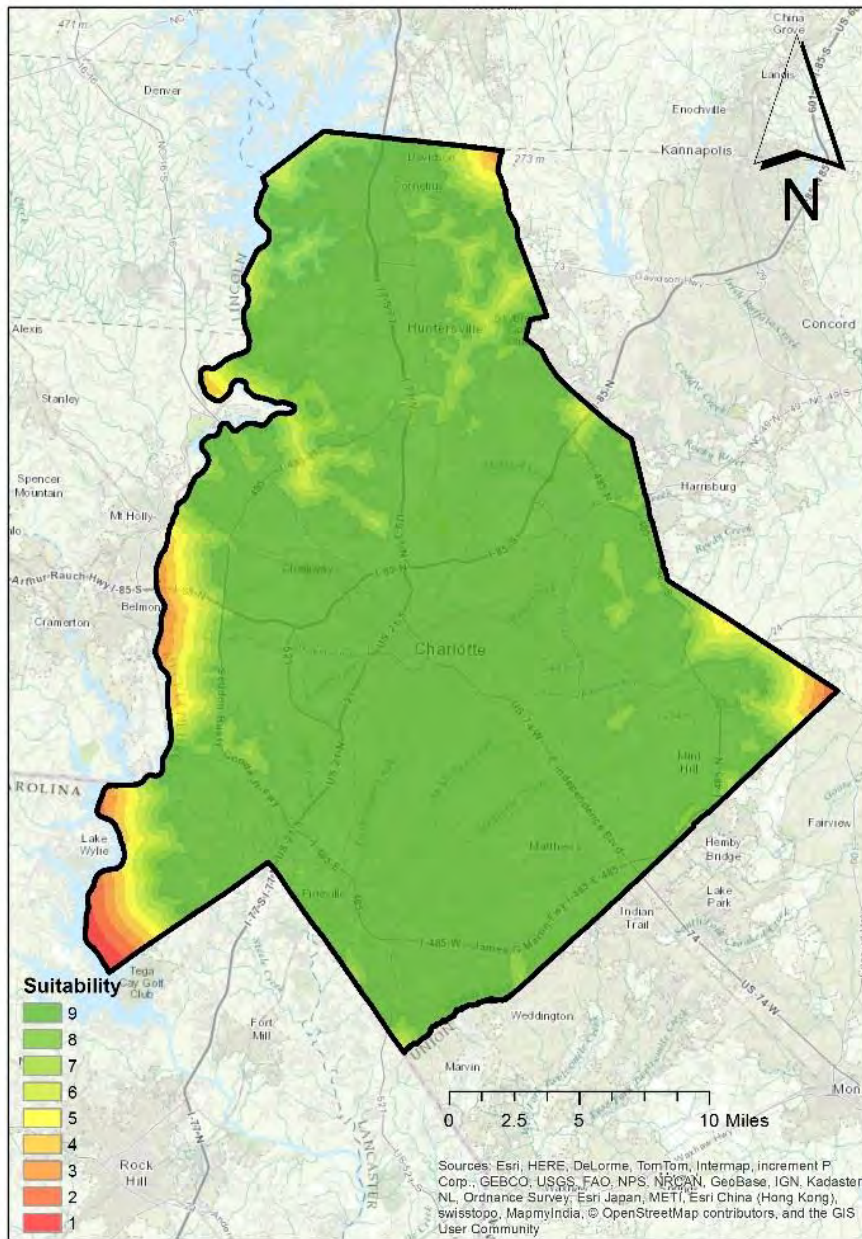


Figure 75: AG3032S0321

Land use: Agriculture

Goal 3: Determine lands suitable for livestock activities

Input: Livestock Physical Suitability MUA, Livestock Economic Suitability MUA

Rationale: Physical and economic suitability are important in determining agricultural suitability.

Output: Livestock Suitability MUA (AG3)

Criteria for Utility Assignment: The MUAs were weighted and combined using the Raster Calculator. Physical suitability was weighted 50 percent and economic suitability was weighted 50 percent.

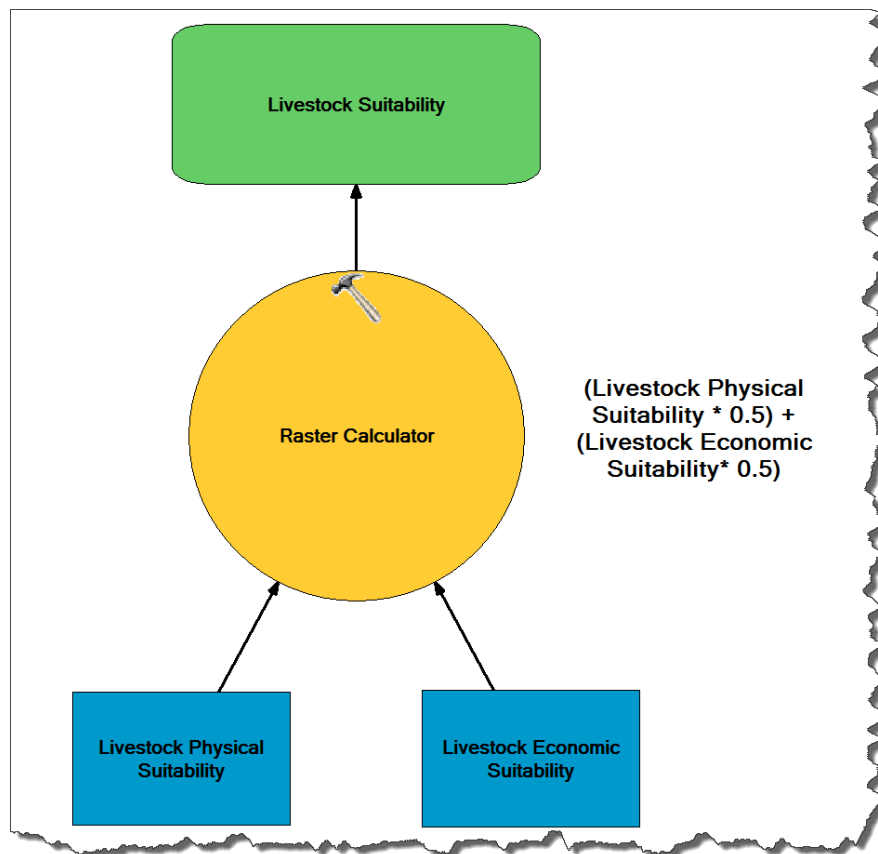


Figure 76: Livestock suitability model

AG3

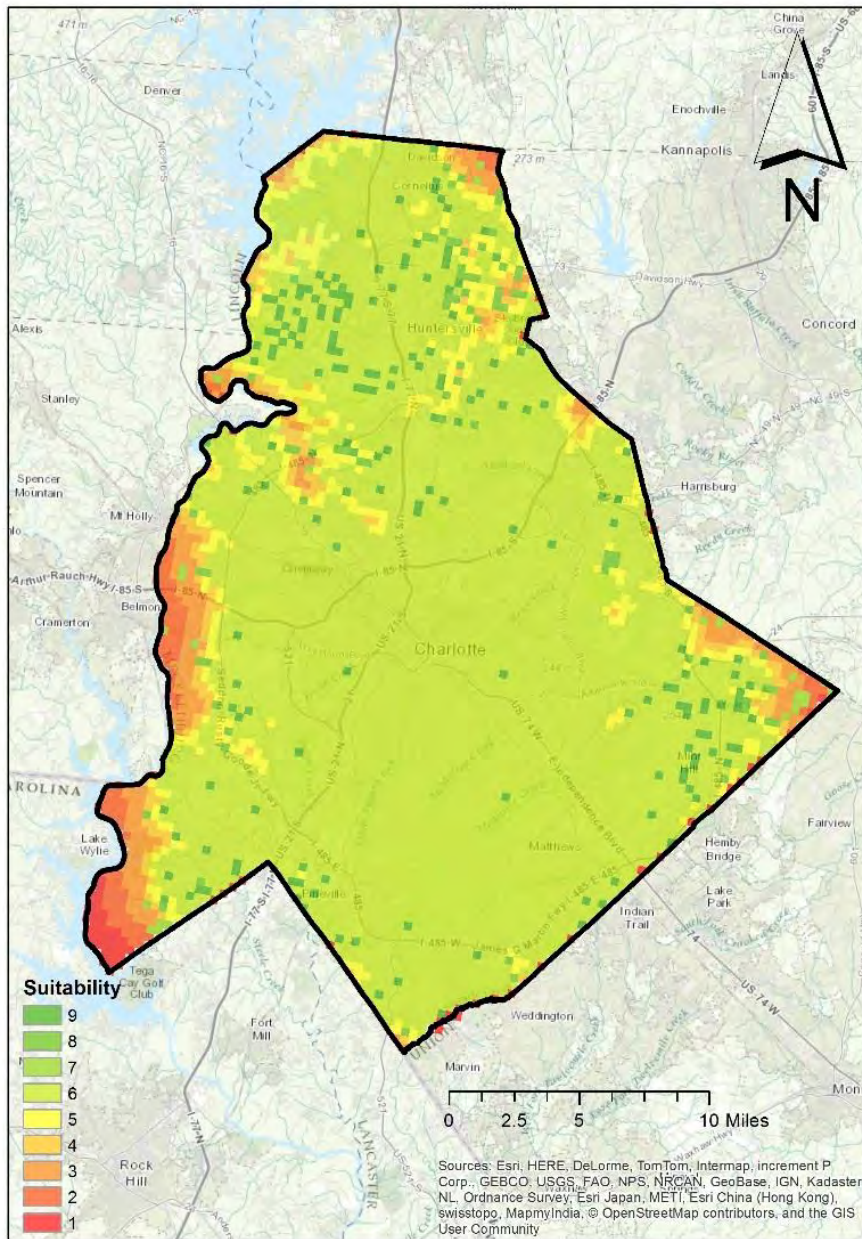


Figure 77: AG3

Land use: Agriculture

Goal 4: Identify lands suitable for timber

Objective 4.1: Determine lands physically suitable for timber

Input: Land Cover

Rationale: If it is currently used for timber, it is physically suitable.

Output: Timber Physical Suitability MUA (AG4O41)

Criteria for Utility Assignment: Areas of existing timber land were assigned a value of 9; all other areas were assigned a value of 1.

Table 27: Existing timber land objective data ranges and UA values

<i>Data Range</i>	<i>Utility Assignment</i>
<i>NoData</i>	1
<i>Timber</i>	9

AG4041

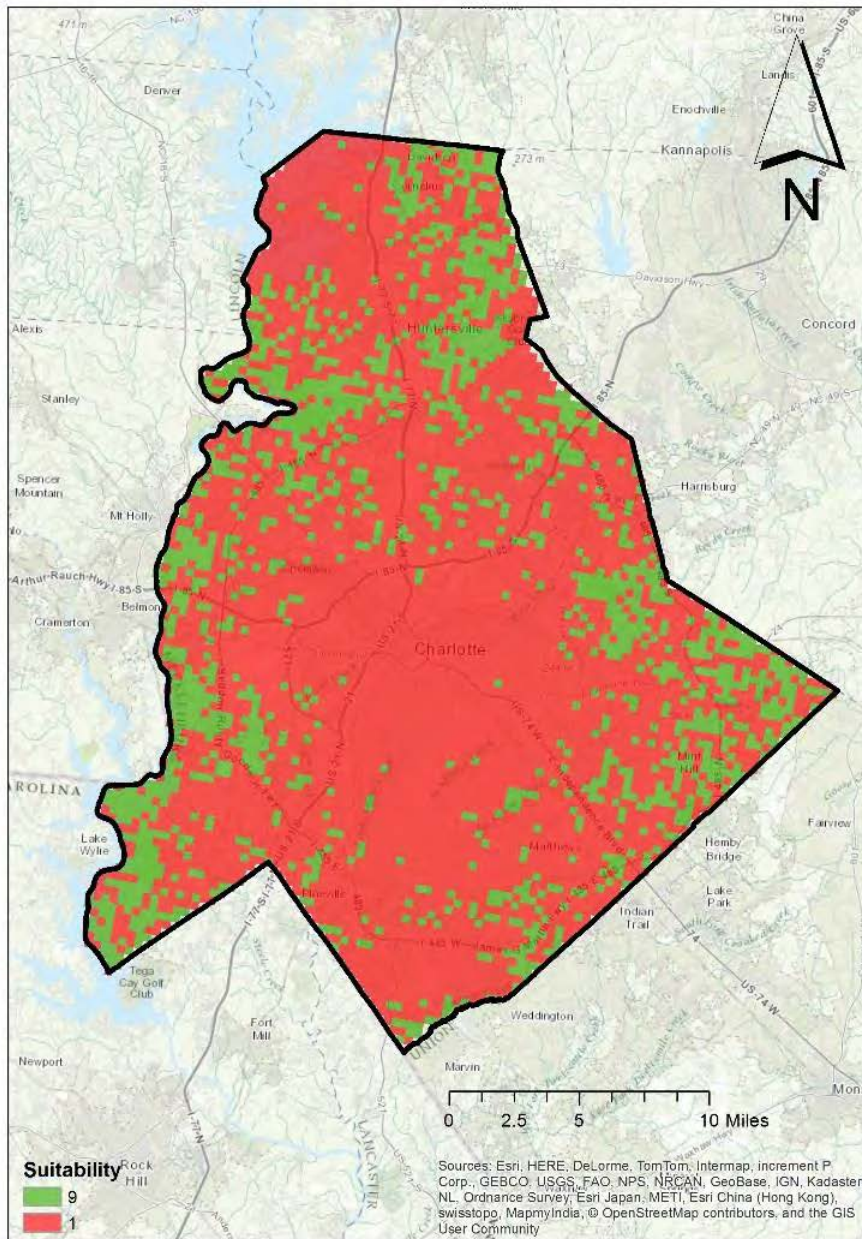


Figure 78: AG4041

Land use: Agriculture

Goal 4: Identify lands suitable for timber

Objective 4.2: Determine lands economically suitable for timber

Sub-objective 4.2.2: Identify lands proximal to markets for timber

Inputs: City and Town Limits

Rationale: The closer to timber markets, the better for lands where timber is produced.

Output: Timber Economic Suitability SUA (AG4O42SO422)

Criteria for Utility Assignment: Euclidean distance was run for City and Town Limits. Zonal statistics were run on the Euclidean Distance from City and Town Limits to determine the mean and standard deviation. Cells with a Euclidean distance less than or equal to the mean were assigned a value of 9 (0-662 ft.); cells within the next quarter standard deviation were assigned a value of 8, and so on, until 2. All the remaining cells were assigned a value of 1.

Table 28: Proximity to timber markets sub-objective data ranges and values

<i>Data Range (in feet)</i>	<i>Utility Assignment</i>
0-662	9
663-2208	8
2209-3753	7
3754-5298	6
5299-6843	5
6844-8388	4
8389-9933	3
9934-11478	2
11479-(All other distances)	1

AG4042SO422

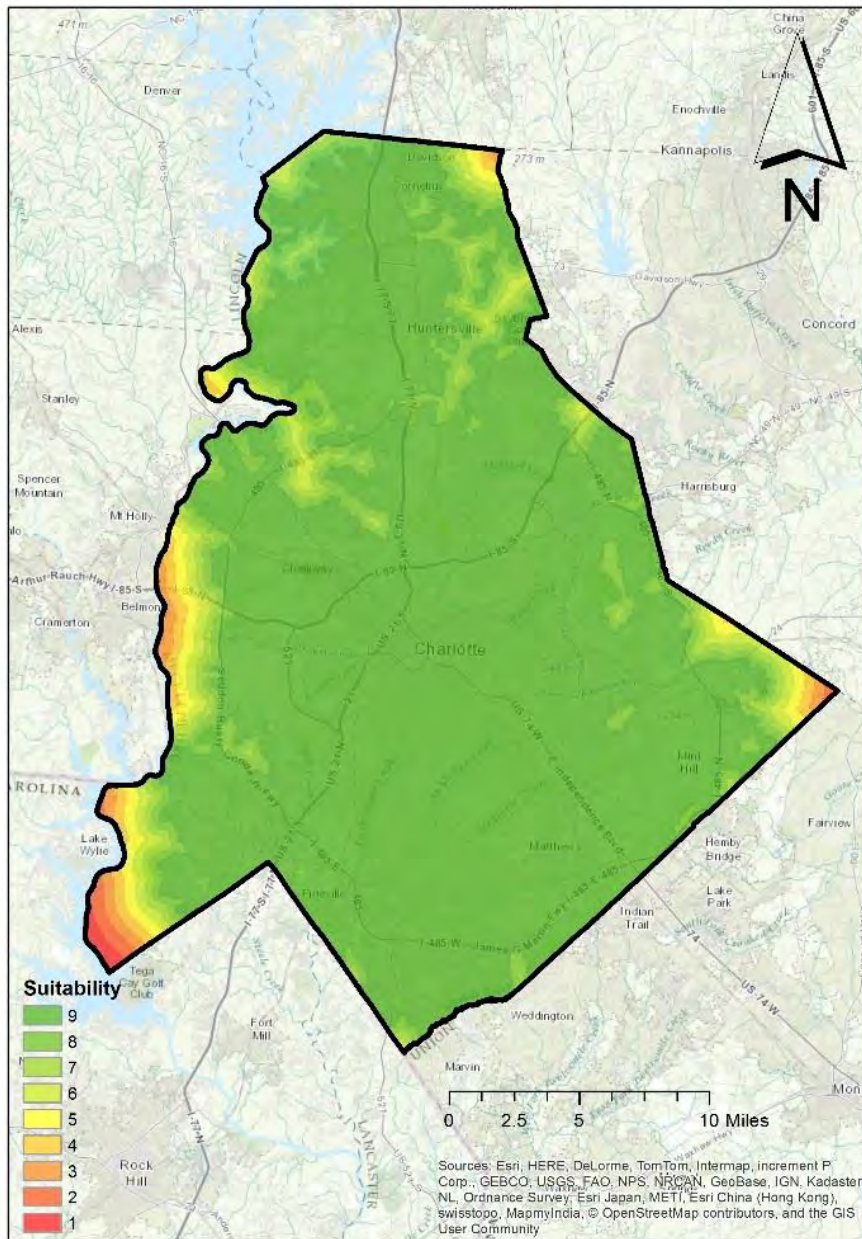


Figure 79: AG4042SO422

Land use: Agriculture

Goal 4: Identify lands suitable for Timber

Input: Timber Physical Suitability MUA, Timber Economic Suitability MUA

Rationale: Physical and economic suitability are important in determining agricultural suitability.

Output: Timber Suitability MUA (AG4)

Criteria for Utility Assignment: The MUAs were weighted and combined using the Raster Calculator. Physical suitability was weighted 50 percent and economic suitability was weighted 50 percent.

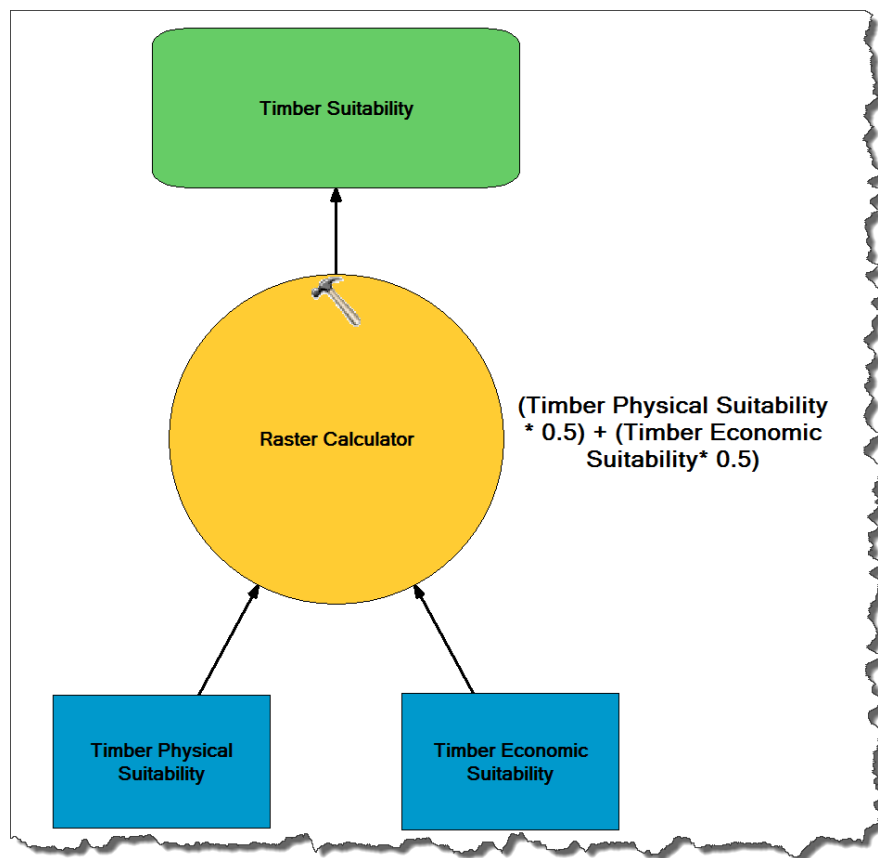


Figure 80: Timber suitability model

AG4

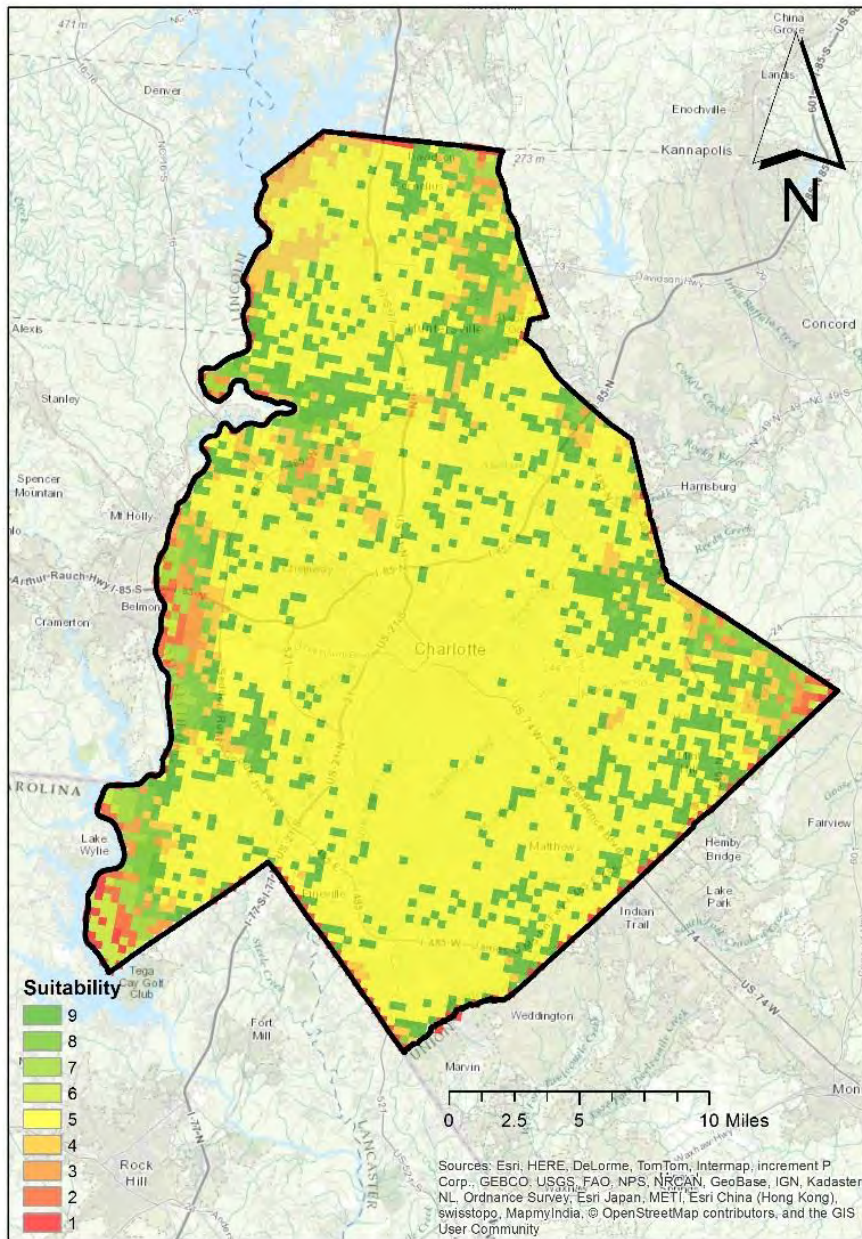


Figure 81: AG4

Land use: Conservation**Goal 1:** Identify lands suitable for protecting biodiversity**Objective 1.1:** Identify lands with high biodiversity**Inputs:** Biological Wildlife Habitat Assessment**Rationale:** Existing conservation lands identified by the North Carolina Department of Environment and Natural Resources all have potentially high biodiversity, and are suitable areas for high biodiversity suitability.**Output:** Biodiversity MUA (CG1011)**Criteria for Utility Assignment:** The Biological Wildlife Habitat Assessment was converted to raster using the Feature to Raster tool. Once in raster format the layer was reclassified using the Reclassify tool to designate all existing conservation lands a suitability value of 9, and all other land a 1.*Table 29: Identify lands with high biodiversity objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Existing Conservation Land</i>	9
<i>All Other Land</i>	1

CG1011

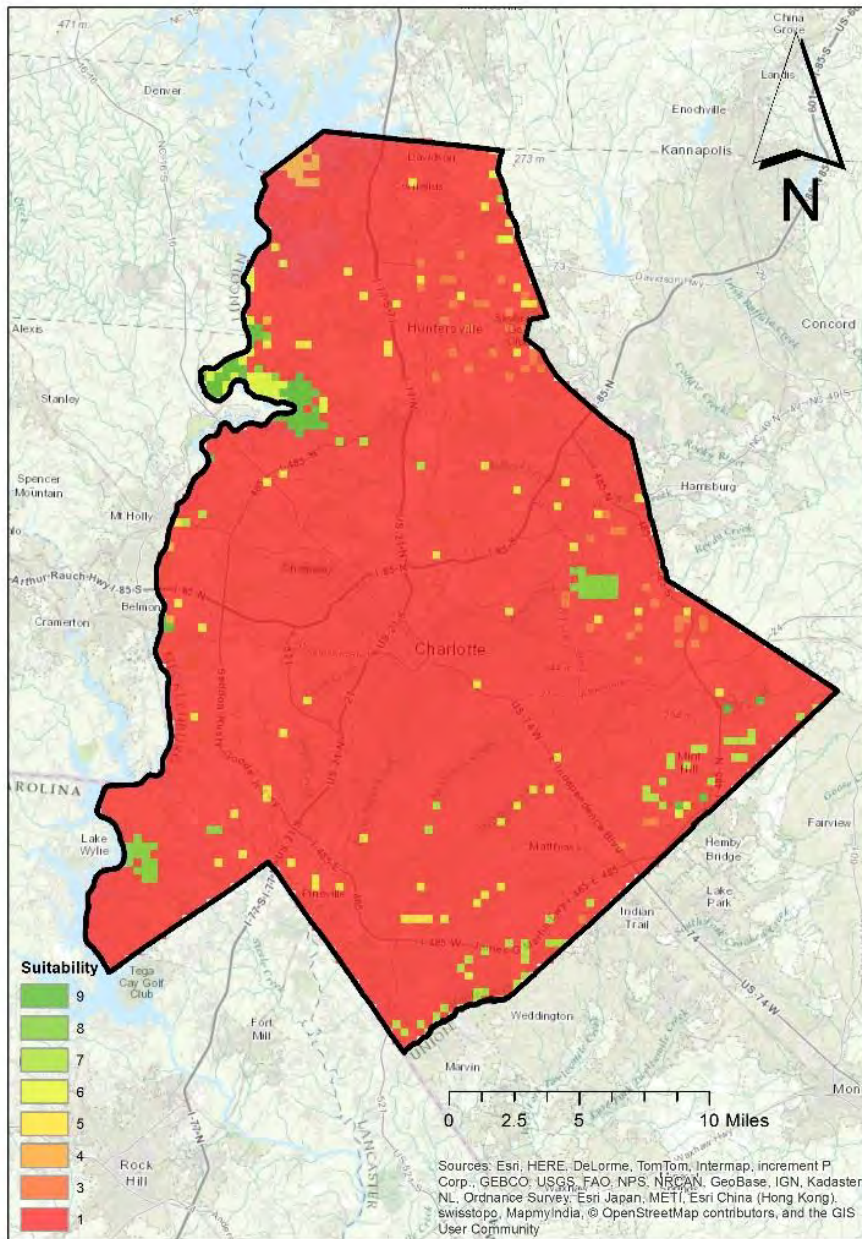


Figure 82: CG1011

Land use: Conservation**Goal 1:** Identify lands suitable for protecting biodiversity**Objective 1.2:** Identify lands with relatively low road density**Input:** Road Density**Rationale:** Lower road density leads to less disturbance of biodiversity.**Output:** Low Road Density SUA (CG1O12)**Criteria for Utility Assignment:** Line Density was run on County Roads. The resulting road densities per square miles were assigned values of 9–1 based on 9 equal intervals, with lowest road density receiving a value of 9 and highest road density receiving a value of 1.*Table 30: Identify lands with relatively low road density objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
0-5.15	9
5.16-10.31	8
10.32-15.46	7
15.47-20.62	6
20.63-25.77	5
25.78-30.93	4
30.94-36.08	3
36.09-41.23	2
41.24-46.39	1

CG1012

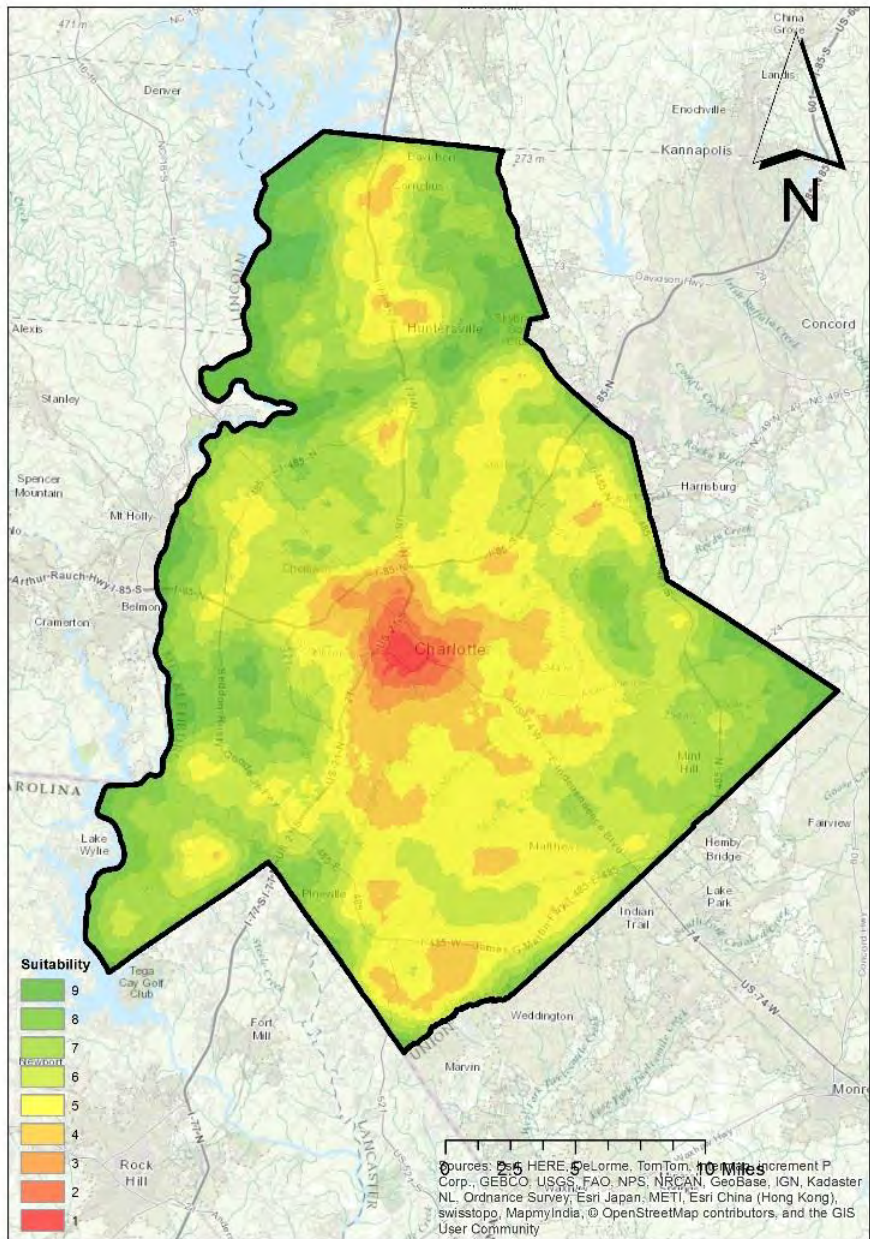


Figure 83: CG1012

Land use: Conservation

Goal 1: Identify lands suitable for protecting biodiversity

Inputs: Native Biodiversity MUA (CG1O11), Low Road Density SUA (CG1O12)

Rationale: Measures of suitability are equal measures of biodiversity.

Output: Biodiversity Protection Suitability SUA (CG1)

Criteria for Utility Assignment: The MUAs were weighted and combined using the Raster Calculator. High biodiversity was weighted 50 percent and low road density was weighted 50 percent.

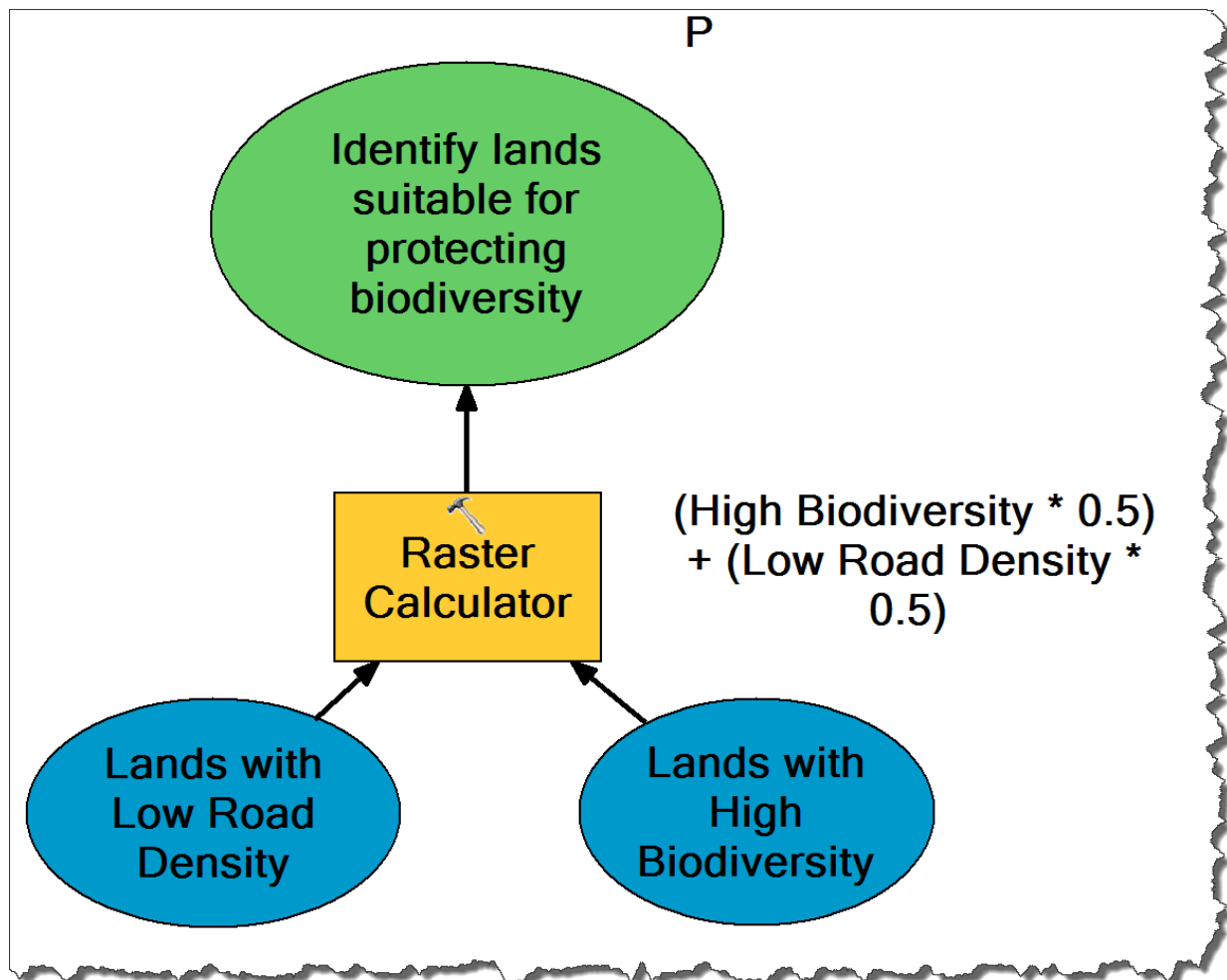


Figure 84: Identify lands suitable for protecting biodiversity model

CG1

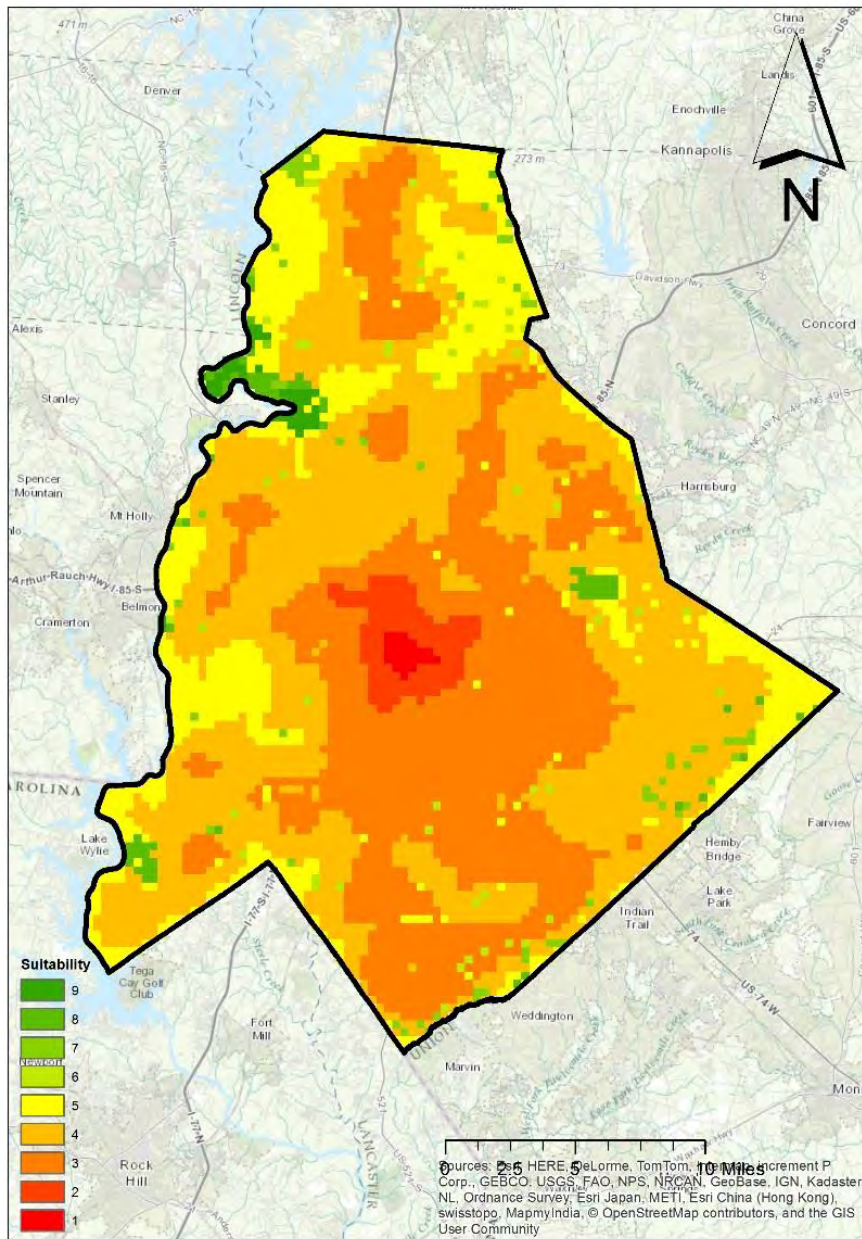


Figure 85: CG1

Land use: Conservation**Goal 2:** Identify lands suitable for protecting water quality**Input:** Rivers, Streams, Lakes, and Ponds**Rationale:** Surface water must be conserved, and thus runoff into surface water needs to be free of contamination.**Output:** Surface Water Feature Buffer SUA (CG2)**Criteria for Utility Assignment:** Euclidean Distance was run on rivers, streams, lakes, and ponds. The Euclidean Distances were then reclassified using the Reclassify tool to designate all land within a body of water and within 100 m (328 ft.) of a body of water as 9 and all other land as 1.*Table 31: Identify lands suitable for protecting water quality goal data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Land Within or Within 100m of a Body of Water</i>	9
<i>All Other Land</i>	1

CG2

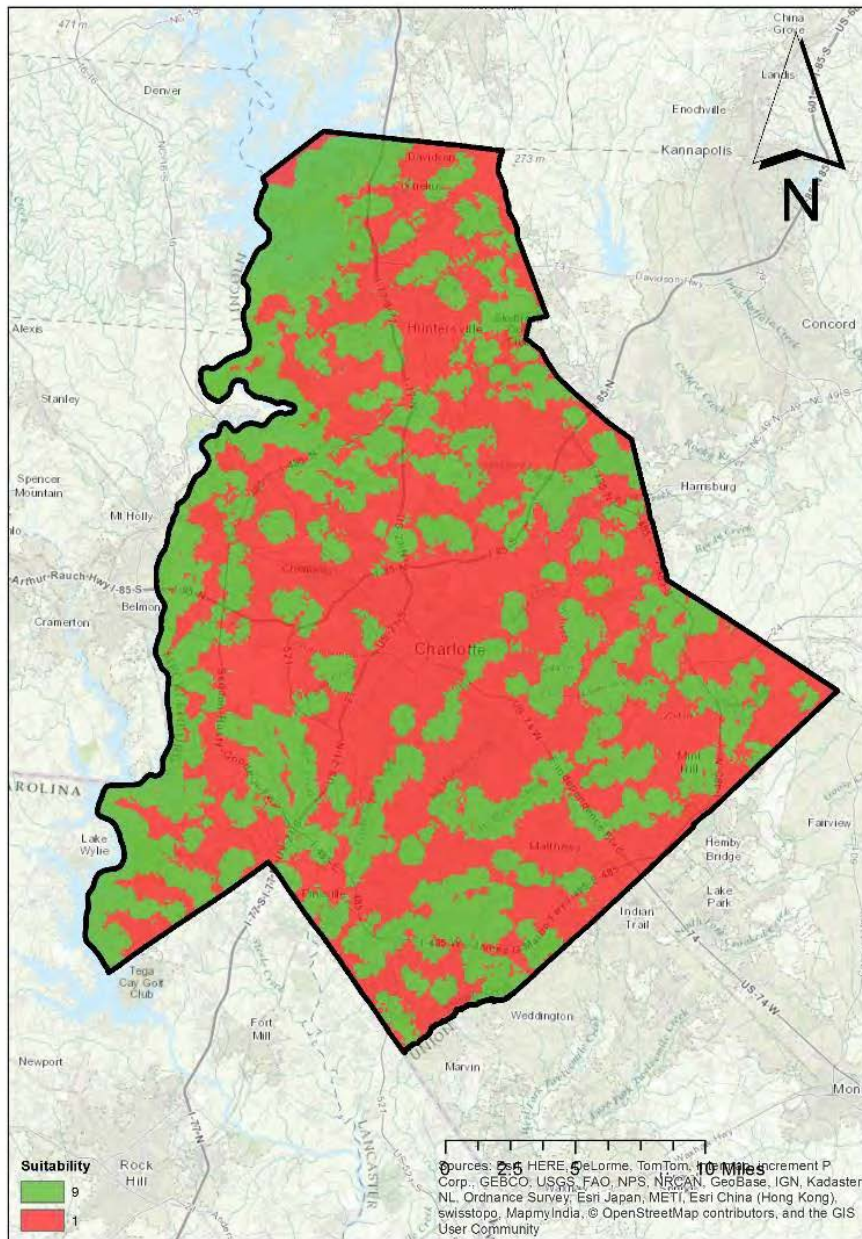


Figure 86: CG2

Land use: Conservation**Goal 3:** Identify lands suitable for protection of important ecological processes**Objective 3.2:** Identify lands important for flooding and flood storage in the landscape**Sub-objective 3.2.1:** Identify wetlands**Input:** Wetlands**Rationale:** Wetlands are important to flooding processes.**Output:** Wetlands SUA (CG3O32SO321)**Criteria for Utility Assignment:** The wetlands layer was converted to raster using the Feature to Raster tool, and then reclassified using the Reclassify tool to designate all wetlands as 9 and all other land as 1.*Table 32: Identify wetlands sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Wetlands</i>	9
<i>All Other Land</i>	1

CG3O32S0321

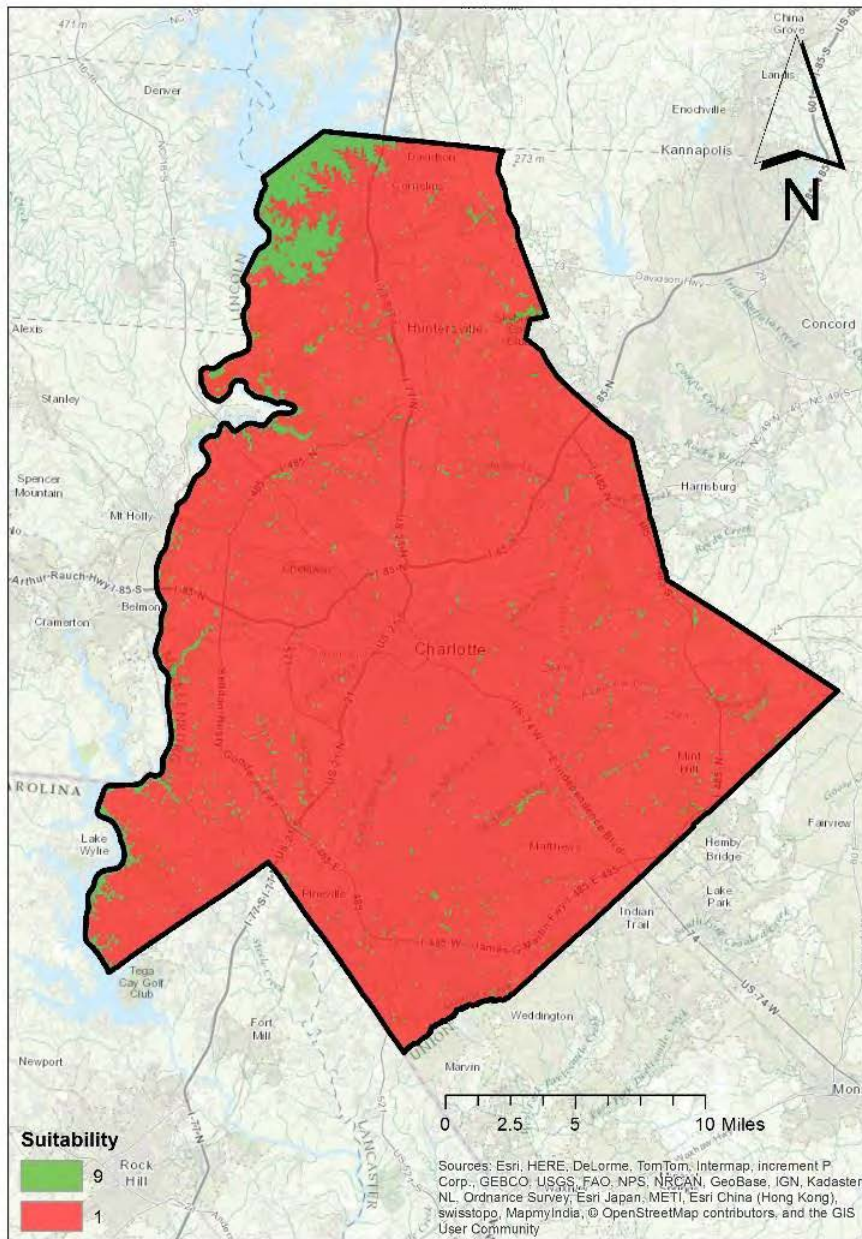


Figure 87: CG3O32S0321

Land use: Conservation

Goal 3: Identify lands suitable for protection of important ecological processes

Objective 3.2: Identify lands important for maintenance of the process of flooding

Sub-objective 3.2.2: Identify rivers to protect their flood storage function

Input: Rivers

Rationale: Rivers are important for protecting flooding processes.

Output: Rivers SUA (CG3O32SO322)

Criteria for Utility Assignment: Euclidean distance was run from rivers. The results were reclassified using the Reclassify tool. Land within a river or within 100 m (328) of a river were designated a suitability value of 9; all other areas were assigned a value of 1.

Table 33: Identify rivers to protect their flood storage function sub-objective data ranges and UA values

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Land Within or Within 100m of a River</i>	9
<i>All Other Land</i>	1

CG3O32S0322

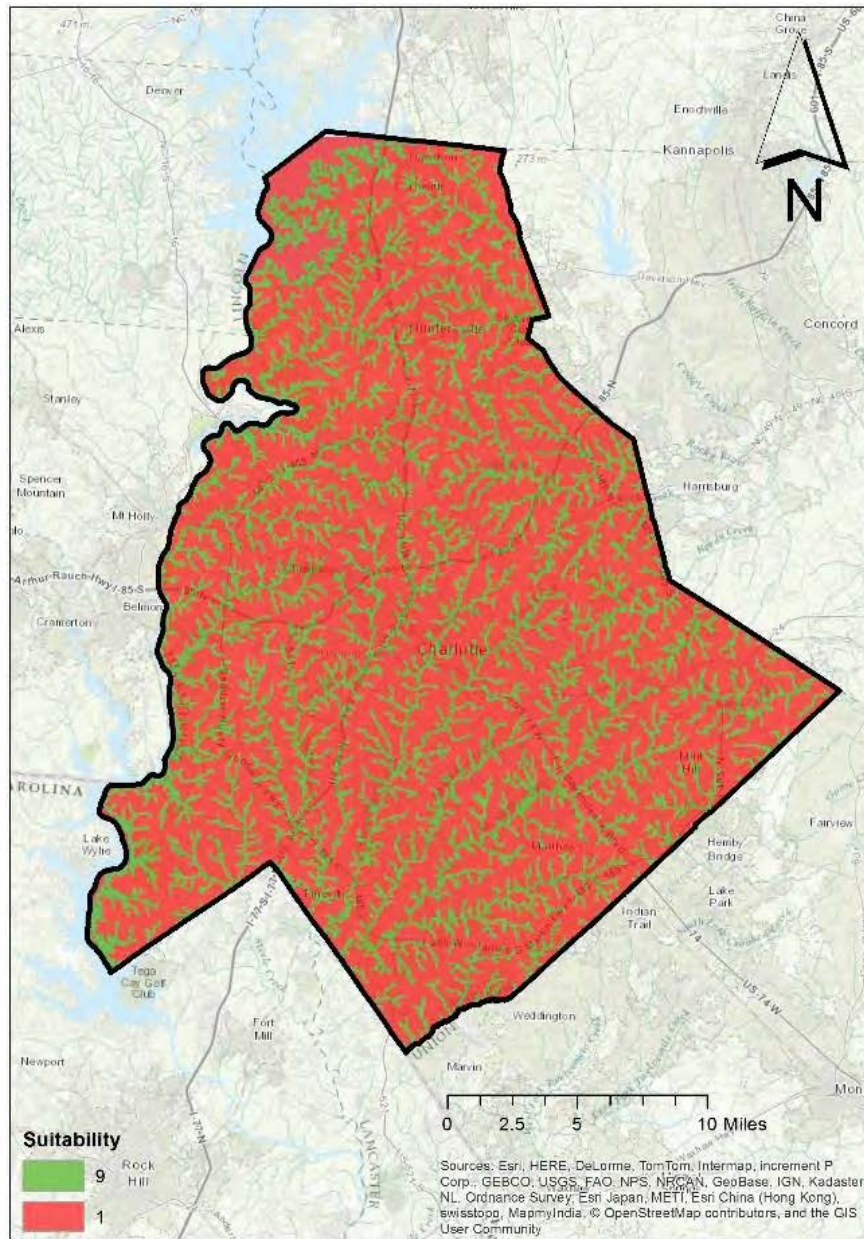


Figure 88: CG3O32S0322

Land use: Conservation

Goal 3: Identify lands suitable for protection of important ecological processes

Objective 3.2: Identify lands important for maintenance of the process of flooding

Sub-objective 3.2.3: Identify open water to protect their flood storage function

Input: Lakes and Ponds

Rationale: Open water is important for protecting flooding processes.

Output: Open Water SUA (CG3O32SO323)

Criteria for Utility Assignment: The Lakes and Ponds layers were joined to create an Open Water layer. The Open Water layer was converted to raster using the Feature to Raster tool, and then reclassified using the Reclassify tool to designate all Open Water as 9 and all other land as 1.

Table 34: Identify open water to protect their flood storage function sub-objective data ranges and UA values

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Open Water</i>	9
<i>All Other Land</i>	1

CG3O32S0323

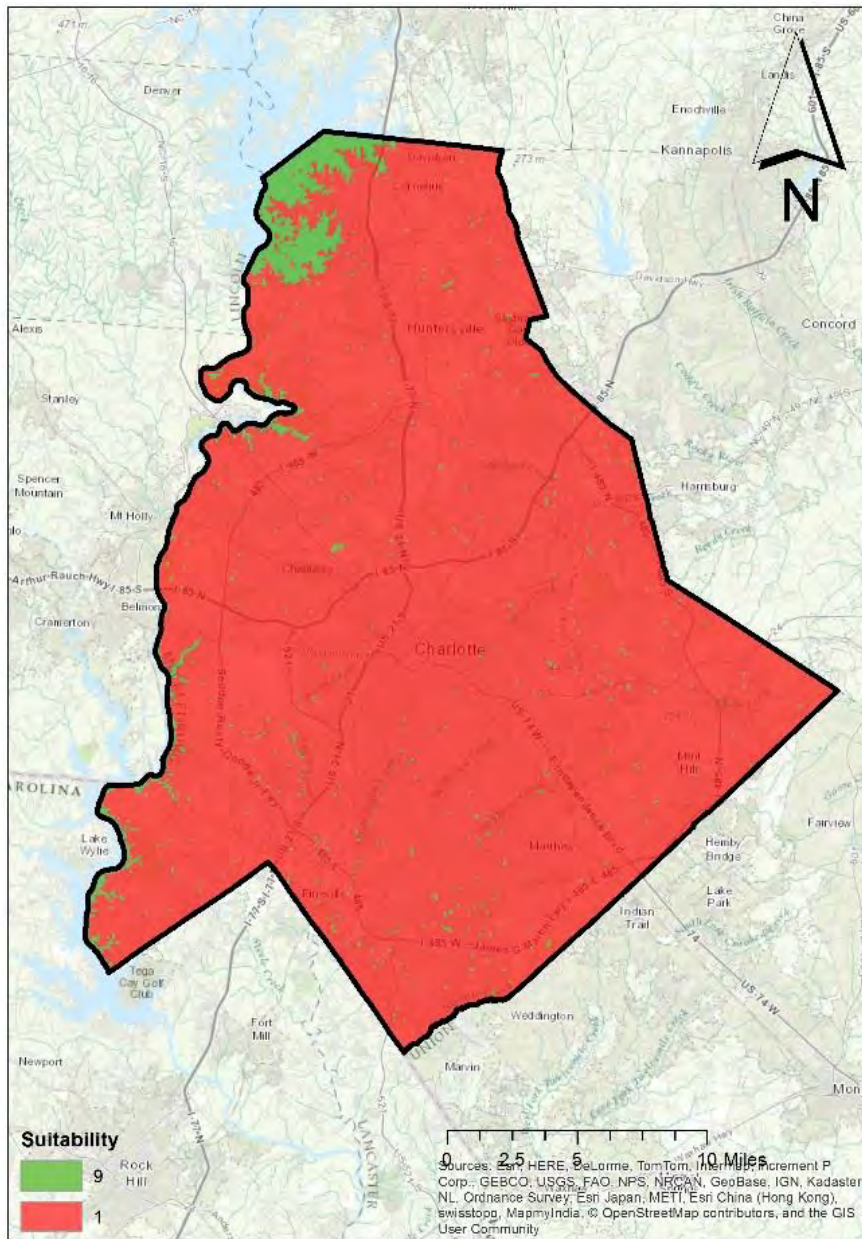


Figure 89: CG3O32S0323

Land use: Conservation

Goal 3: Identify lands suitable for protection of important ecological processes

Input: Wetlands SUA (CG3O32SO321), Rivers SUA (CG3O32SO322), Open Water SUA (CG3O32SO323).

Rationale: People and nature benefit from the protection of storm storage or natural flooding processes.

Output: Flood Process MUA (CG3)

Criteria for Utility Assignment: The three SUAs were combined using a conditional statement within the Raster Calculator tool. If an input cell had a suitability value of 9, the resulting cell was designated a value of 9; otherwise a value of 1 was designated to all other cells.

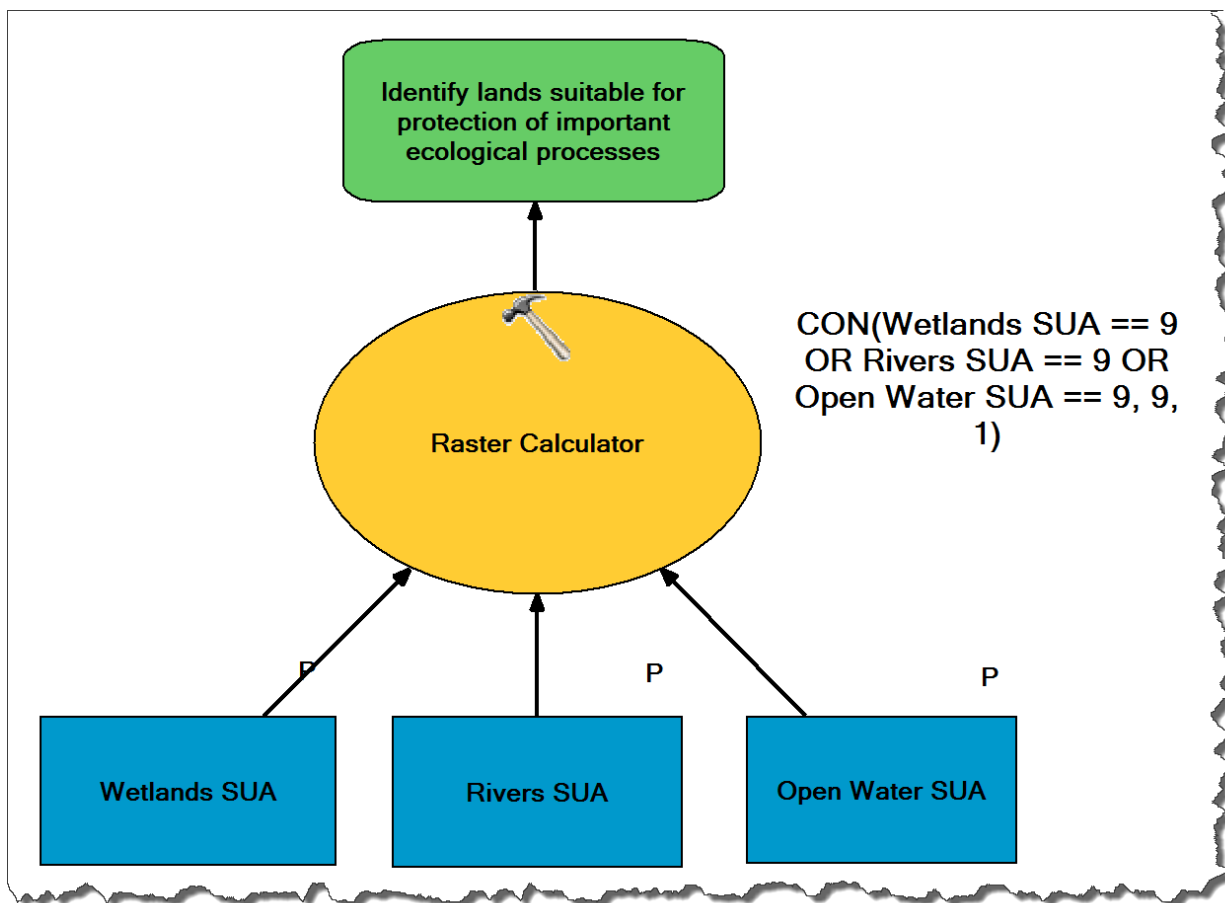


Figure 90: Flood process objective model

CG3

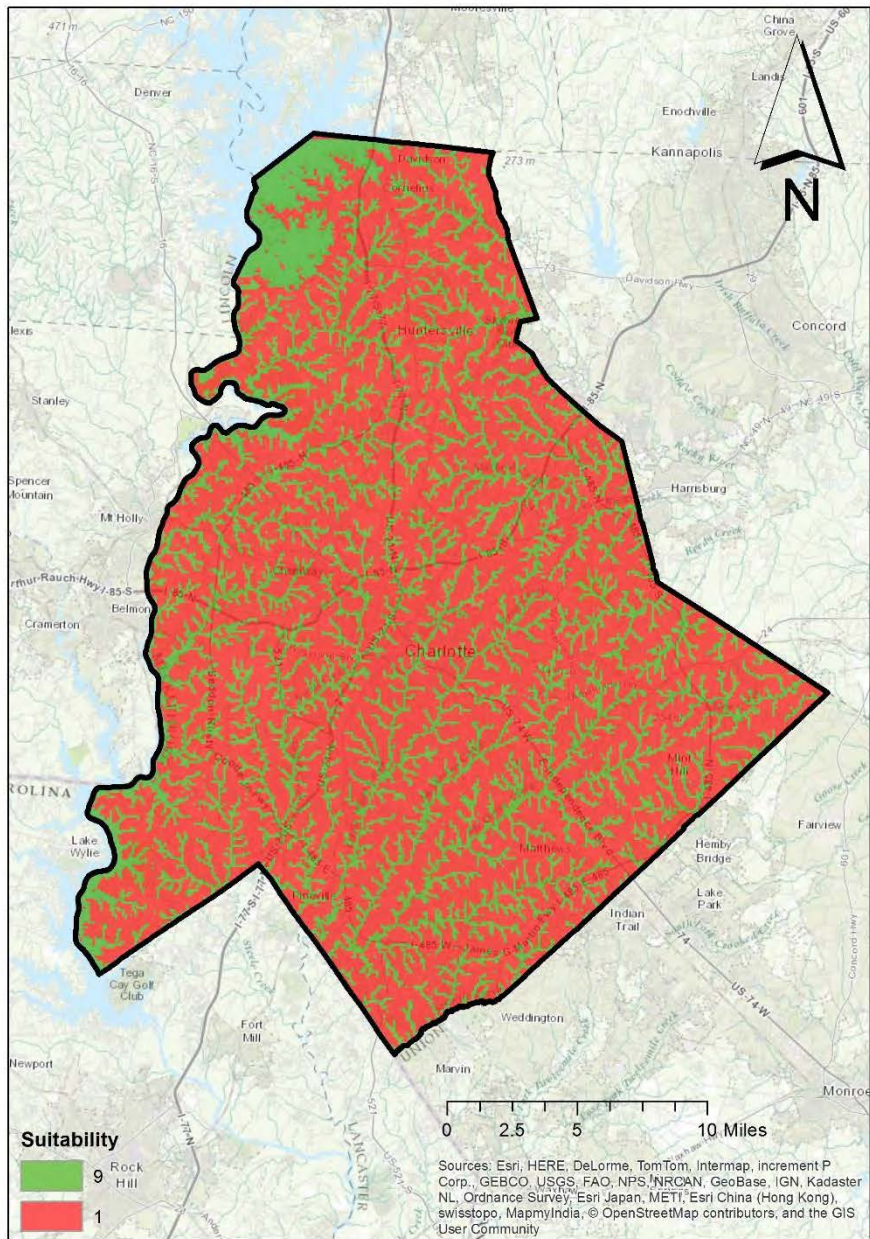


Figure 91: CG3

Land use: Conservation**Goal 4:** Identify lands suitable for resource-based recreation**Objective 4.1:** Identify existing areas used for resource-based recreation**Sub-objective 4.1.1:** Identify existing resource-based parks and recreation areas**Input:** Parks**Rationale:** All existing resource-based parks and recreation areas should be protected.**Output:** Existing Recreation Areas SUA (CG4O41SO411)**Criteria for Utility Assignment:** Existing Resource-based Parks and Recreation Areas were converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to all park land; all other land was assigned a 1.*Table 35: Identify existing resource-based parks and recreation areas sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Existing Resource-based Parks and Recreation Areas</i>	9
<i>All Other Land</i>	1

CG4041SO411

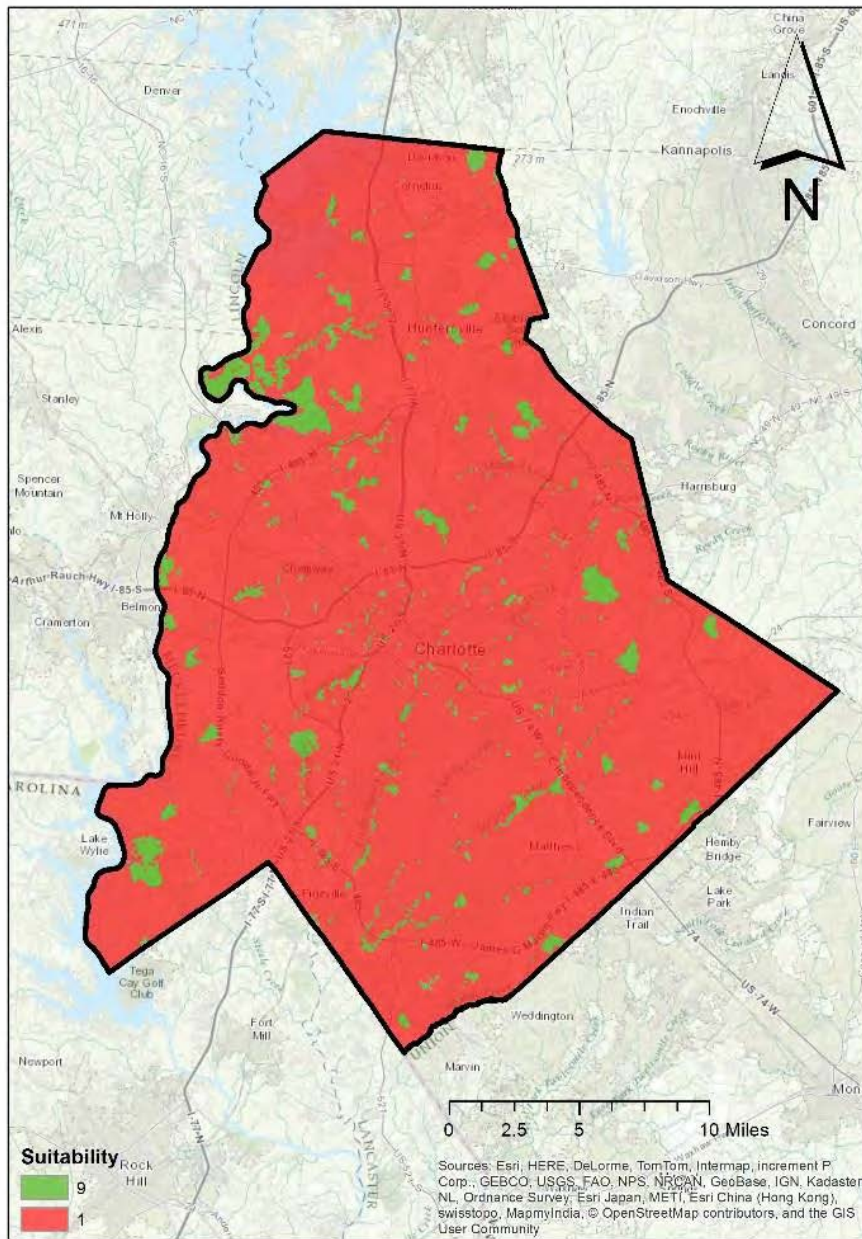


Figure 92: CG4041SO411

Land use: Conservation**Goal 4:** Identify lands suitable for resource-based recreation**Objective 4.1:** Identify existing areas used for resource-based recreation**Sub-objective 4.1.2:** Identify existing and potential trail corridors**Input:** Trails**Rationale:** Protection of existing and proposed trail corridors is of high priority.**Output:** Trail Corridors SUA (CG4O41SO412)**Criteria for Utility Assignment:** Existing trails were converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to trail land; all other land was assigned a 1.*Table 36: Identify existing and potential trail corridors sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Existing trails</i>	9
<i>All Other Land</i>	1

CG4041SO412

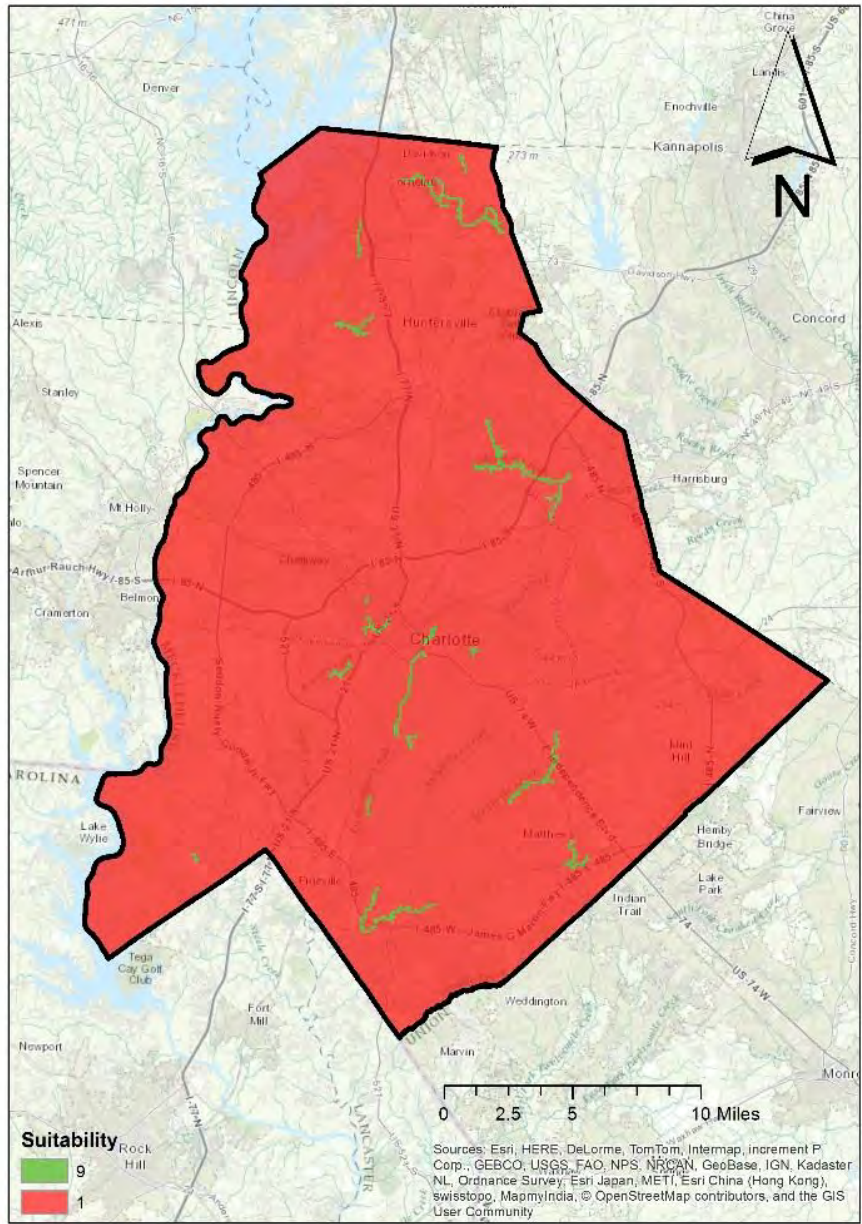


Figure 93: CG4041SO412

Land use: Conservation

Goal 4: Identify lands suitable for resource-based recreation

Objective 4.1: Identify existing areas used for resource-based recreation

Input: Existing Recreation Areas SUA (CG4O41SO411), Trail Corridors SUA (CG4O41SO412)

Rationale: These features have the potential to contribute to recreation.

Output: Existing Recreation Features MUA (CG4O41)

Criteria for Utility Assignment: The input SUAs were combined using a conditional statement such that if a cell had a value of 9 from any of the input SUAs, it was assigned a value of 9; otherwise it was assigned a value of 1.

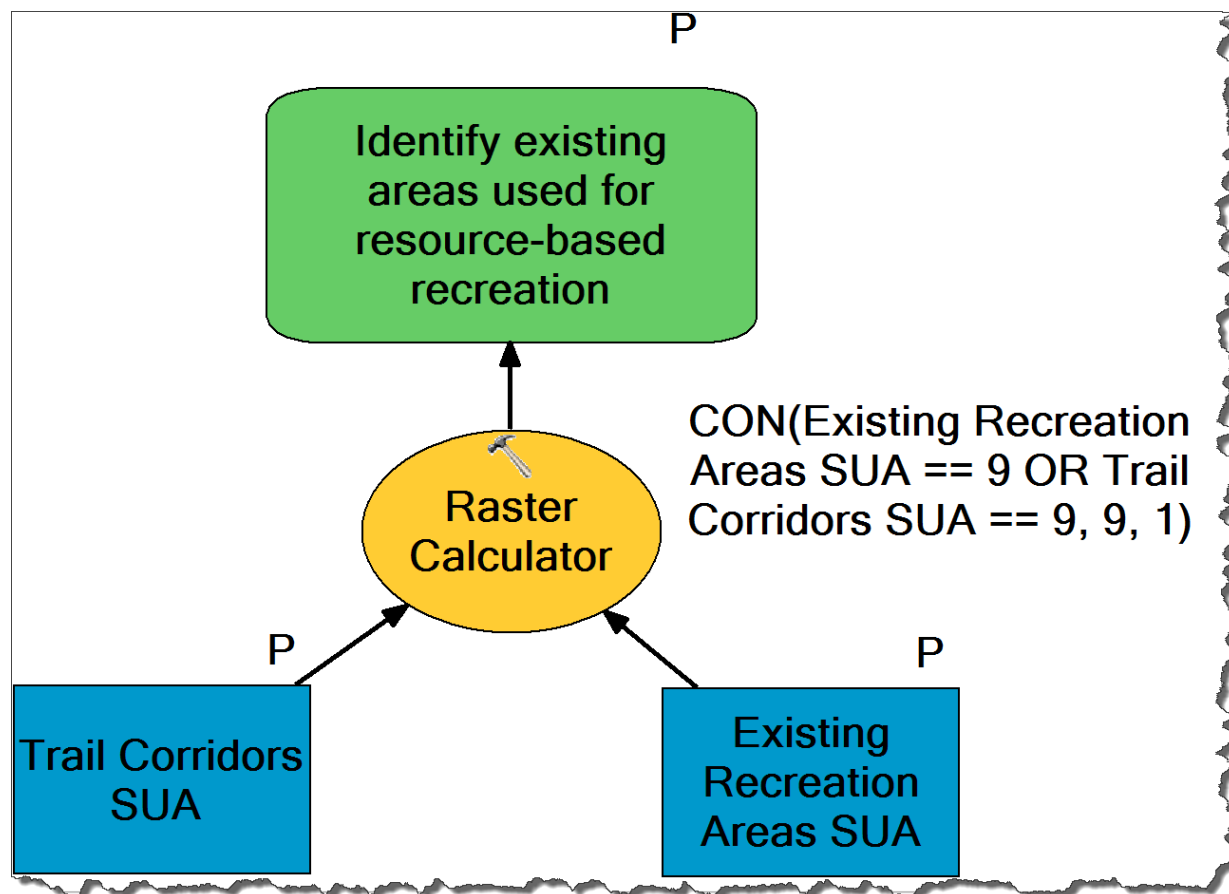


Figure 94: Identify existing areas used for resource-based recreation model

CG4041

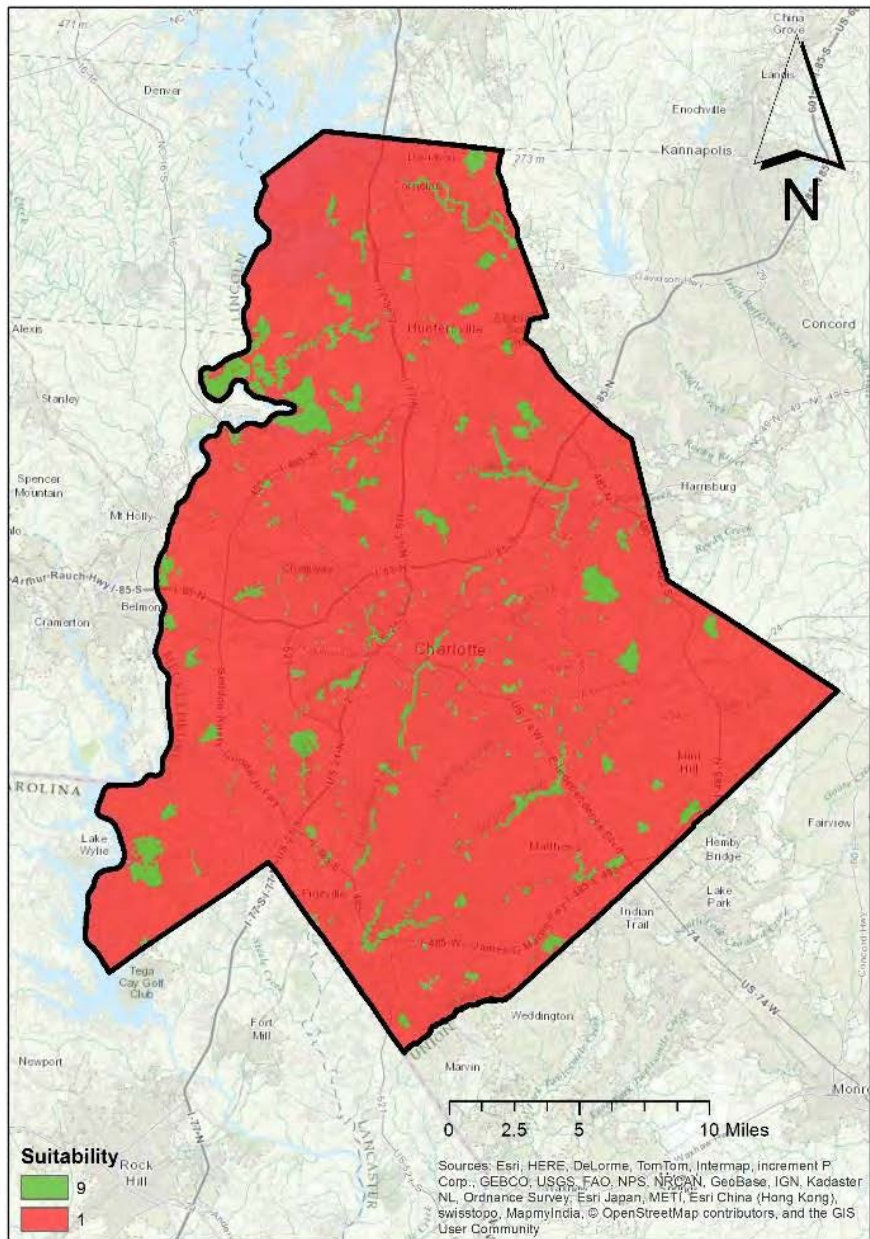


Figure 95: CG4041

Land use: Conservation

Goal 4: Identify lands suitable for resource-based recreation

Objective 4.2: Identify all surface water features with the potential for use for outdoor recreation

Input: Rivers, Streams, Lakes, and Ponds

Rationale: Rivers, streams, lakes, and ponds are important locations for recreation and protection.

Output: Open Water Recreation SUA (CG4O42)

Criteria for Utility Assignment: Rivers, streams, lakes, and ponds were converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to rivers, streams, lakes, and ponds; all other land was assigned a 1.

Table 37: Identify all surface water features with the potential for use for outdoor recreation objective data ranges and UA values

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Rivers, streams, lakes, and ponds</i>	9
<i>All Other Land</i>	1

CG4042

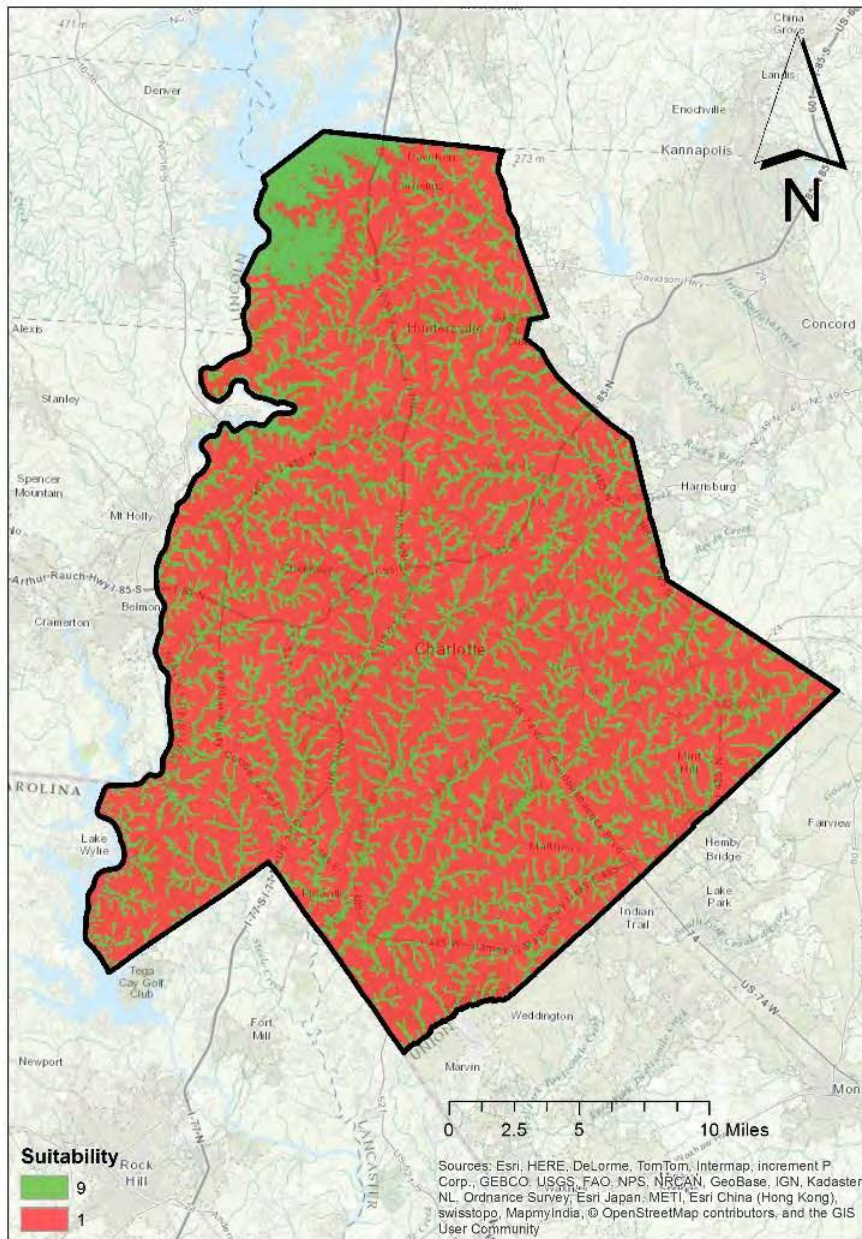


Figure 96: CG4042

Land use: Conservation**Goal 4:** Identify lands suitable for resource-based recreation**Objective 4.3:** Identify railroad corridors for potential use as trail corridors**Input:** Railroads**Rationale:** Railroad corridors have the potential to become trail corridors.**Output:** Railroad Corridors MUA (CG4O43)**Criteria for Utility Assignment:** Railroads were converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to railroad corridor land; all other land was assigned a 1.*Table 38: Identify railroad corridors for potential use as trail corridors objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Railroad Corridors</i>	9
<i>All Other Land</i>	1

CG4O43

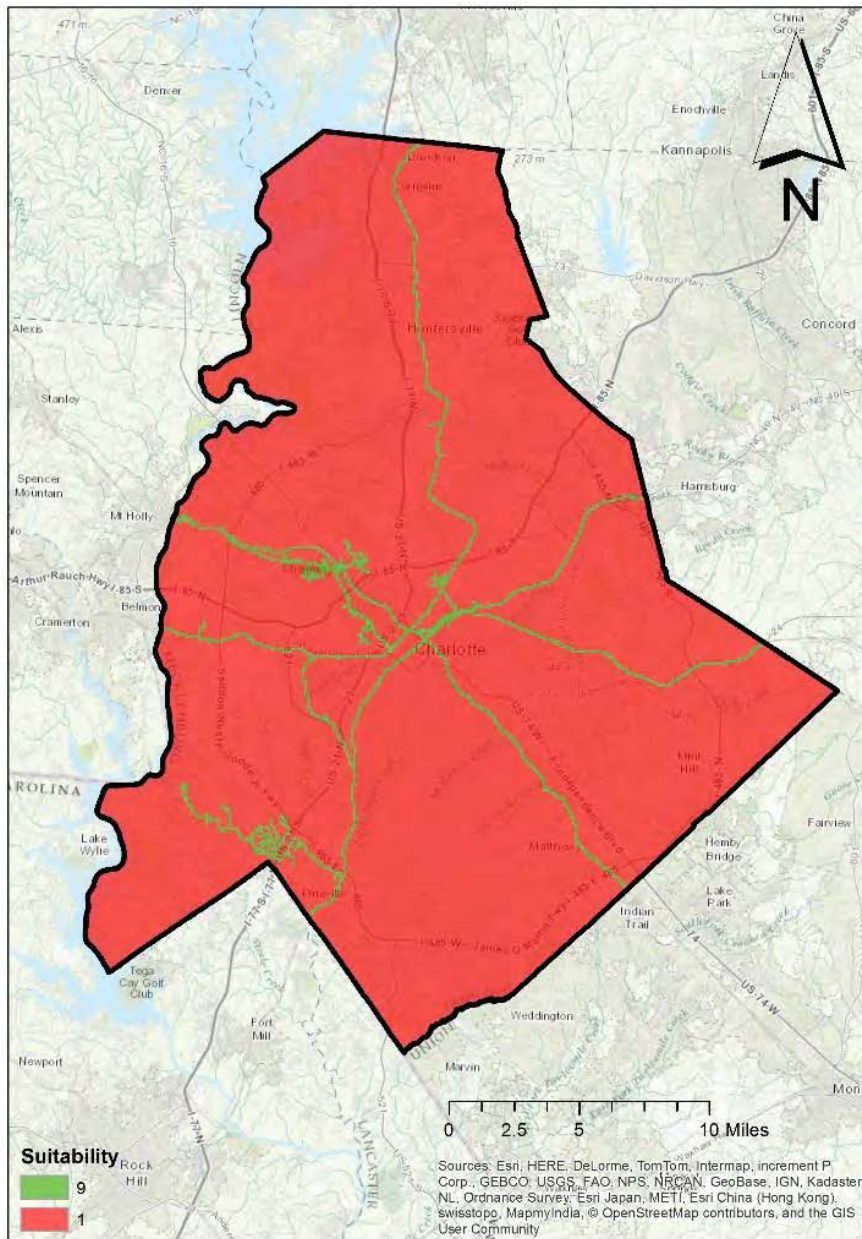


Figure 97: CG4O43

Land use: Conservation

Goal 4: Identify lands suitable for resource-based recreation

Input data layers: Existing Recreation Features MUA (CG4O41), Open Water Recreation SUA (CG4O42), Railroad Corridors MUA (CG4O43)

Rationale: If an input was highly suitable, then it is inherited.

Output: Recreation Suitability MUA (CG4)

Criteria for Utility Assignment: The input MUAs were combined using a conditional statement within the Raster Calculator tool. Where the existing recreation feature values were 9, or the open water recreation values were 9, or the railroad corridor values were 9, the resulting cells were designated a suitability value of 9; otherwise all other land was designated a 1.

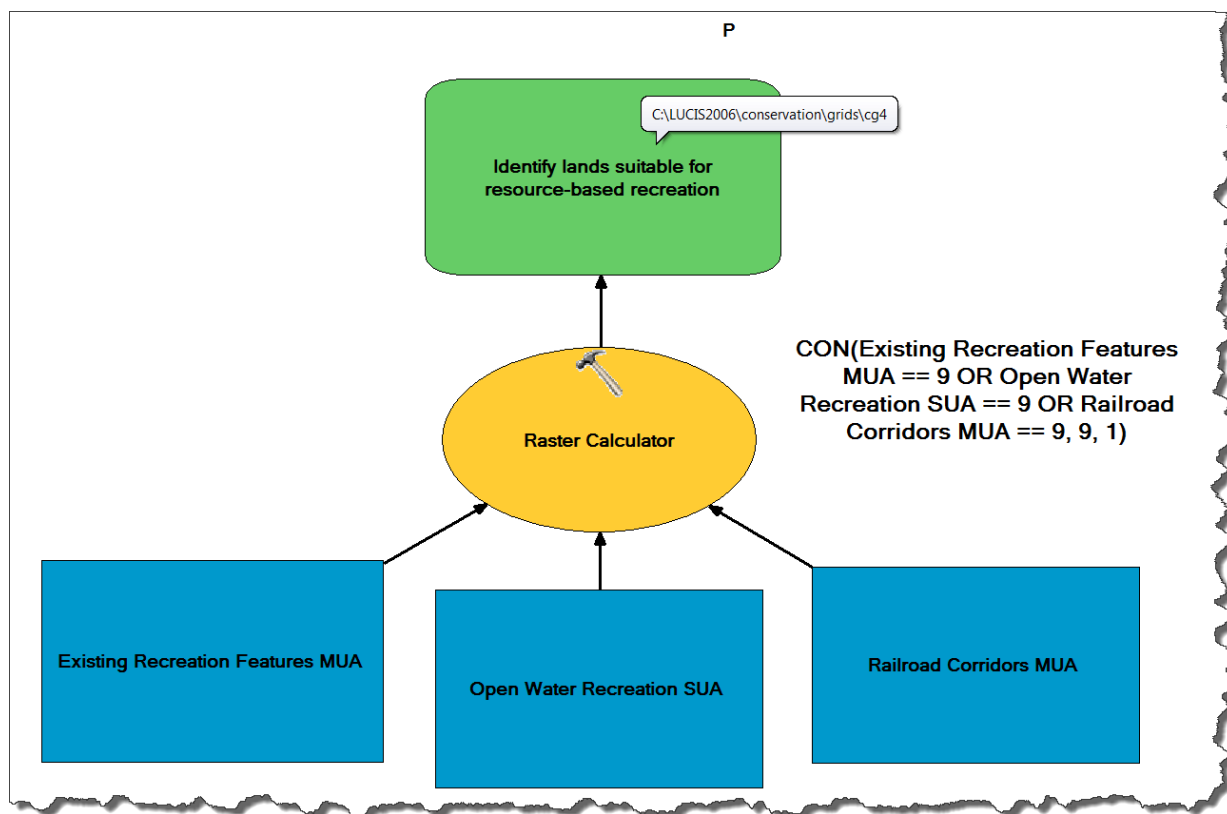


Figure 98: Identify lands suitable for resource-based recreation model

CG4

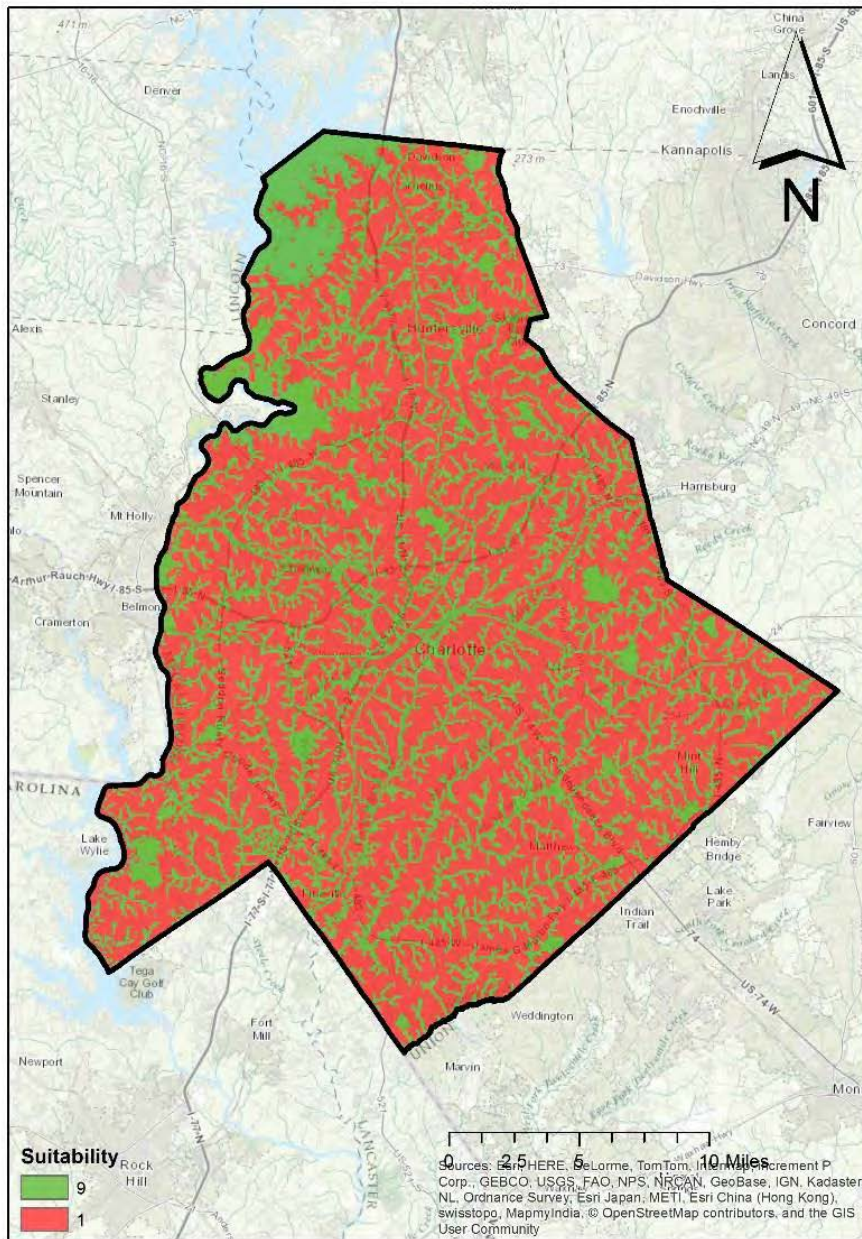


Figure 99: CG4

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.1:** Determine lands physically suitable for residential land use**Sub-objective 1.1.2:** Identify lands free of flood potential**Input:** 100 Year Floodplain**Rationale:** Building within wetlands or open water is costly and risky.**Output:** Flood Construction Suitability SUA (UG1O11SO112)**Criteria for Utility Assignment:** The 100 year floodplain was converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to land outside of the floodplain and 1 to land within the floodplain.*Table 39: Identify lands free of flood potential sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Lands free of a floodplain</i>	9
<i>Land within a floodplain</i>	1

UG1011S0112

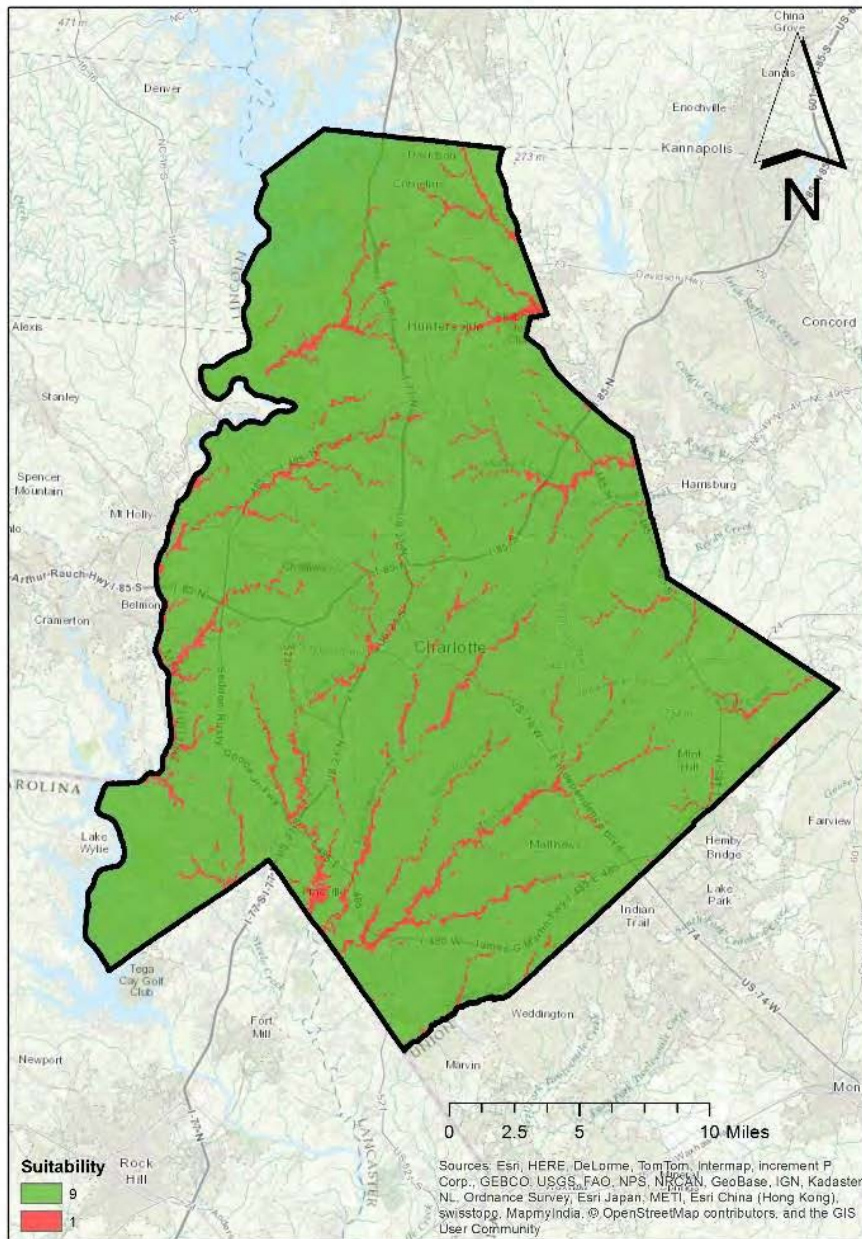


Figure 100: UG1011S0112

Land use: Urban

Goal 1: Identify lands suitable for residential land use

Objective 1.1: Determine lands physically suitable for residential land use

Sub-objective 1.1.3: Identify quiet areas

Input: Major Roads, Airports, Railroads

Rationale: Quiet is beneficial to residential developments.

Output: Residential Quiet MUA (UG1O11SO113)

Criteria for Utility Assignment: Euclidean distance was run from major roads, airports, and railroads. Euclidean distance from major roads was reclassified using the Reclassify tool to designate land 0–200 meters away from major roads a value of 1, 200–350 meters a value of 2, and all remaining distances a value of 9. Euclidean distance from airports was reclassified using the Reclassify tool in 1,000 meter increments with the closest increment being designated a value of 1 and all other increments beyond 8,000 meters designated a value of 9. Euclidean distance from railroads was reclassified using the Reclassify tool to designated land 0–500 meters from railroads a value of 1, 500–1,000 meters a value of 6, and all other lands was designated a value of 9. The resulting SUAs were combined and weighted using the Raster Calculator tool.

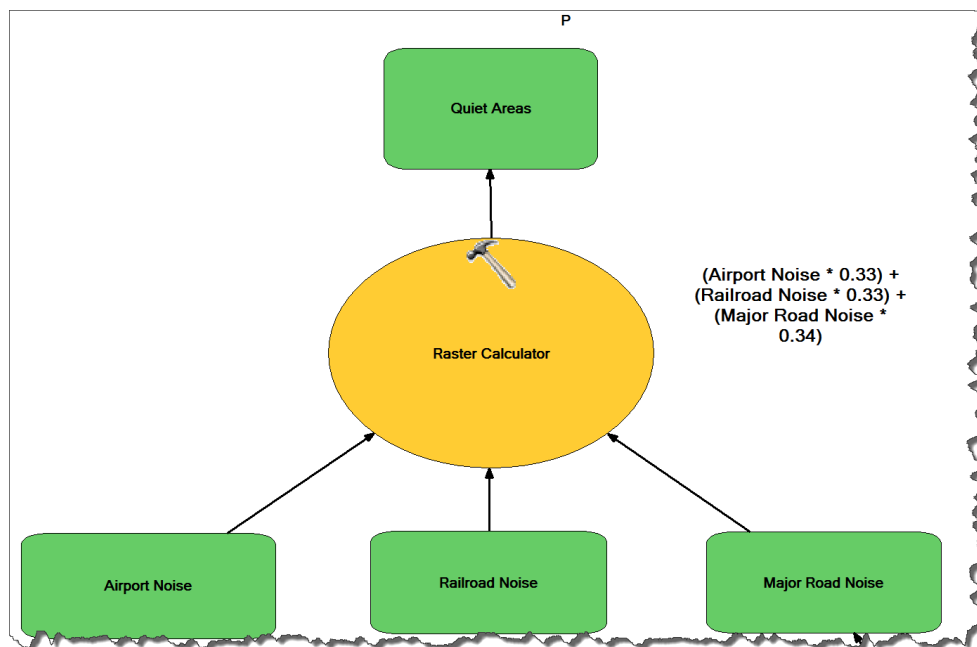


Figure 101: Identify quiet areas model

UG1011SO113

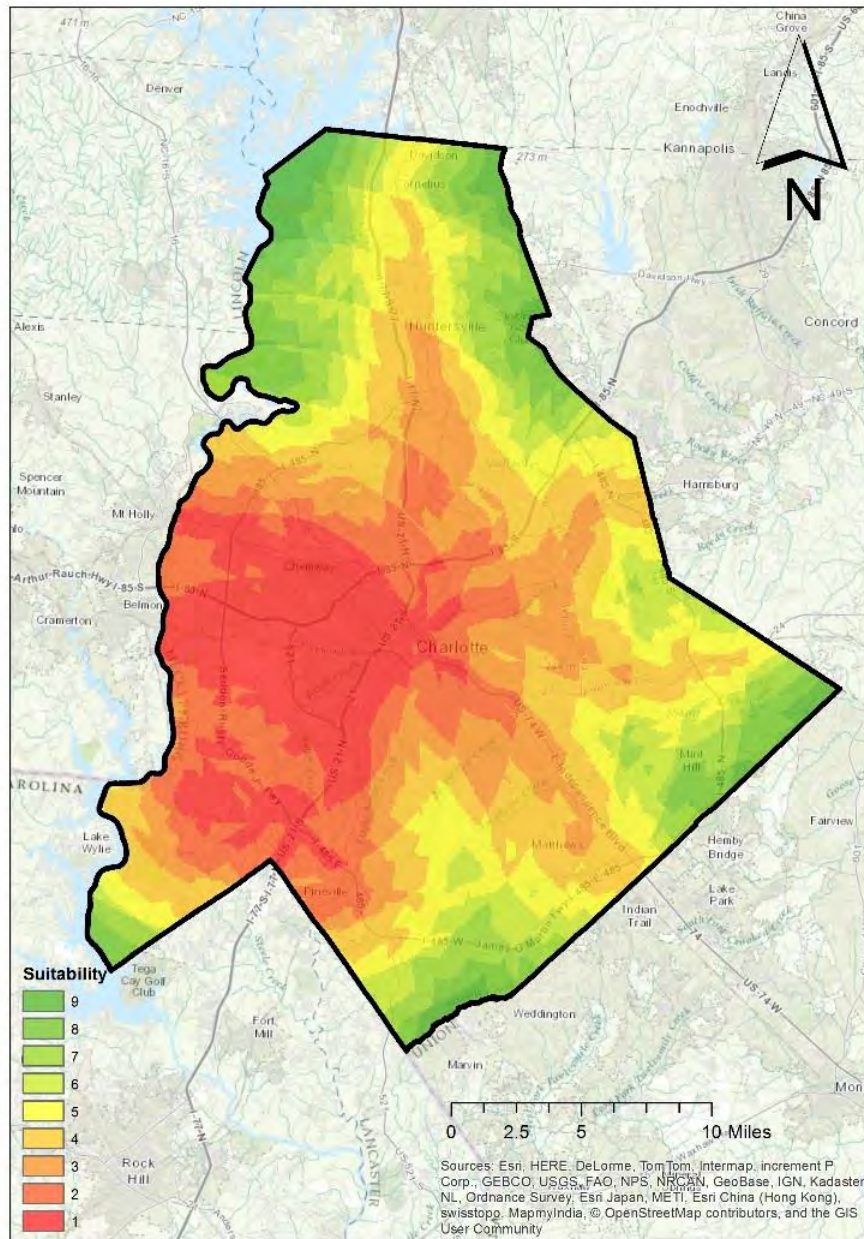


Figure 102: UG1011SO113

Land use: Urban

Goal 1: Identify lands suitable for residential land use

Objective 1.1: Determine lands physically suitable for residential land use

Input: Flood Construction Suitability SUA (UG1O11SO112), Residential Quiet MUA (UG1O11SO113)

Rationale for value assignment: Areas physically suitable for residential development are quiet. Flooding was considered critical to determining physical suitability because of increased insurance costs.

Output: Residential Physical Suitability MUA (UG1O11)

Criteria for Utility Assignment: The input SUAs and MUAs were weighted and combined using the Raster Calculator.

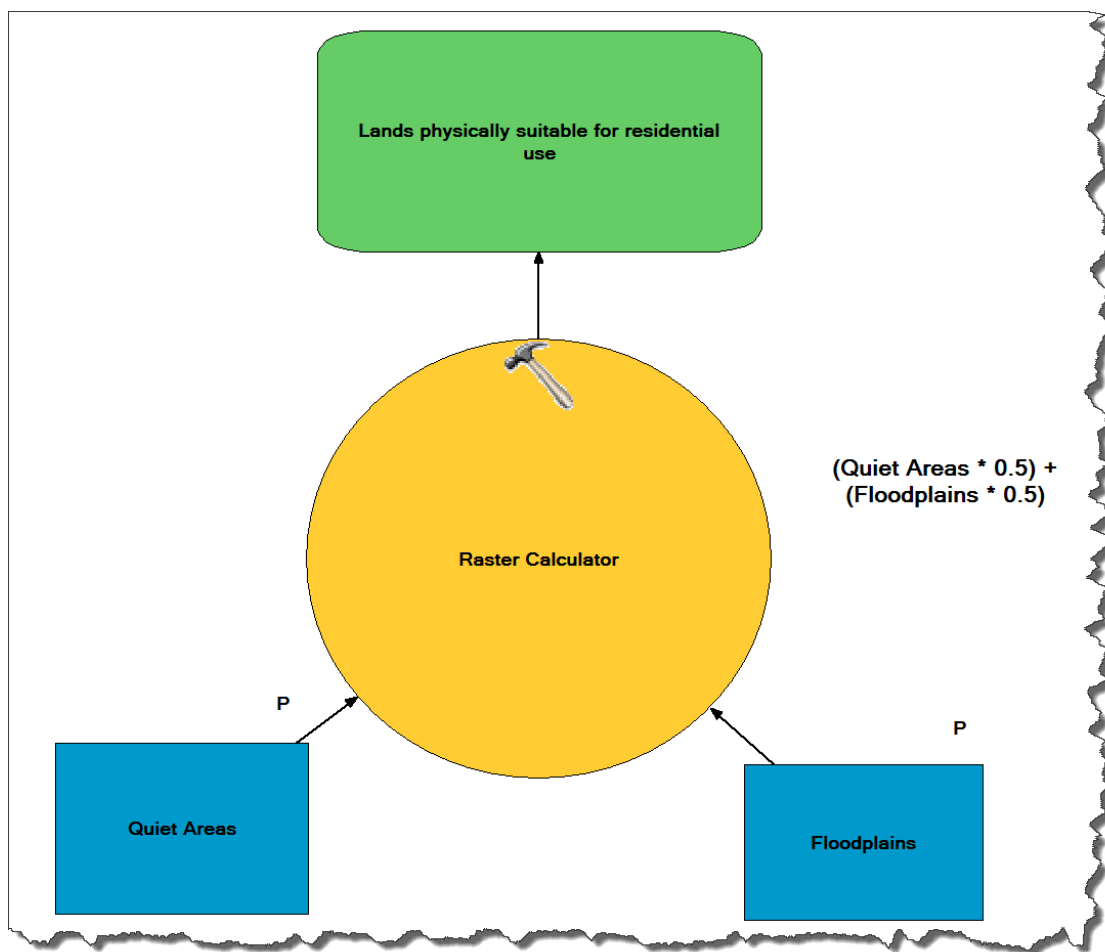


Figure 103: Determine lands physically suitable for residential land use model

UG1011

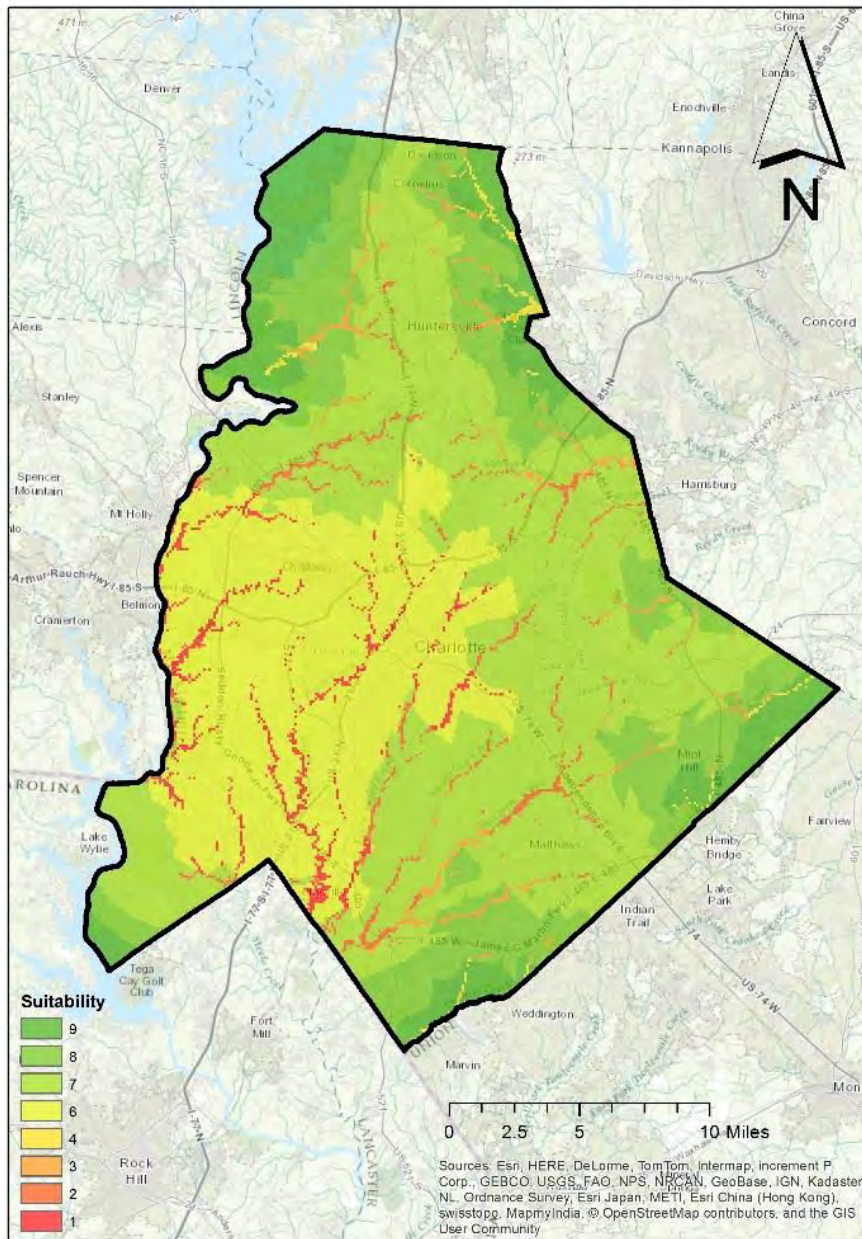


Figure 104: UG1011

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.2:** Determine lands economically suitable for residential land use**Sub-objective 1.2.1:** Identify lands proximal to existing residential development**Input:** Existing Residential Land (Parcels)**Rationale:** People prefer to live near one another.**Output:** Residential Proximity to Residential SUA (UG1O12SO121)

Criteria for Utility Assignment: Euclidean distance was run from existing residential parcels. The resulting Euclidean distance results were reclassified using the Reclassify tool to designate all land within 495 feet of current residential land a value of 9, and all land beyond 496 feet were designated a value of 1.

Table 40: Identify lands proximal to existing residential development sub-objective data ranges and UA values

<i>Data Range (feet)</i>	<i>Utility Assignment</i>
<i>0-495</i>	<i>9</i>
<i>496-All other land</i>	<i>1</i>

UG1012S0121

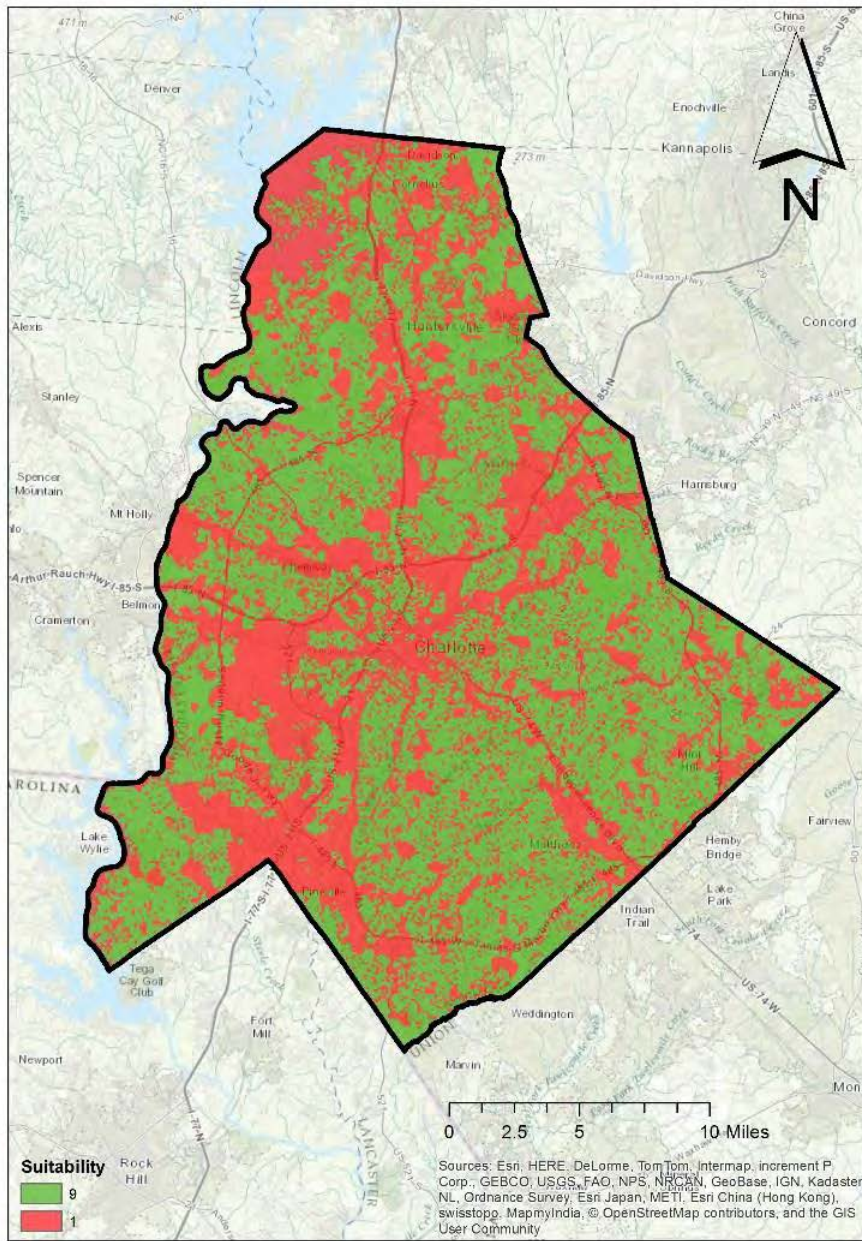


Figure 105: UG1012S0121

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.2:** Determine lands economically suitable for residential land use**Sub-objective 1.2.2:** Identify lands proximal to schools**Input:** Schools**Rationale:** People prefer to live near schools.**Output:** Residential Proximity to Schools SUA (UG1O12SO122)

Criteria for Utility Assignment: Euclidean distance was run on schools and then zonal statistics were run on the Euclidean distance results to determine the mean distance of existing residential parcels from schools and the standard deviation. Land with values of 0 to the mean were designated a value of 9. The remaining lands were designated values 8–2 in standard-deviation intervals. The remaining land was designated a value of 1.

Table 41: Identify lands proximal to schools sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 4860</i>	<i>9</i>
<i>4861 – 8443</i>	<i>8</i>
<i>8444 – 12,026</i>	<i>7</i>
<i>12,027 – 15,609</i>	<i>6</i>
<i>15,610 – 19,192</i>	<i>5</i>
<i>19,193 – 22,775</i>	<i>4</i>
<i>22,776 – 26,358</i>	<i>3</i>
<i>26,359 – 29,941</i>	<i>2</i>
<i>29,942 – all remaining</i>	<i>1</i>

UG1012S0122

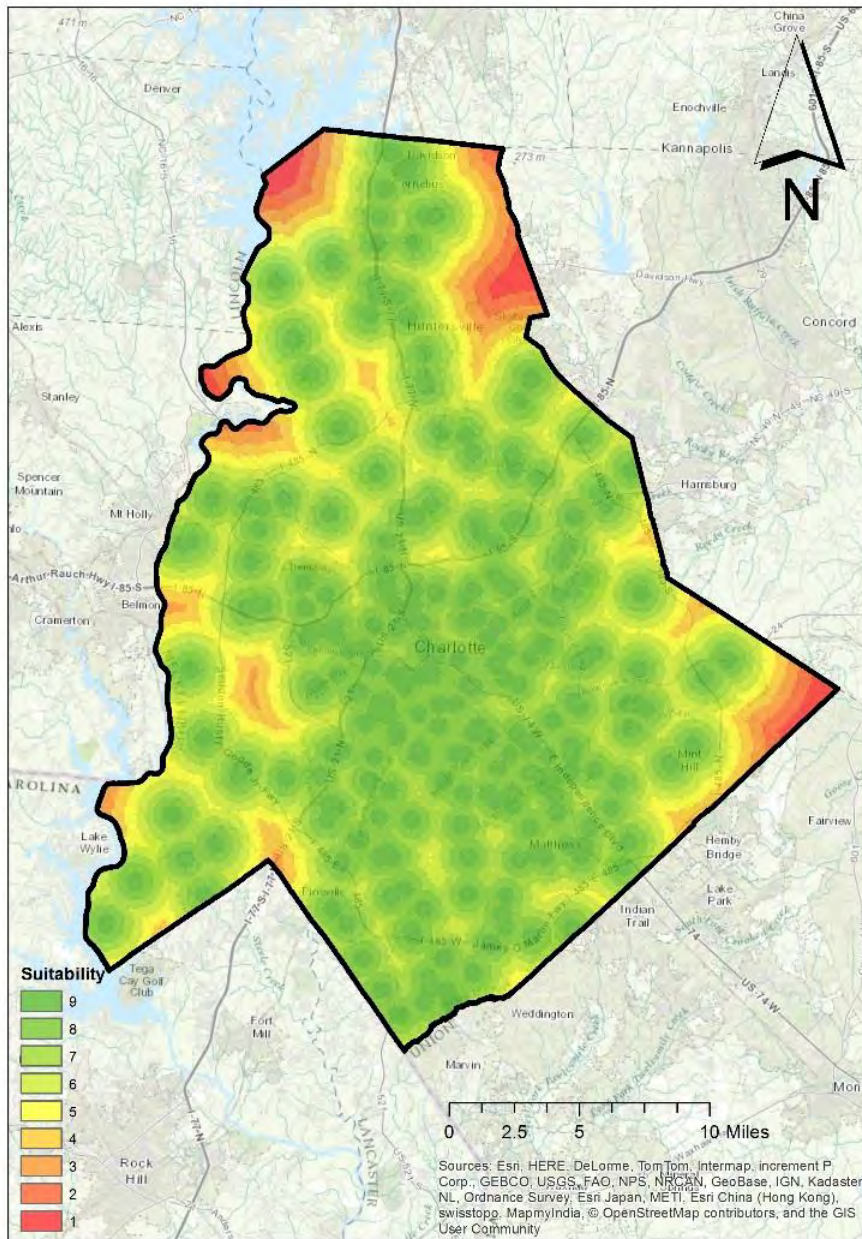


Figure 106: UG1012S0122

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.2:** Determine lands economically suitable for residential land use**Sub-objective 1.2.3:** Identify lands proximal to hospitals**Input:** Hospitals**Rationale:** People prefer to live near hospitals.**Output:** Residential Proximity to Hospitals SUA (UG1O12SO123)

Criteria for Utility Assignment: Euclidean distance was run on hospitals and then zonal statistics were run to determine the mean distance of existing residential parcels from hospitals and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 42: Identify lands proximal to hospitals sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 13,614</i>	<i>9</i>
<i>13,615 – 15,840</i>	<i>8</i>
<i>15,841 – 18,066</i>	<i>7</i>
<i>18,067 – 20,292</i>	<i>6</i>
<i>20,293 – 22,518</i>	<i>5</i>
<i>22,519 – 24,744</i>	<i>4</i>
<i>24,745 – 26,970</i>	<i>3</i>
<i>26,971 – 29,196</i>	<i>2</i>
<i>29,197 – all remaining</i>	<i>1</i>

UG1012S0123

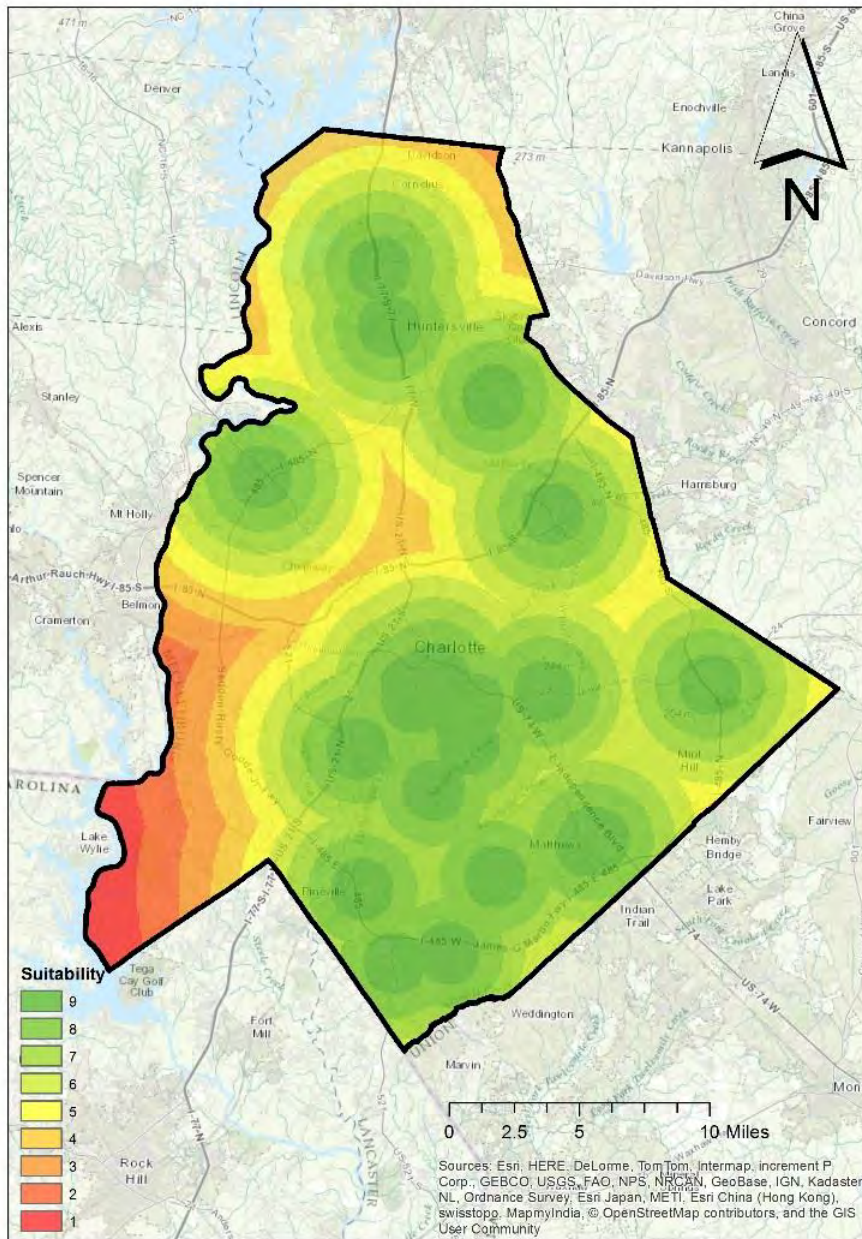


Figure 107: UG1012S0123

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.2:** Determine lands economically suitable for residential land use**Sub-objective 1.2.4:** Identify lands proximal to roads**Input:** Major Roads**Rationale:** It is convenient to be close to major roads.**Output:** Residential Proximity to Major Roads SUA (UG1O12SO124)

Criteria for Utility Assignment: Euclidean distance was run on major roads and then zonal statistics were run to determine the mean distance of existing residential parcels from major roads and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 43: Identify lands proximal to roads sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 3875	9
3876 – 7515	8
7516 – 11,155	7
11,156 – 14,795	6
14,796 – 18,435	5
18,436 – 22,075	4
22,076 – 25,715	3
25,716 – 29,355	2
29,356 – all remaining	1

UG1012S0124

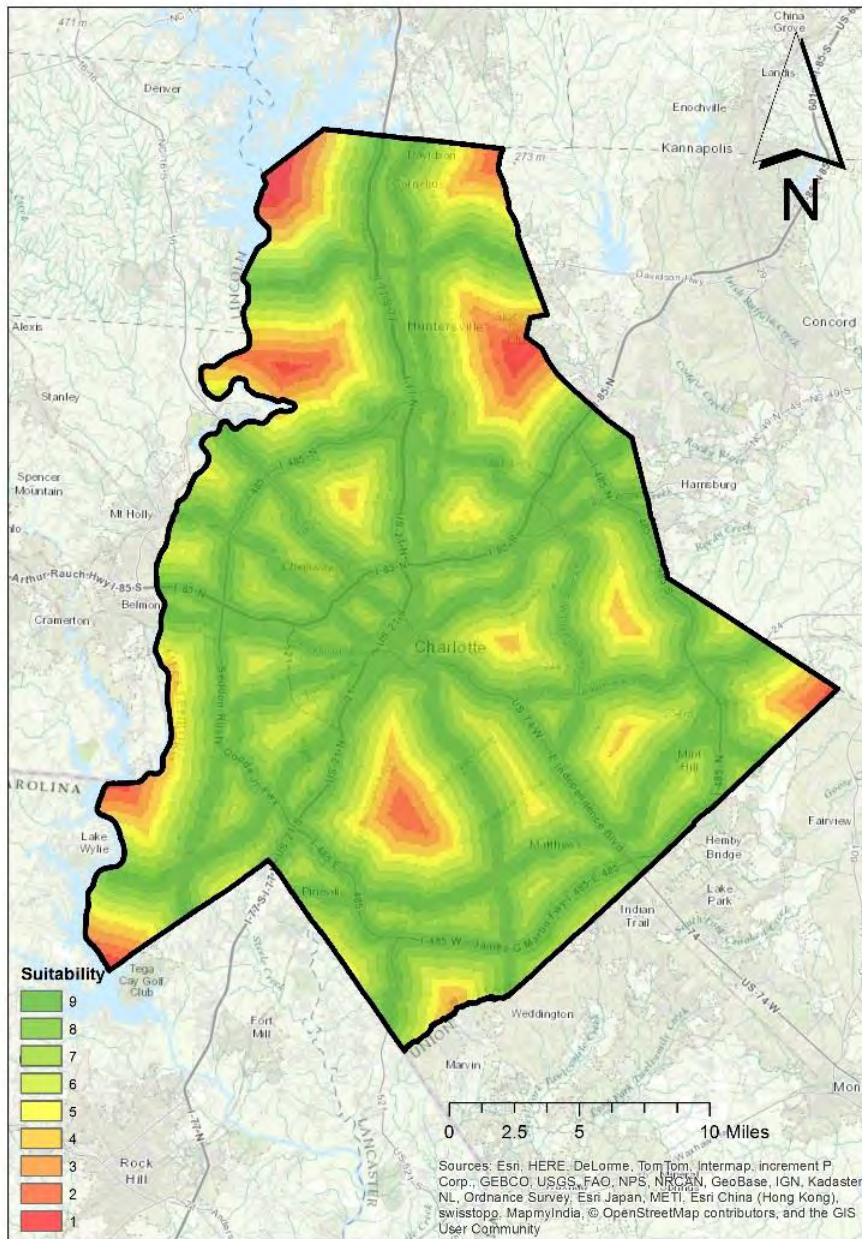


Figure 108: UG1012S0124

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.2:** Determine lands economically suitable for residential land use**Sub-objective 1.2.5:** Identify lands proximal to airports**Input:** Airport**Rationale:** It is convenient to be close to regional airports.**Output:** Residential Proximity to Airports SUA (UG1O12SO125)**Criteria for Utility Assignment:** Euclidean distance was run on the airport. The results were then reclassified using the Reclassify tool at natural breaks, with the closest interval to the airport being designated a value of 9 and the furthest a value of 1.*Table 44: Identify lands proximal to airports sub-objective data ranges and UA values*

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 11,321</i>	9
<i>11,322 – 22,643</i>	8
<i>22,644 – 33,964</i>	7
<i>33,965 – 45,286</i>	6
<i>45,287 – 56,608</i>	5
<i>56,609 – 67,929</i>	4
<i>67,930 – 79,251</i>	3
<i>79,252 – 90,573</i>	2
<i>90,573 – all remaining</i>	1

UG1012S0125

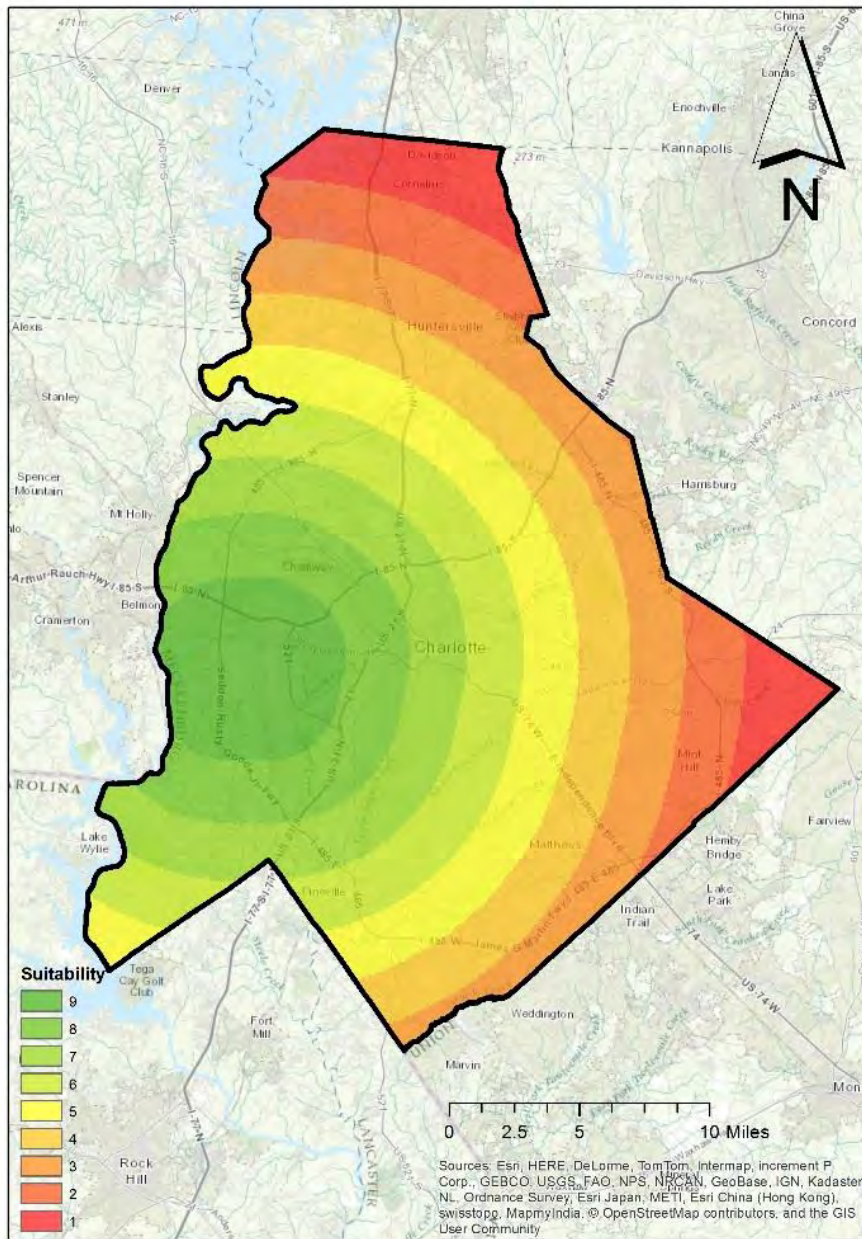


Figure 109: UG1012S0125

Land use: Urban**Goal 1:** Identify lands suitable for residential land use**Objective 1.2:** Determine lands economically suitable for residential land use**Sub-objective 1.2.6:** Identify lands proximal to parks and historic sites**Input:** Parks and Historic Sites**Rationale:** People like to live near parks and historic sites.**Output:** Residential Proximity to Parks/Cultural and Historic Sites SUA (UG1O12SO126)

Criteria for Utility Assignment: Euclidean distance was run on the airport and then zonal statistics were run to determine the mean distance of existing residential parcels from the airport and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 45: Identify lands proximal to parks and historic sites sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 5377	9
5378 – 8907	8
8908 – 12,437	7
12,438 – 15,967	6
15,968 – 19,497	5
19,498 – 23,027	4
23,028 – 26,557	3
26,558 – 30,087	2
30,088 – all remaining	1

UG1012S0126

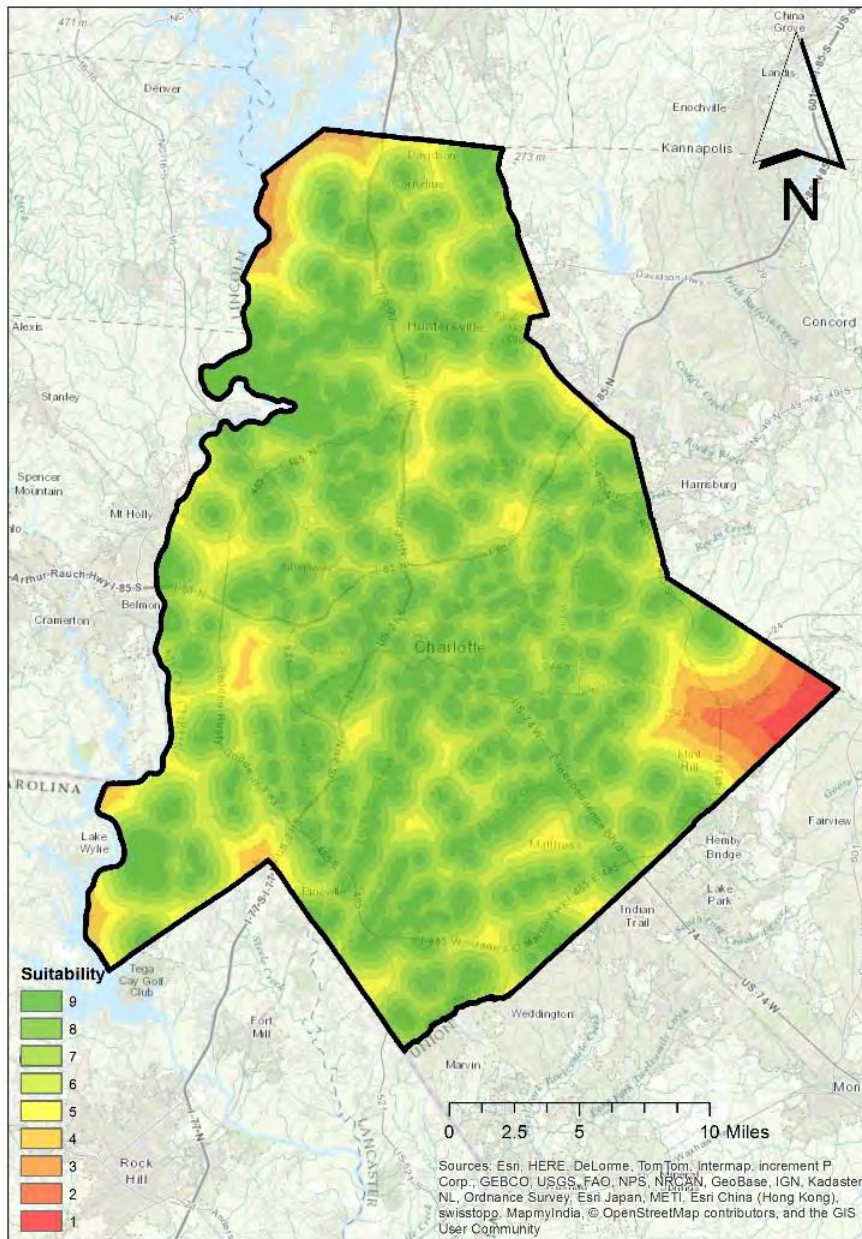


Figure 110: UG1012S0126

Land use: Urban

Goal 1: Identify lands suitable for residential land use

Objective 1.2: Determine lands economically suitable for residential land use

Input: Residential Proximity to Residential SUA (UG1O12SO121), Residential Proximity to Schools SUA (UG1O12SO122), Residential Proximity to Hospitals SUA (UG1O12SO123), Residential Proximity to Major Roads SUA (UG1O12SO124), Residential Proximity to Airports SUA (UG1O12SO125), Residential Proximity to Parks/Cultural & Historic Sites SUA (UG1O12SO126)

Rationale: Areas economically suitable for residential development are close to existing residential areas, schools, hospitals, roads, airports, parks and historic sites.

Output: Residential Economic Suitability MUA (UG1O12)

Criteria for Utility Assignment: The input SUAs were weighted and combined the Raster Calculator tool.

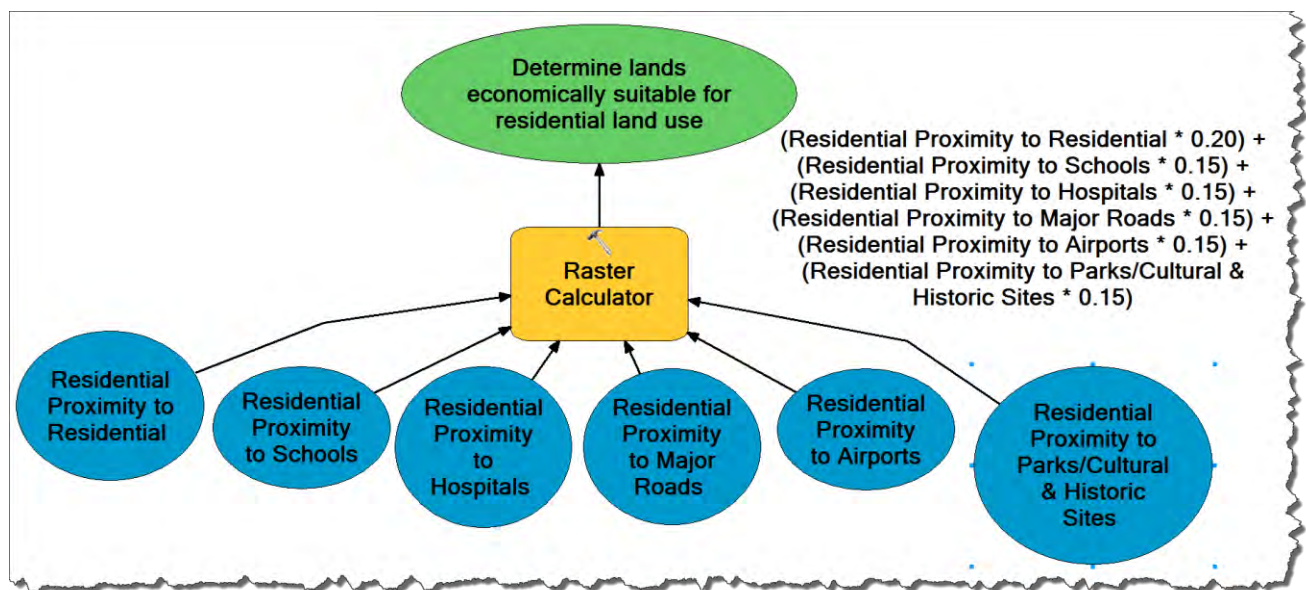


Figure 111: Determine lands economically suitable for residential land use model

UG1012

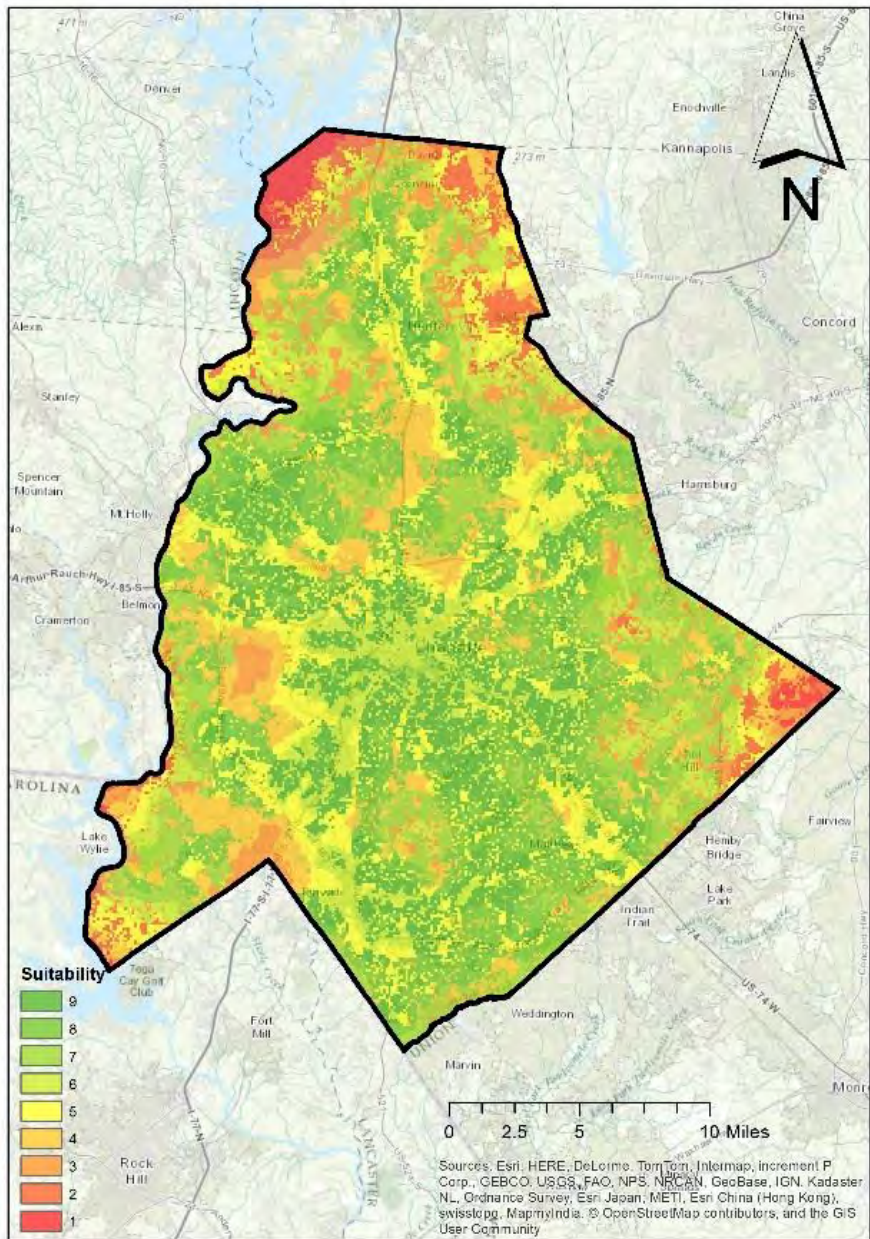


Figure 112: UG1012

Land use: Urban

Goal 1: Identify lands suitable for residential land use

Input: Residential Physical Suitability MUA (UG1O11), Residential Economic Suitability MUA (UG1O12), Existing Residential Areas (Parcels)

Rationale: If an area is currently residential, it is suitable for residential land use. If it is not residential, then its suitability is derived from equally weighted physical and economic suitabilities.

Output: Residential Suitability MUA (UG1)

Criteria for Utility Assignment: The MUAs were combined and weighted equally using the Raster Calculator tool. Existing residential parcels were reclassified using the Reclassify tool to designate a value of 9, and all other areas assigned a value of 1. Then a conditional statement was ensured that all existing residential land retained their value of 9 and that all other land was assigned the weighted value resulting from the Raster Calculator equation.

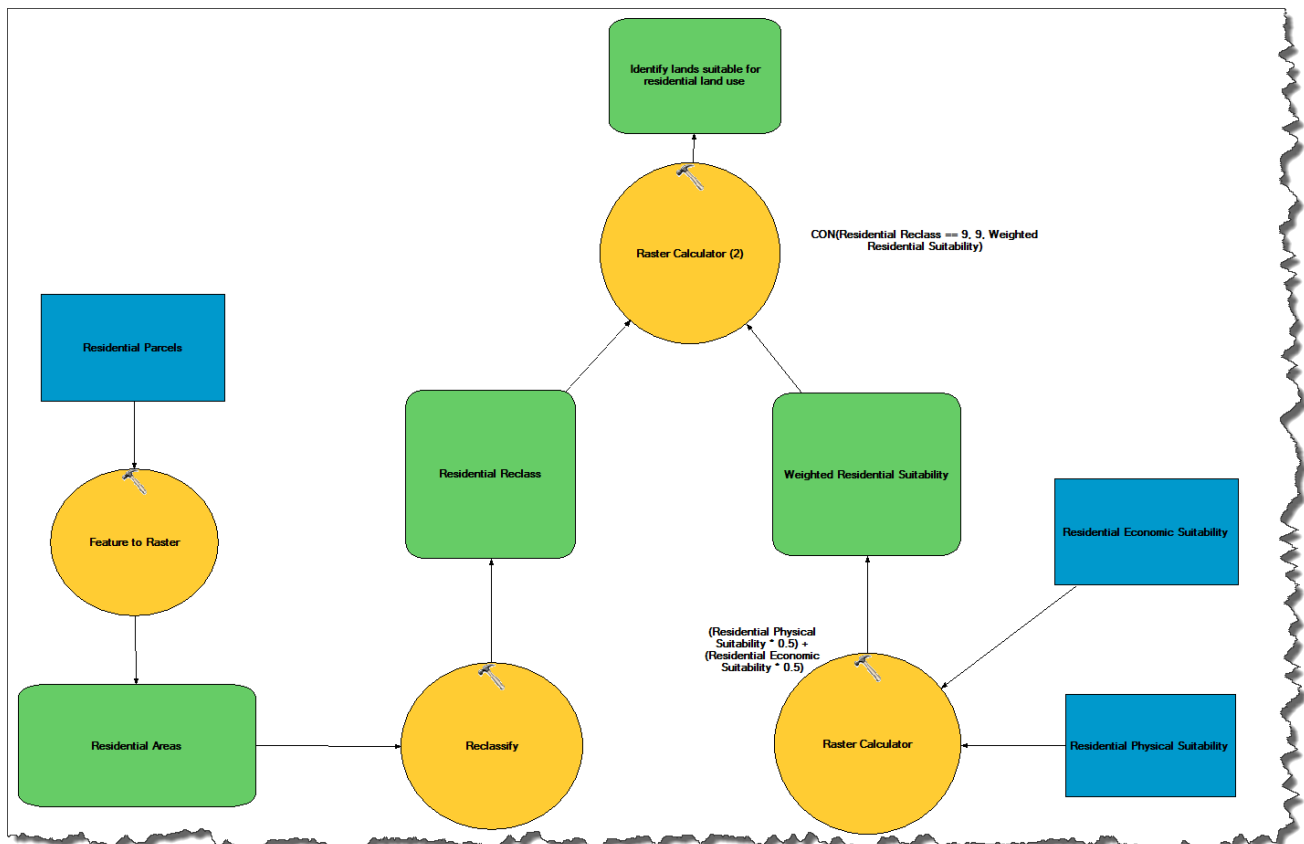


Figure 113: Identify lands suitable for residential land use model

UG1

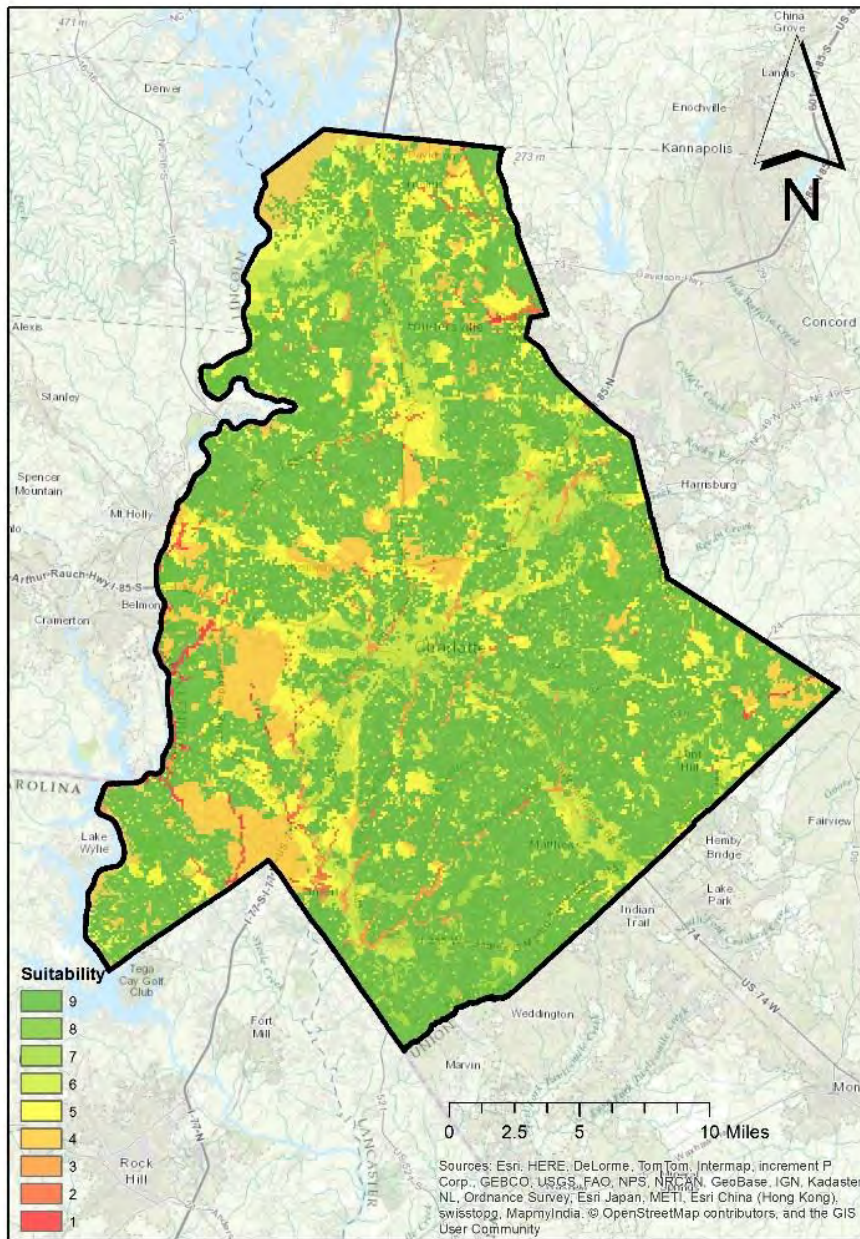


Figure 114: UG1

Land use: Urban**Goal 2:** Identify lands suitable for office/commercial land use**Objective 2.1:** Determine lands physically suitable for office/commercial land use**Sub-objective 2.1.2:** Identify lands free of flood potential**Input:** 100 Year Floodplain**Rationale:** Building within wetlands or open water is costly and risky.**Output:** Flood Construction Suitability SUA (UG2O21SO212)**Criteria for Utility Assignment:** The 100 year floodplain was converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to land outside of the floodplain and 1 to land within the floodplain.*Table 46: Identify lands free of flood potential sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Lands free of a floodplain</i>	9
<i>Land within a floodplain</i>	1

UG2021SO212

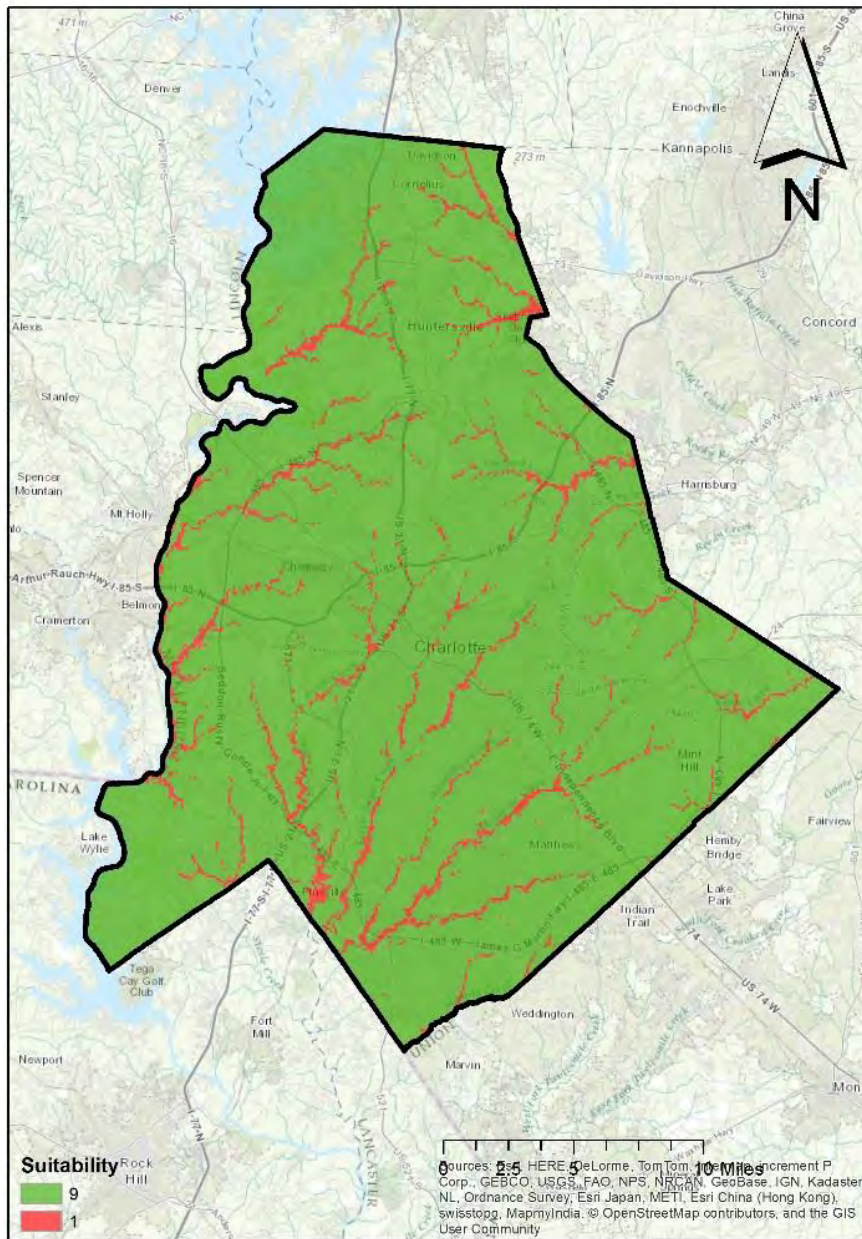


Figure 115: UG2021SO212

Land use: Urban

Goal 2: Identify lands suitable for office/commercial land use

Objective 2.1: Determine lands physically suitable for office/commercial land use

Sub-objective 2.1.3: Identify quiet areas

Input: Major Roads, Airports, Railroads

Rationale: Quiet areas are beneficial to office/commercial developments.

Output: Office/Commercial Quiet SUA (UG2O21SO213)

Criteria for Utility Assignment: Euclidean distance was run from major roads, airports, and railroads. Euclidean distance from major roads was reclassified using the Reclassify tool to designate land 0–200 meters away from major roads a value of 1, 200–350 meters a value of 2, and all remaining distances a value of 9. Euclidean distance from airports was reclassified using the Reclassify tool in 1,000 meter increments with the closest increment being designated a value of 1 and all other increments beyond 8,000 meters designated a value of 9. Euclidean distance from railroads was reclassified using the Reclassify tool to designate land 0–500 meters from railroads a value of 1, 500–1,000 meters a value of 6, and all other lands was designated a value of 9. The resulting SUAs were combined and weighted using the Raster Calculator tool.

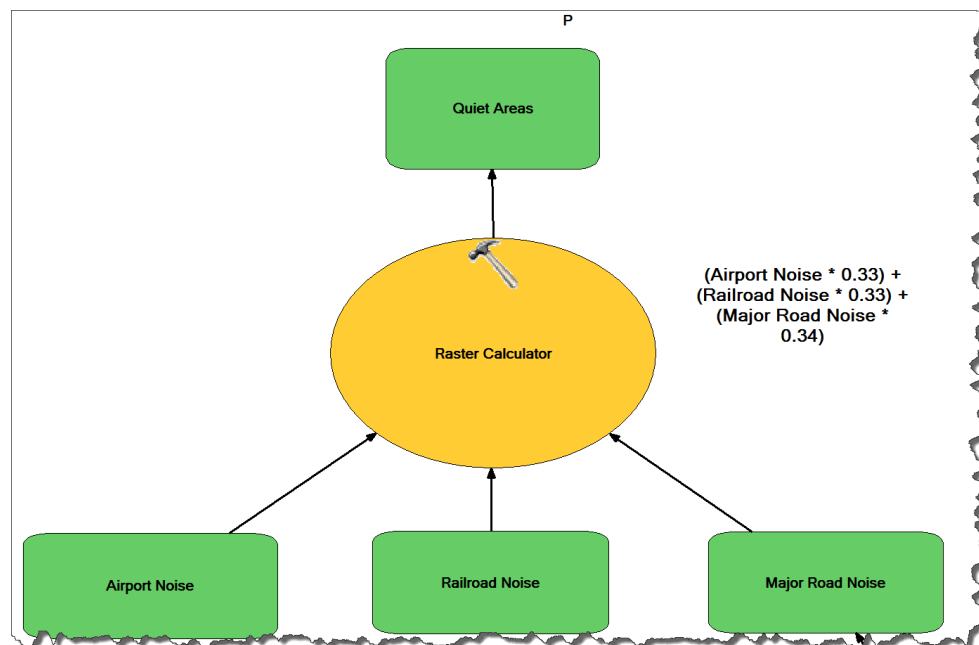


Figure 116: Identify quiet areas model

UG2021SO213

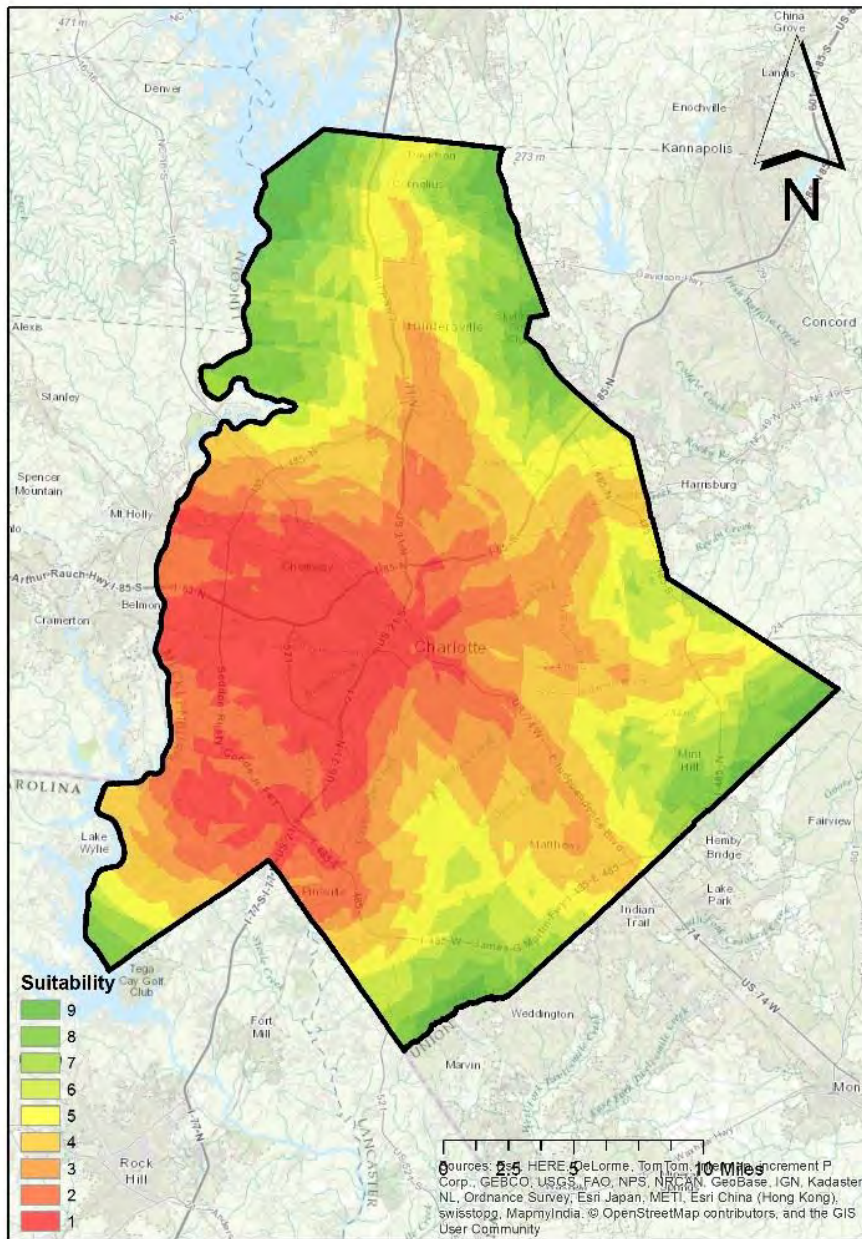


Figure 117: UG2021SO213

Land use: Urban

Goal 2: Identify lands suitable for office/commercial land use

Objective 2.1: Determine lands physically suitable for office/commercial land use

Input: Flood Construction Suitability SUA (UG2021SO212), Office/Commercial Quiet SUA (UG2021SO213)

Rationale: Areas physically suitable for residential development are those that are quiet. Flooding was considered critical to determining physical suitability because of increased building and insurance costs.

Output: Office/Commercial Physical Suitability MUA (UG2021)

Criteria for Utility Assignment: The input SUAs were weighted and combined as follows using the Raster Calculator tool.

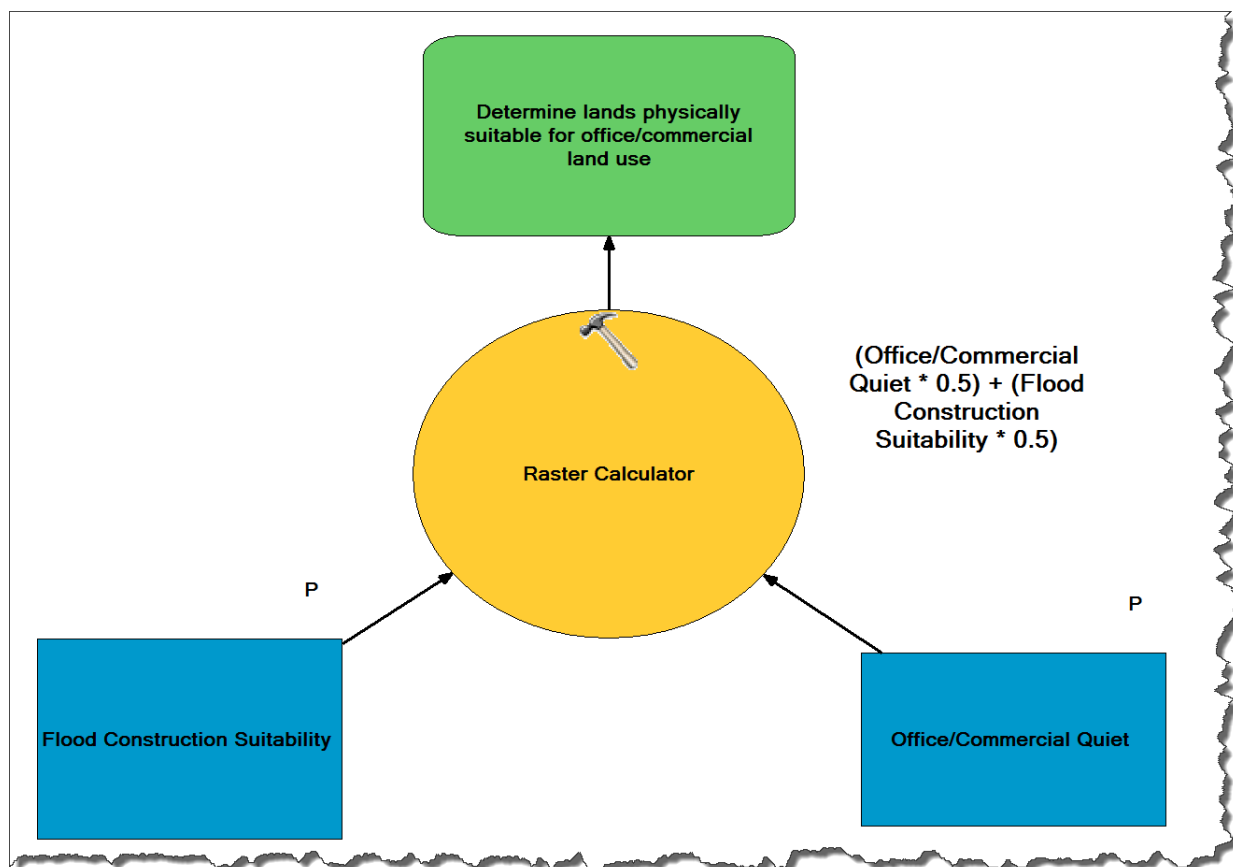


Figure 118: Determine lands physically suitable for office/commercial land use model

UG2021

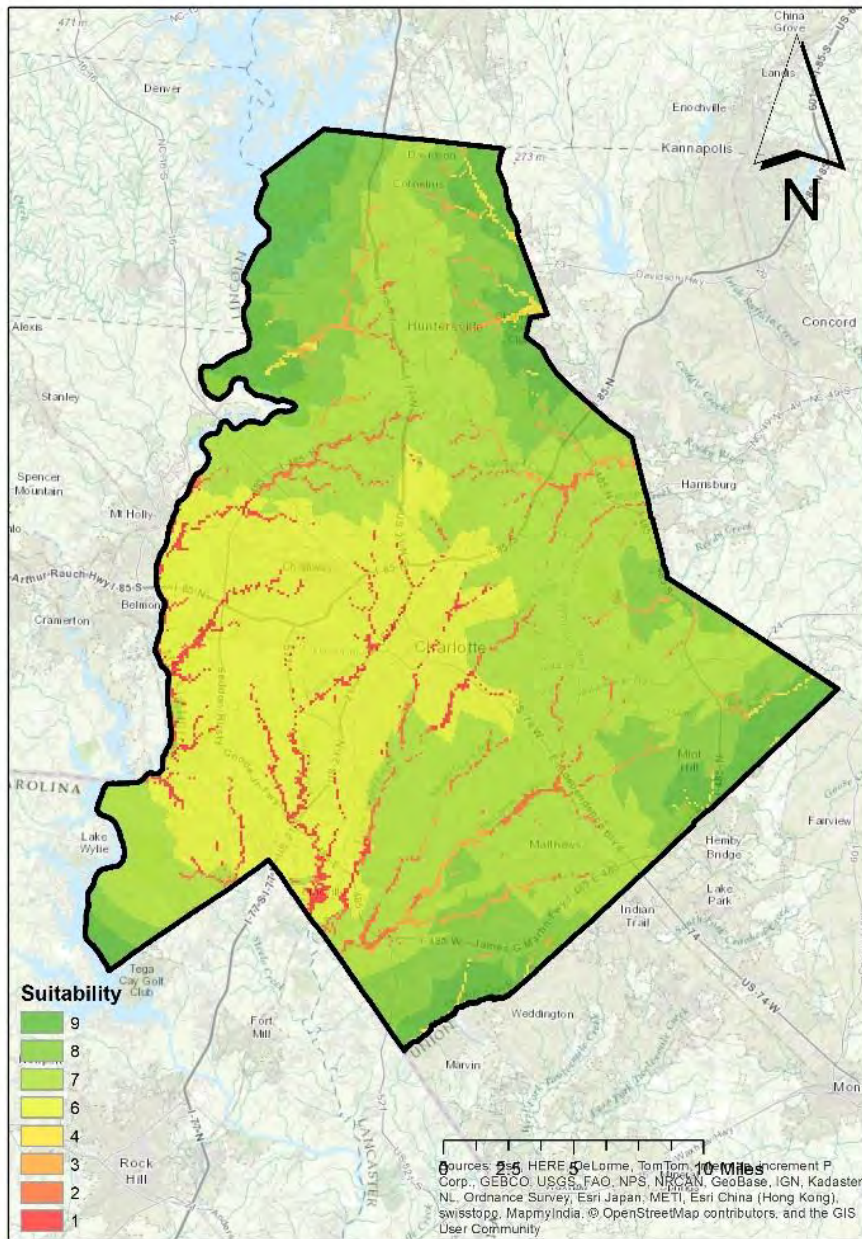


Figure 119: UG2021

Land use: Urban**Goal 2:** Identify lands suitable for office/commercial land use**Objective 2.2:** Determine lands economically suitable for office/commercial land use**Sub-objective 2.2.1:** Identify lands proximal to existing residential development**Input:** Parcels**Rationale:** Office/Commercial development success increases with proximity to residential land uses.**Output:** Office Commercial Proximity to Residential SUA (UG2O22SO221)**Criteria for Utility Assignment:** Euclidean distance was run from existing residential parcels. The resulting Euclidean distance results were reclassified using the Reclassify tool to designate all land within 495 feet of current residential land a value of 9, and all land beyond 496 feet were designated a value of 1.*Table 47: Identify lands proximal to existing residential development sub-objective data ranges and UA values*

<i>Data Range (feet)</i>	<i>Utility Assignment</i>
<i>0-495</i>	9
<i>496-All other land</i>	1

UG2022SO221

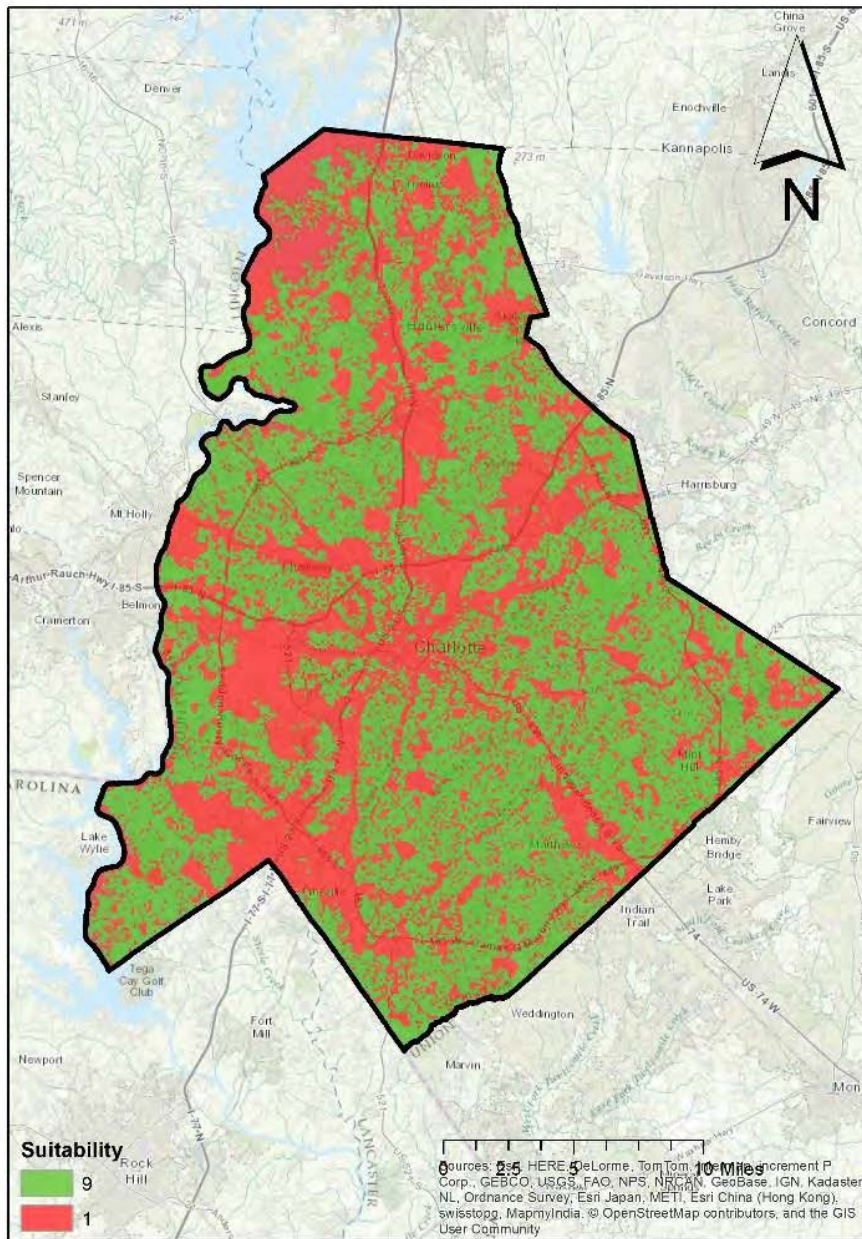


Figure 120: UG2022SO221

Land use: Urban**Goal 2:** Identify lands suitable for office/commercial land use**Objective 2.2:** Determine lands economically suitable for office/commercial land use**Sub-objective 2.2.2:** Identify lands within and proximal to existing city limits**Input:** City Limits**Rationale:** Office/commercial development success increases in urban areas.**Output:** Office/Commercial Proximity to City Limits SUA (UG2O22SO222)

Criteria for Utility Assignment: Euclidean distance was run on city limits and then zonal statistics were run to determine the mean distance of existing residential parcels from city limits and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 48: Identify lands within and proximal to existing city limits sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 819	9
820 – 2928	8
2929 – 5037	7
5038 – 7146	6
7147 – 9255	5
9256 – 11,364	4
11,365 – 13,473	3
13,474 – 15,582	2
15,583 – all remaining	1

UG2022SO222

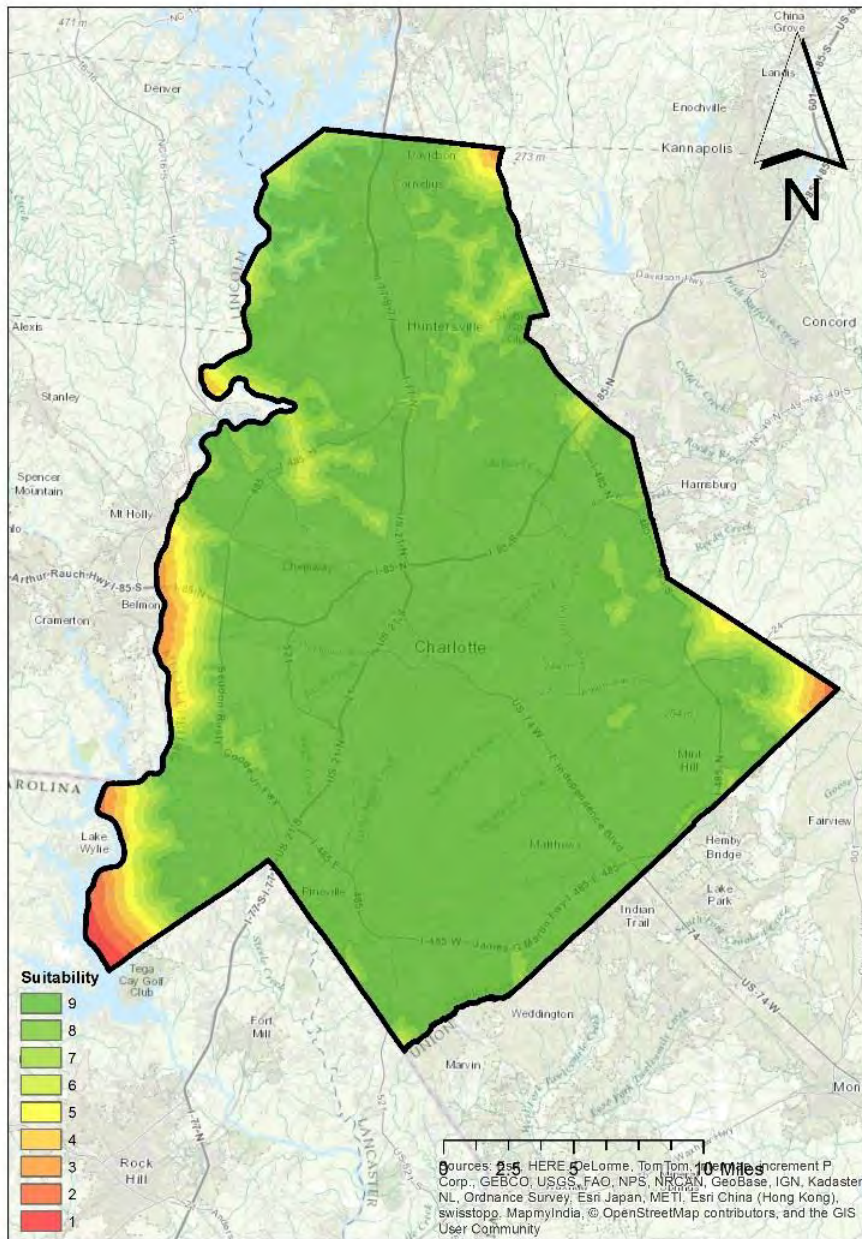


Figure 121: UG2022SO222

Land use: Urban**Goal 2:** Identify lands suitable for office/commercial land use**Objective 2.2:** Determine lands economically suitable for office/commercial land use**Sub-objective 2.2.3:** Identify lands proximal to roads**Input:** Euclidean Distance from Major Roads (preprocessed in residential model (UG1O12SO124))**Rationale:** It is convenient to be close to major roads.**Output:** Office/Commercial Proximity to Major Roads SUA (UG2O22SO223)

Criteria for Utility Assignment: Euclidean distance was run on major roads and then zonal statistics were run to determine the mean distance of existing residential parcels from major roads and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 49: Identify lands proximal to roads sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 3875	9
3876 – 7515	8
7516 – 11,155	7
11,156 – 14,795	6
14,796 – 18,435	5
18,436 – 22,075	4
22,076 – 25,715	3
25,716 – 29,355	2
29,356 – all remaining	1

UG2022S0223

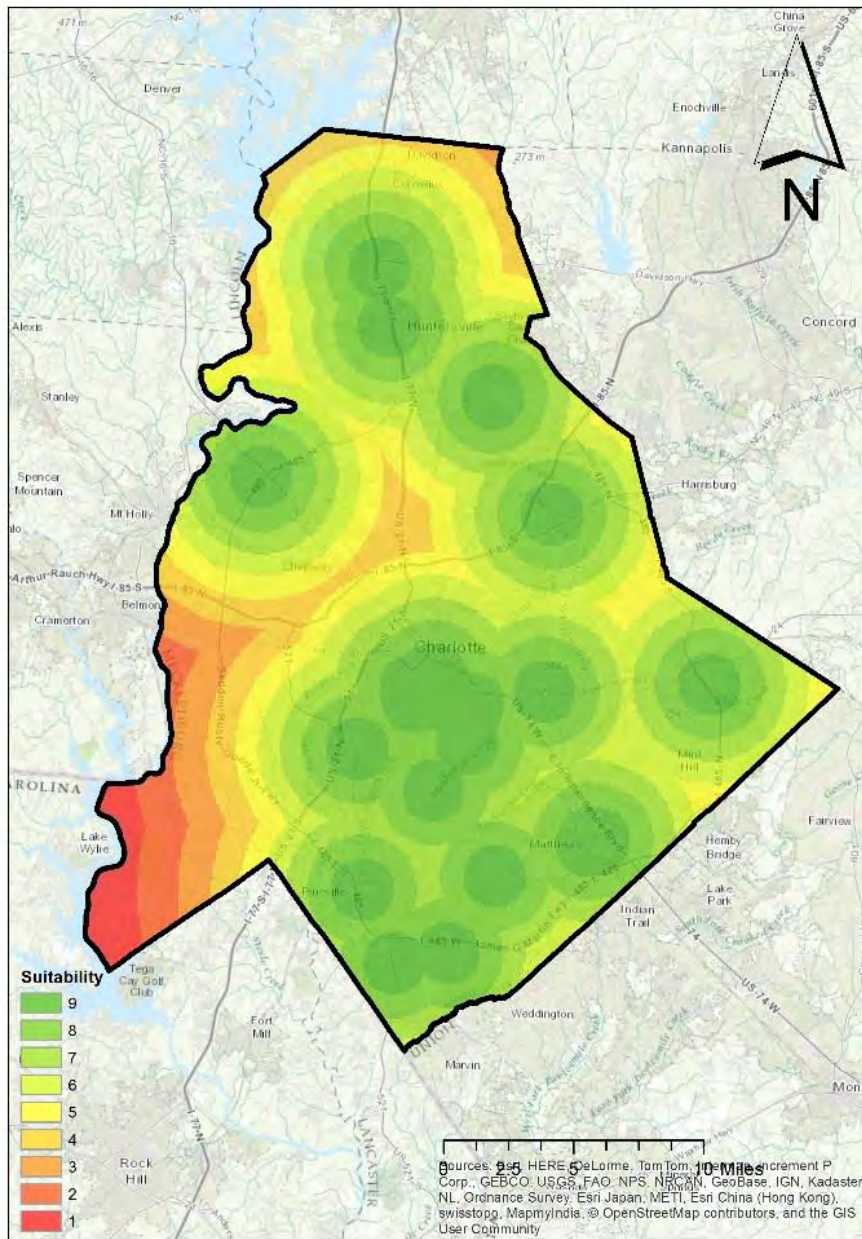


Figure 122: UG2022S0223

Land use: Urban

Goal 2: Identify lands suitable for office/commercial land use

Objective 2.2: Determine lands economically suitable for office/commercial land use

Sub-objective 2.2.5: Identify lands proximal to airports

Input: Airports

Rationale: It is convenient for office and commercial areas to be close to airports.

Output: Office/Commercial Proximity to Airports SUA (UG2O22SO225)

Criteria for Utility Assignment: Euclidean distance was run on the airport. The results were then reclassified using the Reclassify tool at natural breaks, with the closest interval to the airport being designated a value of 9 and the furthest a value of 1.

Table 50: Identify lands proximal to airports sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 11,321</i>	9
<i>11,322 – 22,643</i>	8
<i>22,644 – 33,964</i>	7
<i>33,965 – 45,286</i>	6
<i>45,287 – 56,608</i>	5
<i>56,609 – 67,929</i>	4
<i>67,930 – 79,251</i>	3
<i>79,252 – 90,573</i>	2
<i>90,573 – all remaining</i>	1

UG2022S0225

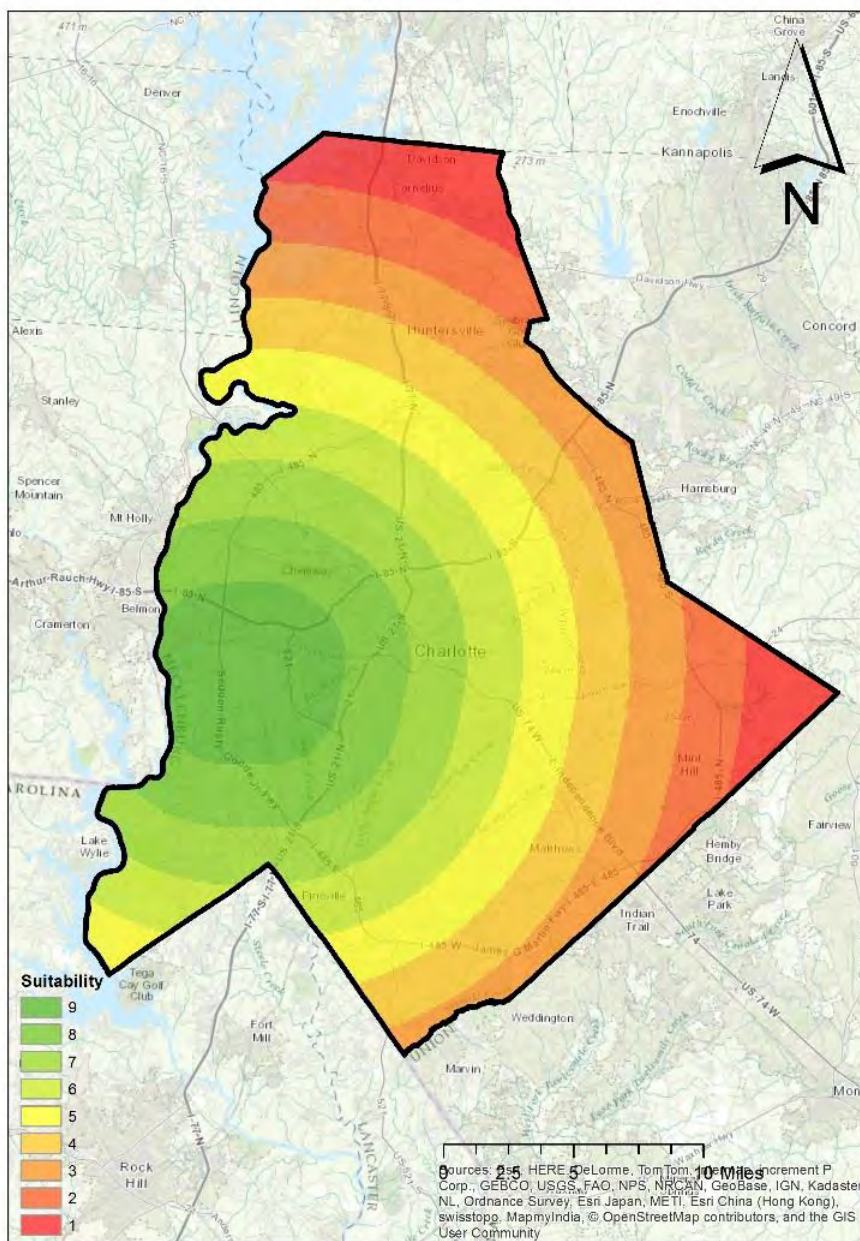


Figure 123: UG2022S0225

Land use: Urban**Goal 2:** Identify lands suitable for office/commercial land use**Objective 2.2:** Determine lands economically suitable for office/commercial land use**Sub-objective 2.2.6:** Identify lands proximal to parks and historic sites**Input:** Parks and Historic Sites**Rationale:** Proximity to parks and historic sites is an amenity for office/commercial developments.**Output:** Office/Commercial Proximity to Parks/Cultural & Historic Sites MUA (UG2O22SO226)

Criteria for Utility Assignment: Euclidean distance was run on the airport and then zonal statistics were run to determine the mean distance of existing residential parcels from the airport and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 51: Identify lands proximal to parks and historic sites sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 5377	9
5378 – 8907	8
8908 – 12,437	7
12,438 – 15,967	6
15,968 – 19,497	5
19,498 – 23,027	4
23,028 – 26,557	3
26,558 – 30,087	2
30,088 – all remaining	1

UG2022SO226

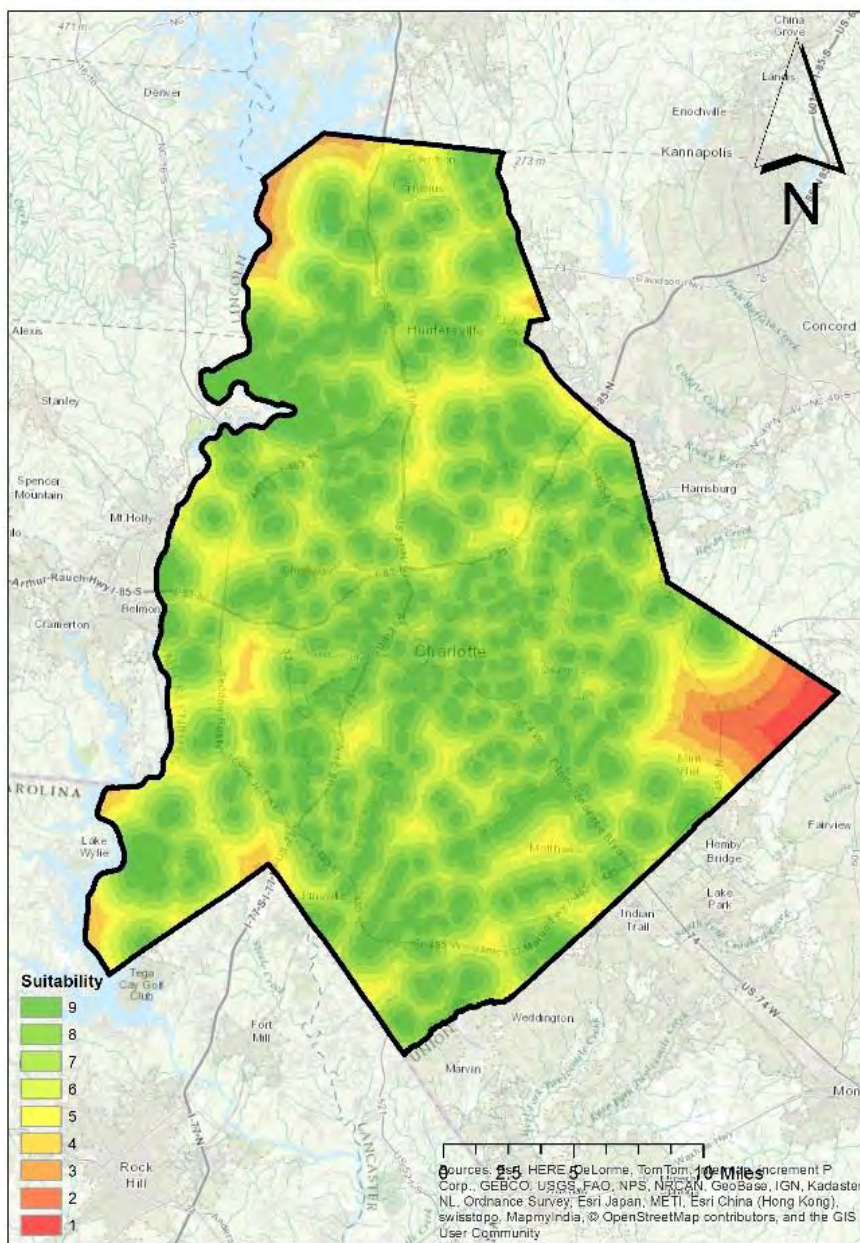


Figure 124: UG2022SO226

Land use: Urban**Goal 2:** Identify lands suitable for office/commercial land use**Objective 2.2:** Determine lands economically suitable for office/commercial land use**Sub-objective 2.2.9:** Identify lands proximal to existing office/commercial land use**Input:** Parcels**Rationale:** Office/commercial developments benefit from being close to other office/commercial developments.**Output:** Office/Commercial Proximity to Office/Commercial SUA (UG2022SO229)**Criteria for Utility Assignment:** Euclidean distance was run on the commercial parcels and then zonal statistics were run to determine the mean distance and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.*Table 52: Identify lands proximal to existing office/commercial land use sub-objective data ranges and UA values*

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 2136	9
2137 – 4341	8
4342 – 6546	7
6547 – 8751	6
8752 – 10,956	5
10,957 – 13,161	4
13,162 – 15,366	3
15,367 – 17,571	2
17,572 – all remaining	1

UG2022SO229

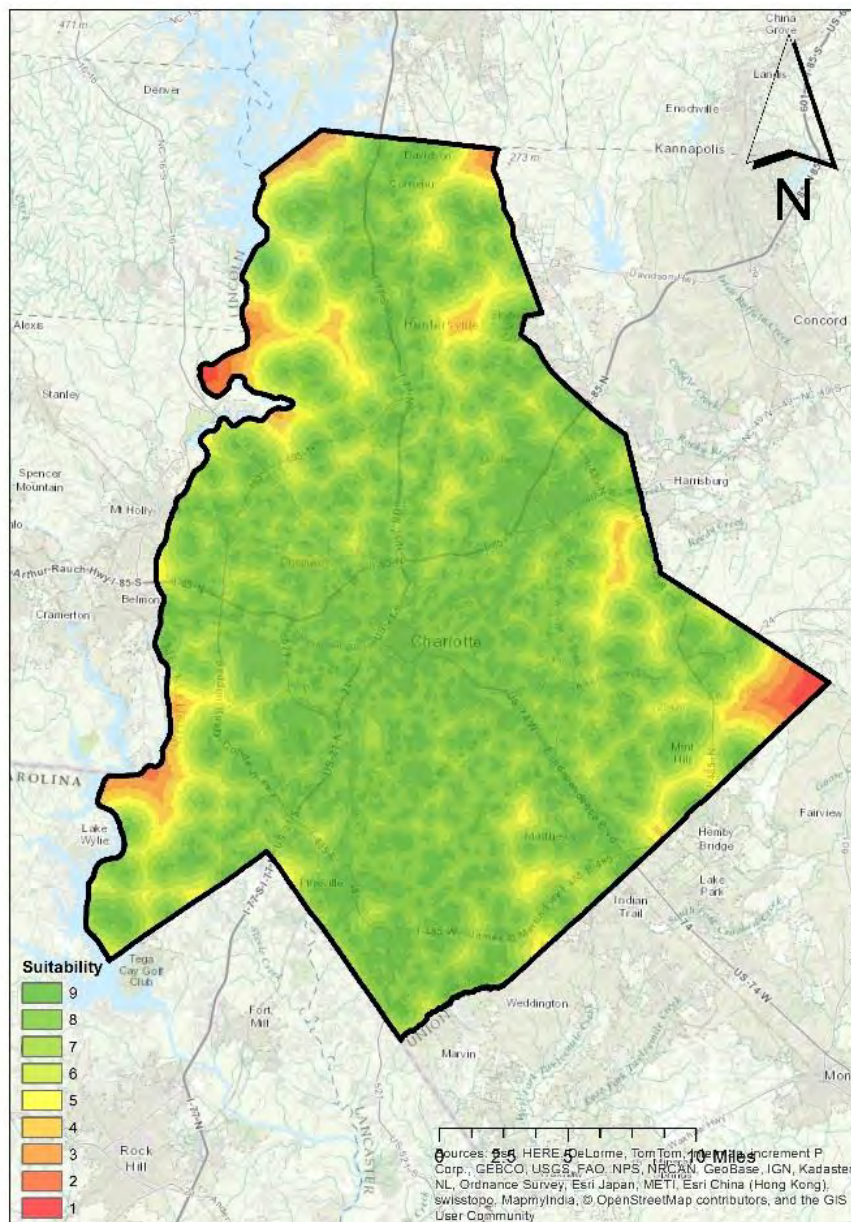


Figure 125: UG2022SO229

Land use: Urban

Goal 2: Identify lands suitable for office/commercial land use

Objective 2.2: Determine lands economically suitable for office/commercial land use

Input: Office Commercial Proximity to Residential SUA (UG2O22SO221), Office Commercial Proximity to City Limits SUA (UG2O22SO222), Office/Commercial Proximity to Major Roads SUA (UG2O22SO223), Office/Commercial Proximity to Airports SUA (UG2O22SO225), Office/Commercial Proximity to Parks/Cultural & Historic Sites MUA (UG2O22SO226), Office/Commercial Proximity to Office/Commercial SUA (UG2O22SO229)

Rationale: Areas economically suitable for office/commercial development are inside or close to city limits; close to existing residential areas, major roads, airports, parks, historic sites, and existing office/commercial areas.

Output: Office/Commercial Economic Suitability MUA (UG2O22)

Criteria for Utility Assignment: The input SUAs and MUAs were weighted and combined using the Raster Calculator tool.

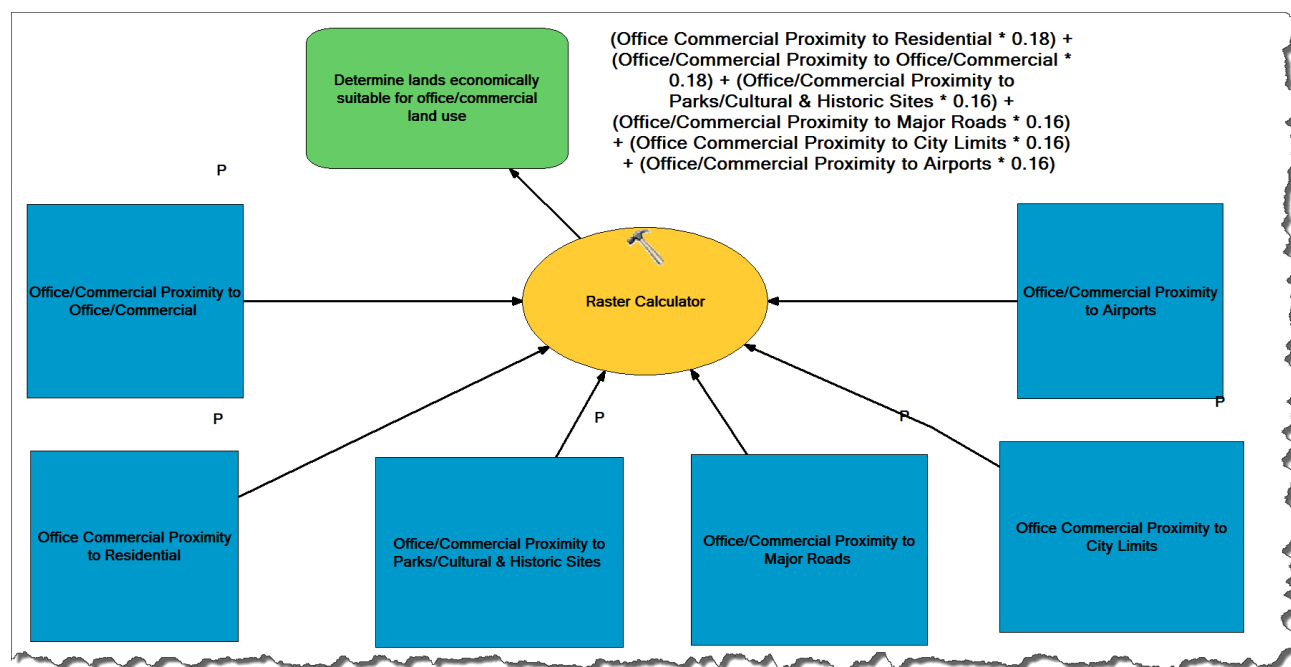


Figure 126: Determine lands economically suitable for office/commercial land use model

UG2022

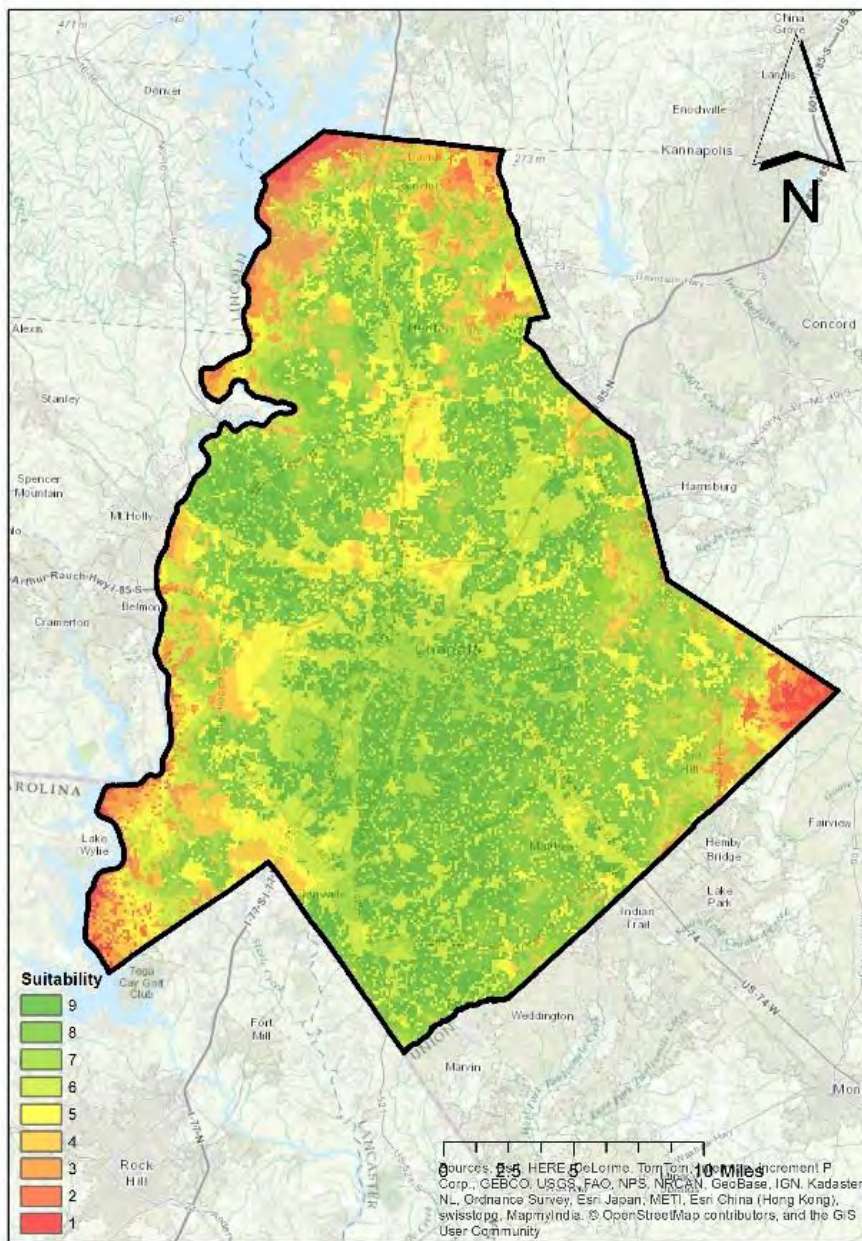


Figure 127: UG2022

Land use: Urban

Goal 2: Identify lands suitable for office/commercial land use

Input: Office/Commercial Physical Suitability MUA (UG2021), Office/Commercial Economic Suitability MUA (UG2022)

Rationale: Physical and economic criteria are important in determining office/commercial suitability.

Output: Office/Commercial Suitability MUA (UG2)

Criteria for Utility Assignment: The MUAs were combined and weighted equally using the Raster Calculator tool. Existing commercial parcels were reclassified using the Reclassify tool to designate a value of 9, and all other areas assigned a value of 1. Then a conditional statement was ensured that all existing commercial land retained their value of 9 and that all other land was assigned the weighted value resulting from the Raster Calculator equation.

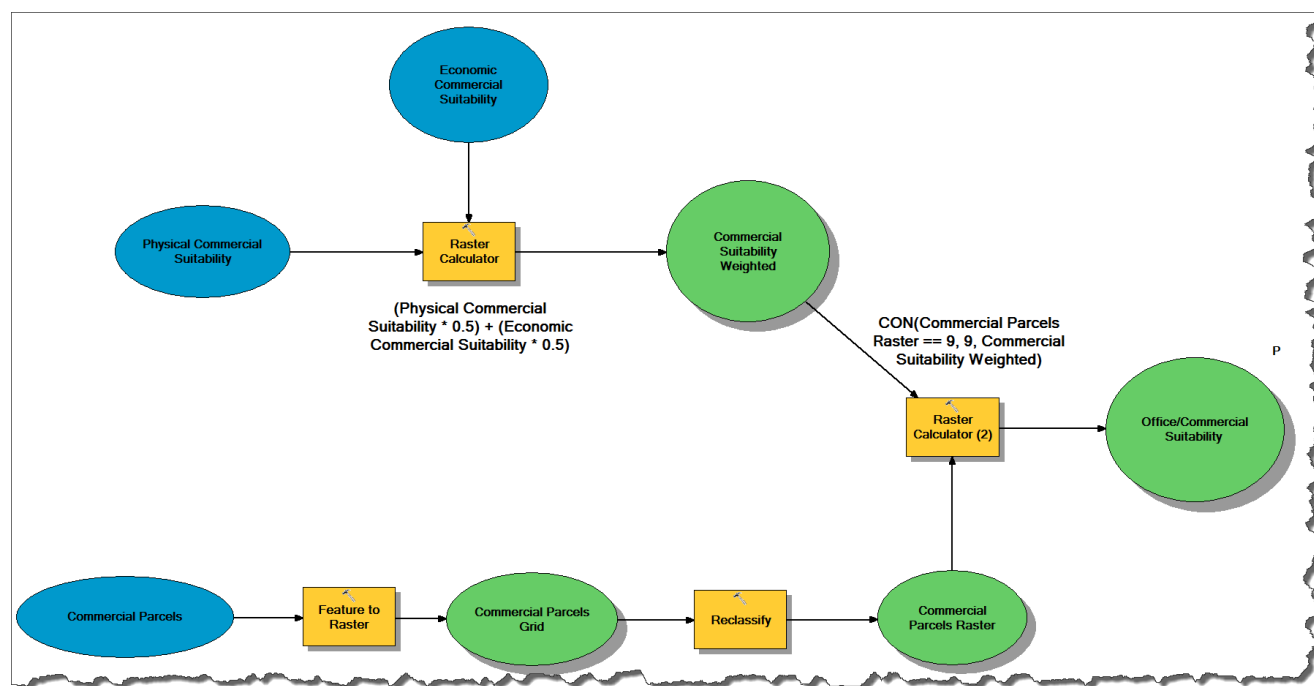


Figure 128: Identify lands suitable for office/commercial land use model

UG2

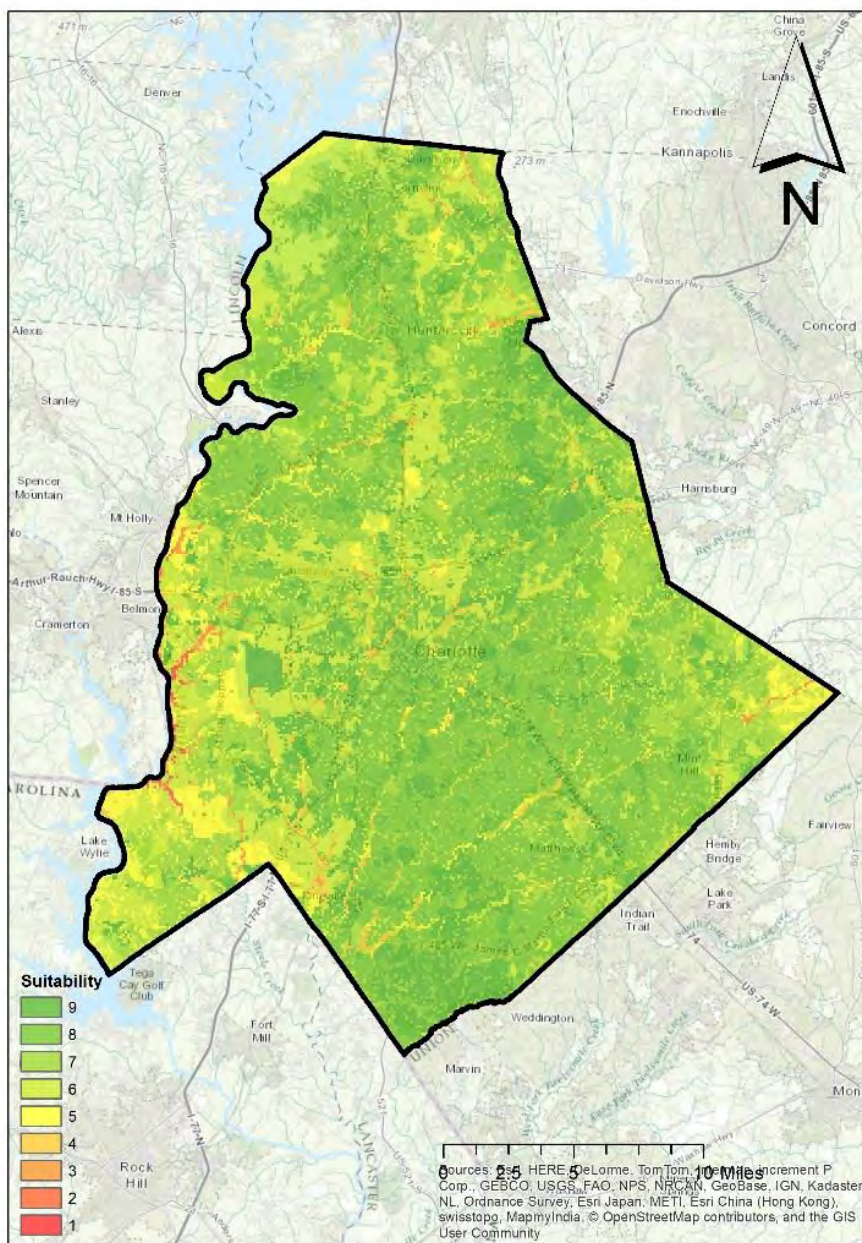


Figure 129: UG2

Land use: Urban**Goal 3:** Identify lands suitable for retail land use**Objective 3.1:** Determine lands physically suitable for retail land use**Input:** 100 Year Floodplain**Rationale:** Building within a floodplain or open water is costly and risky.**Output:** Retail Physical Suitability MUA (UG3O31)**Criteria for Utility Assignment:** The 100 year floodplain was converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to land outside of the floodplain and 1 to land within the floodplain.*Table 53: Identify lands free of flood potential sub-objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Lands free of a floodplain</i>	9
<i>Land within a floodplain</i>	1

UG3031

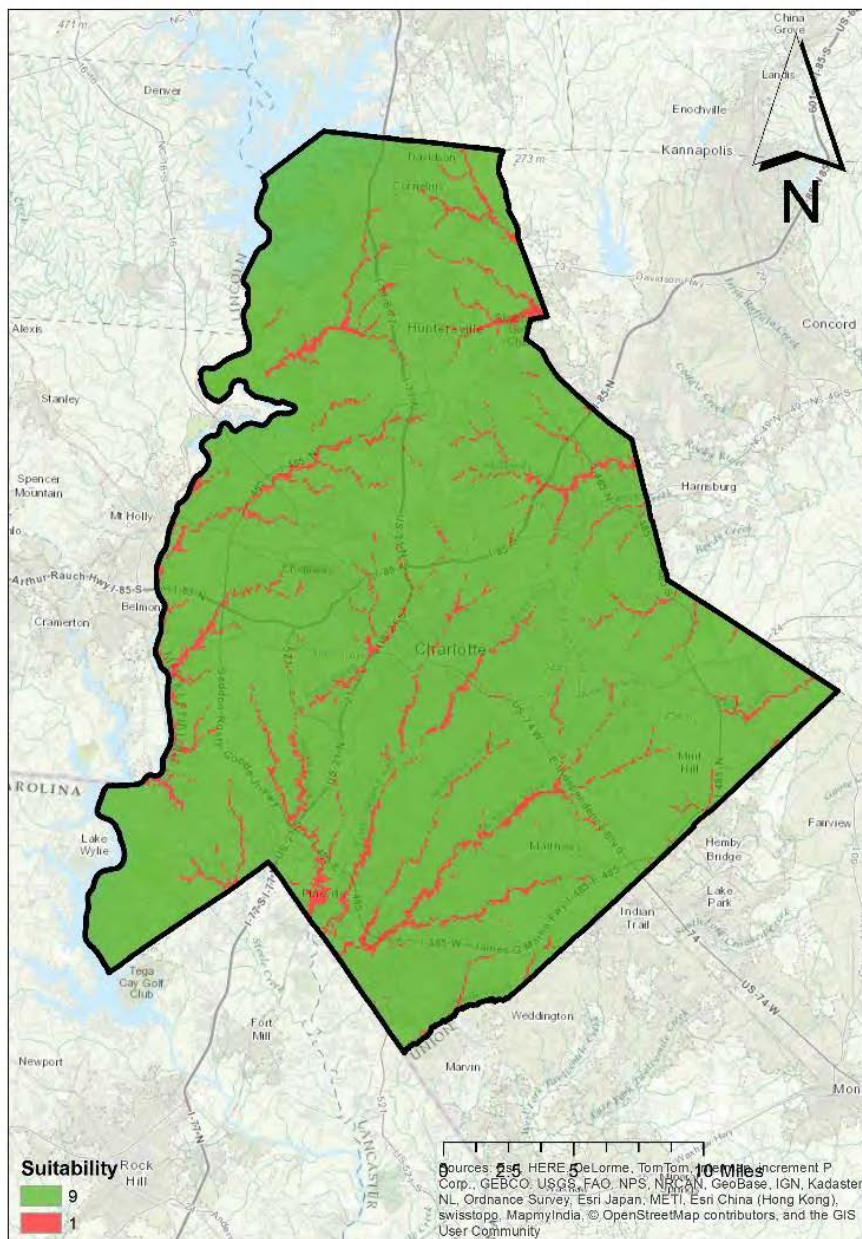


Figure 130: UG3031

Land use: Urban**Goal 3:** Identify lands suitable for retail land use**Objective 3.2:** Determine lands economically suitable for retail land use**Sub-objective 3.2.1:** Identify lands proximal to existing residential development**Input:** Parcels**Rationale:** Retail development success increases with proximity residential land uses.**Output:** Retail Proximity to Residential SUA (UG3O32SO321)

Criteria for Utility Assignment: Euclidean distance was run from existing residential parcels. The resulting Euclidean distance results were reclassified using the Reclassify tool to designate all land within 495 feet of current residential land a value of 9, and all land beyond 496 feet were designated a value of 1.

Table 54: Identify lands proximal to existing residential development sub-objective data ranges and UA values

<i>Data Range (feet)</i>	<i>Utility Assignment</i>
<i>0-495</i>	<i>9</i>
<i>496-All other land</i>	<i>1</i>

UG3032S0321

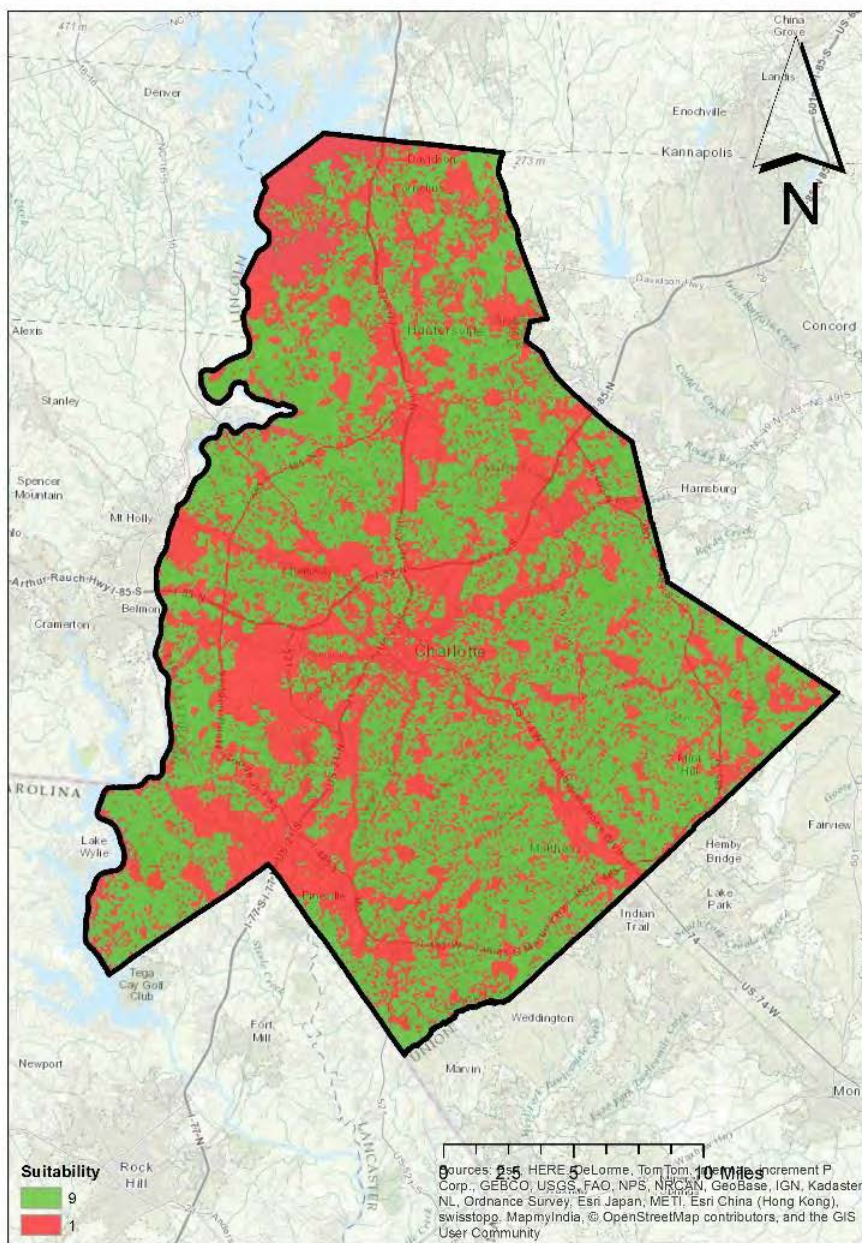


Figure 131: UG3032S0321

Land use: Urban**Goal 3:** Identify lands suitable for retail land use**Objective 3.2:** Determine lands economically suitable for retail land use**Sub-objective 3.2.2:** Identify lands proximal to existing retail land use**Input:** Parcels**Rationale:** Retail developments benefit from being close to other retail developments.**Output:** Retail Proximity to Retail SUA (UG3O32SO322)

Criteria for Utility Assignment: Euclidean distance was run from existing retail parcels. The resulting Euclidean distance results were reclassified using the Reclassify tool to designate all land within 25,899 feet of current retail land a value of 9, and all land beyond 25,899 feet were designated a value of 1.

Table 55: Identify lands proximal to existing retail land use sub-objective data ranges and UA values

<i>Data Range (feet)</i>	<i>Utility Assignment</i>
<i>0 – 25,899</i>	9
<i>25,899 – All other land</i>	1

UG3032S0322

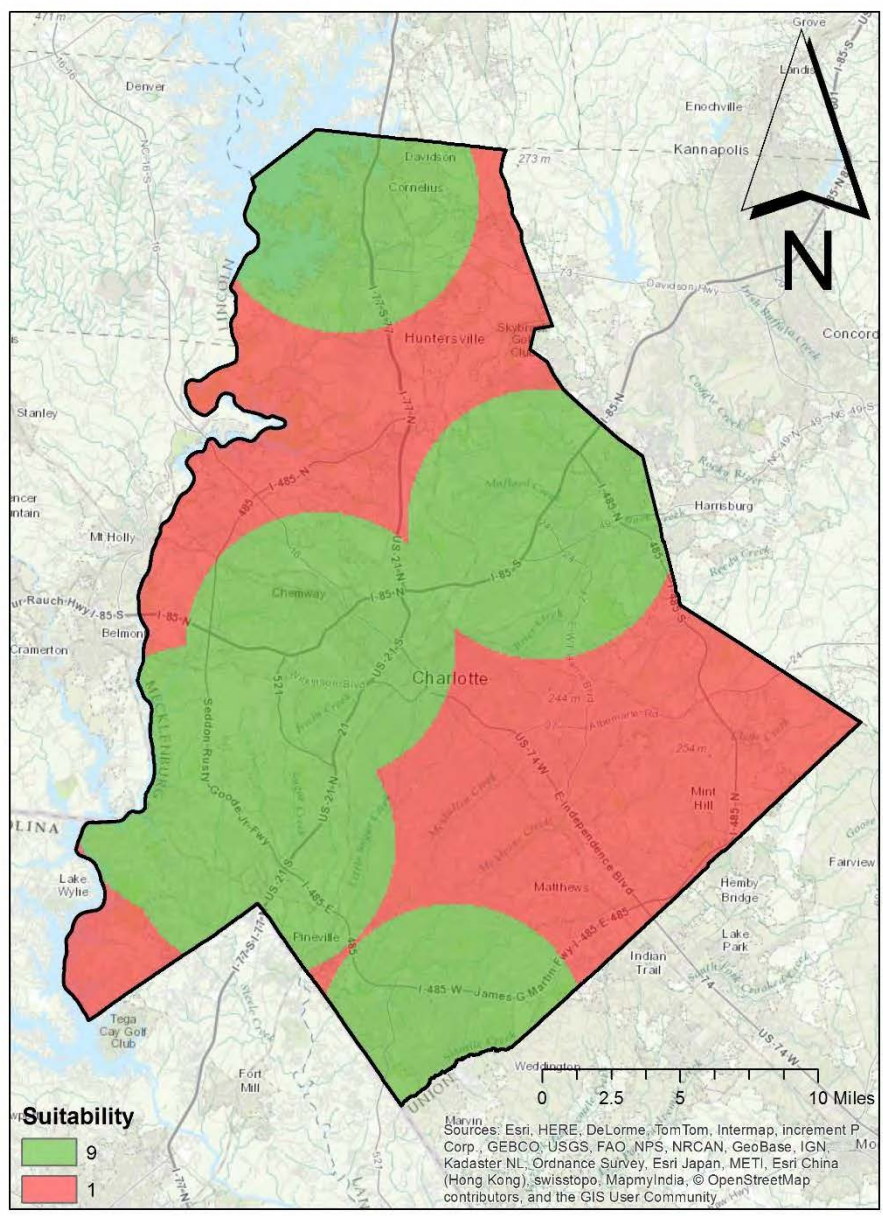


Figure 132: UG3032S0322

Land use: Urban**Goal 3:** Identify lands suitable for retail land use**Objective 3.2:** Determine lands economically suitable for retail land use**Sub-objective 3.2.3:** Identify lands proximal to roads

Input: Euclidean Distance from Major Roads (preprocessed in residential model UG1O12SO124)

Rationale: It is convenient to be close to major roads.

Output: Retail Proximity to Major Roads SUA (UG3O32SO323)

Criteria for Utility Assignment: Euclidean distance was run on major roads and then zonal statistics were run to determine the mean distance of existing residential parcels from major roads and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 56: Identify lands proximal to roads sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 3875	9
3876 – 7515	8
7516 – 11,155	7
11,156 – 14,795	6
14,796 – 18,435	5
18,436 – 22,075	4
22,076 – 25,715	3
25,716 – 29,355	2
29,356 – all remaining	1

UG3032S0323

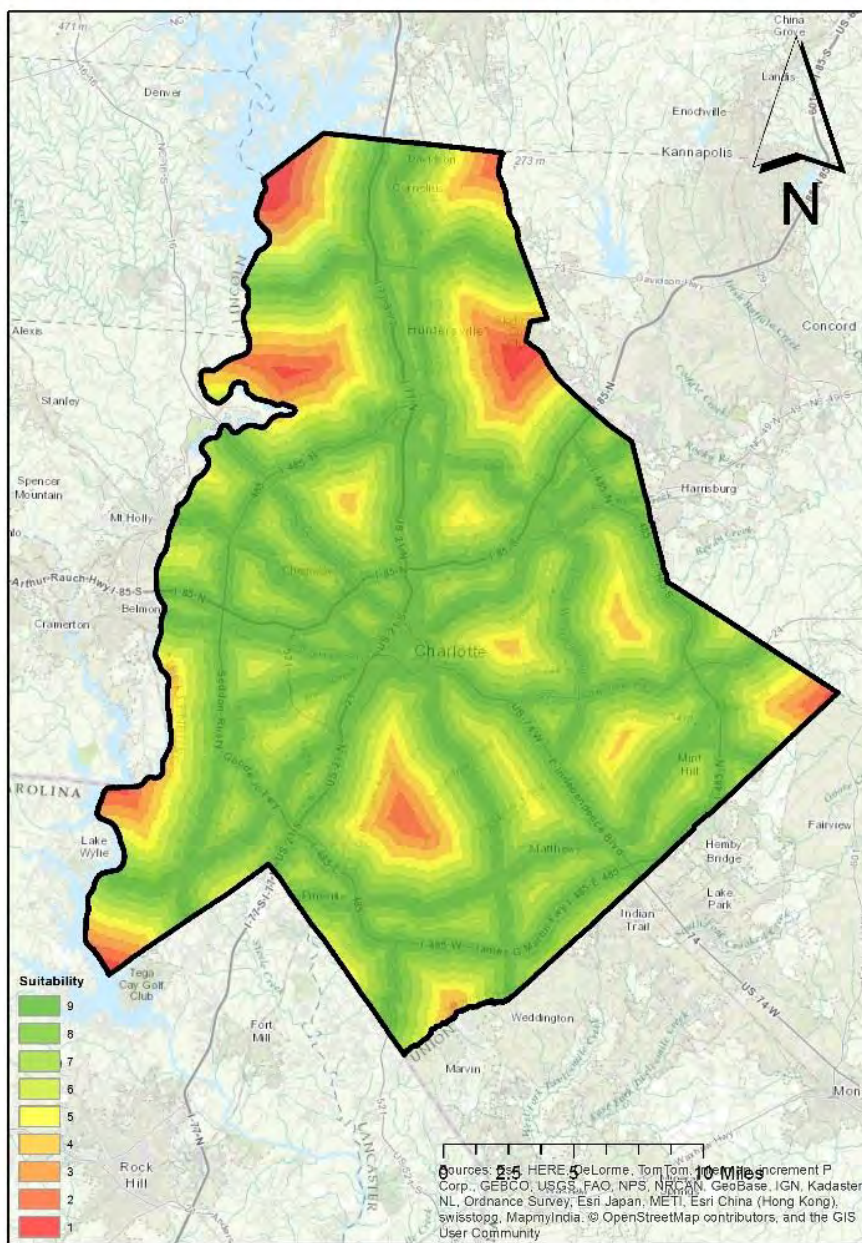


Figure 133: UG3032S0323

Land use: Urban**Goal 3:** Identify lands suitable for retail land use**Objective 3.2:** Determine lands economically suitable for retail land use**Sub-objective 3.2.7:** Identify lands within and proximal to existing city limits**Input:** City Limits**Rationale:** Retail development success increases in urban areas.**Output:** Proximity to City Limits SUA (UG3O32SO327)

Criteria for Utility Assignment: Euclidean distance was run on city limits and then zonal statistics were run to determine the mean distance of existing residential parcels from city limits and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 57: Identify lands within and proximal to existing city limits sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 819</i>	<i>9</i>
<i>820 – 2928</i>	<i>8</i>
<i>2929 – 5037</i>	<i>7</i>
<i>5038 – 7146</i>	<i>6</i>
<i>7147 – 9255</i>	<i>5</i>
<i>9256 – 11,364</i>	<i>4</i>
<i>11,365 – 13,473</i>	<i>3</i>
<i>13,474 – 15,582</i>	<i>2</i>
<i>15,583 – all remaining</i>	<i>1</i>

Land use: Urban

Goal 3: Identify lands suitable for retail land use

Objective 3.2: Determine lands economically suitable for retail land use

Input: Retail Proximity to Residential SUA (UG3O32SO321), Retail Proximity to Retail SUA (UG3O32SO322), Retail Proximity to Major Roads SUA (UG3O32SO323), Retail Proximity to City Limits SUA (UG3O32SO327)

Rationale: Areas economically suitable for retail development are inside or close to city limits; close to existing residential areas, and major roads.

Output: Retail Economic Suitability MUA (UG3O32)

Criteria for Utility Assignment: The input SUAs and MUAs were weighted and combined using the Raster Calculator tool.

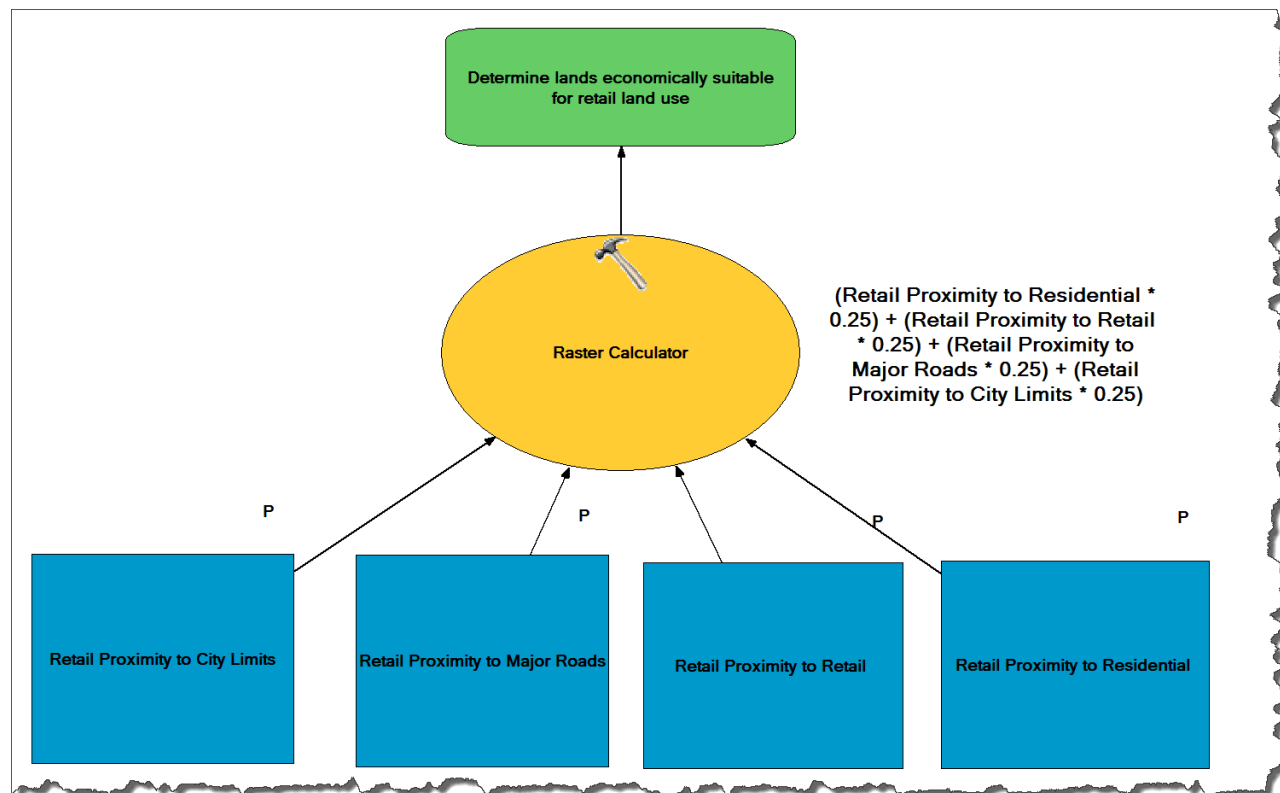


Figure 135: Determine lands economically suitable for retail land use model

Land use: Urban

Goal 3: Identify lands suitable for retail land use

Input: Retail Physical Suitability MUA (UG2O21), Retail Economic Suitability MUA (UG2O22)

Rationale: Physical and economic criteria are important in determining retail suitability.

Output: Retail Suitability MUA (UG3)

Criteria for Utility Assignment: The MUAs were combined and weighted equally using the Raster Calculator tool. Existing commercial parcels were reclassified using the Reclassify tool to designate a value of 9, and all other areas assigned a value of 1. Then a conditional statement was ensured that all existing commercial land retained their value of 9 and that all other land was assigned the weighted value resulting from the Raster Calculator equation.

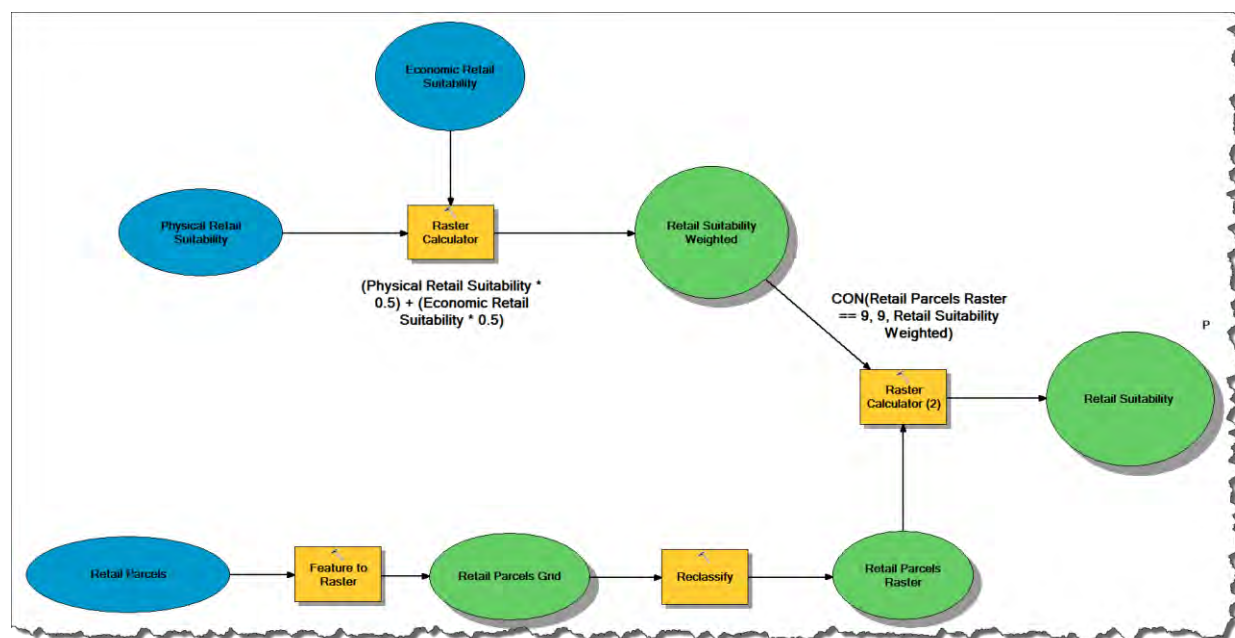


Figure 137: Identify lands suitable for retail land use model

UG3

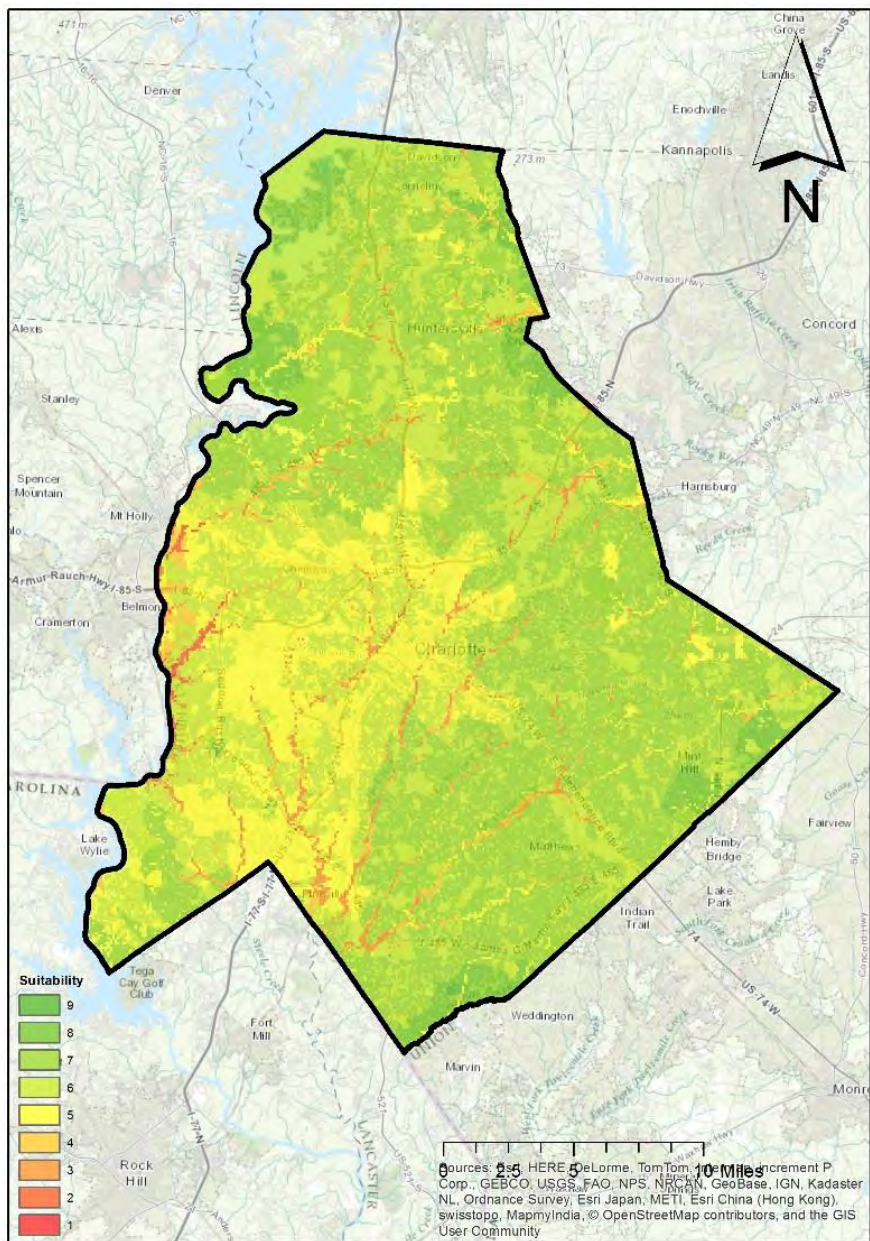


Figure 138: UG3

Land use: Urban**Goal 4:** Identify lands for industrial land use**Objective 4.1:** Determine lands physically suitable for retail land use**Input:** 100 Year Floodplain**Rationale:** Building within a floodplain or open water is costly and risky.**Output:** Industrial Physical Suitability MUA (UG4O41)**Criteria for Utility Assignment:** The 100 year floodplain was converted to raster using the Feature to Raster tool and then reclassified using the Reclassify tool to assign a value of 9 to land outside of the floodplain and 1 to land within the floodplain.*Table 58: Identify lands free of flood potential objective data ranges and UA values*

<i>Data Range</i>	<i>Utility Assignment</i>
<i>Lands free of a floodplain</i>	9
<i>Land within a floodplain</i>	1

UG4041

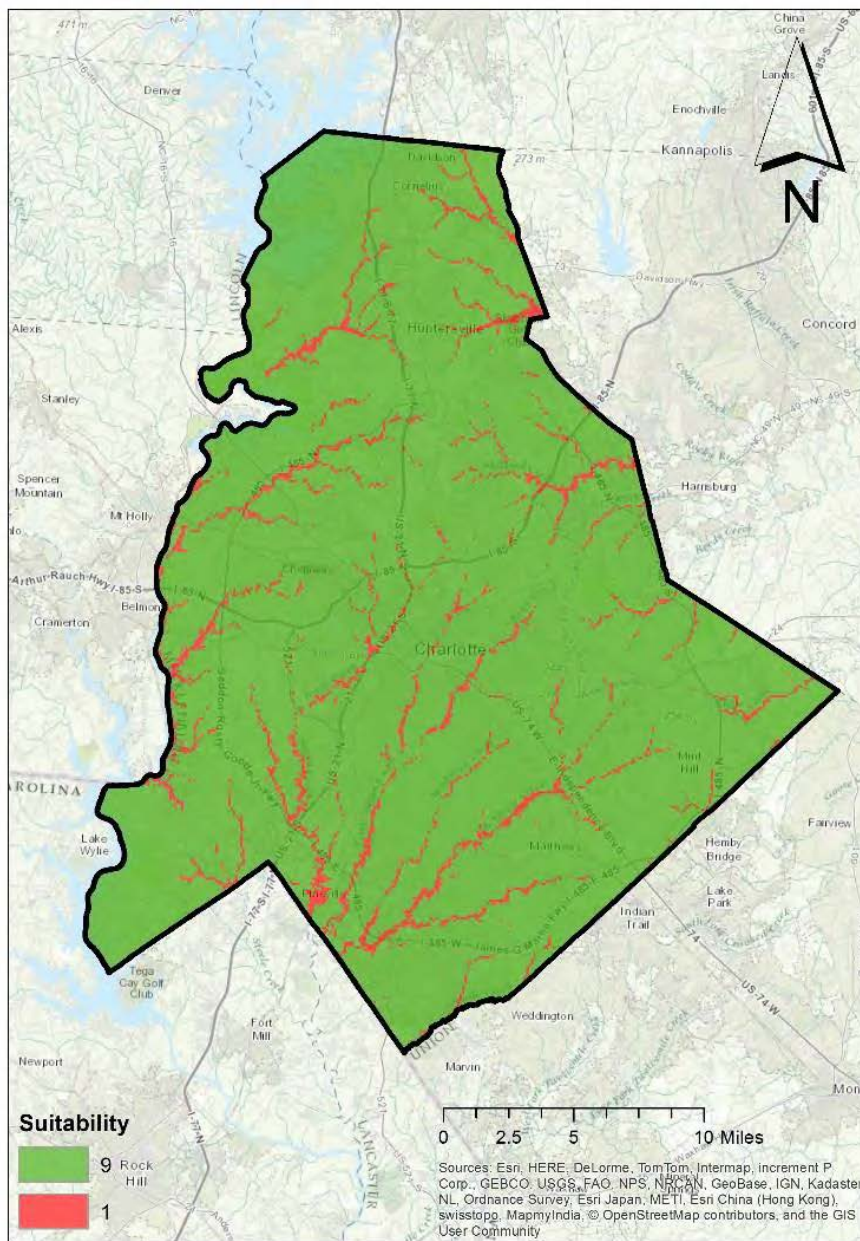


Figure 139: UG4041

Land use: Urban**Goal 4:** Identify lands suitable for industrial land use**Objective 4.2:** Identify lands economically suitable for industrial use**Sub-objective 4.2.1:** Identify lands away from existing residential development**Input:** Parcels**Rationale:** Industrial development success increases with distance from residential land uses.**Output:** Industrial Distance from Residential SUA (UG4O42SO421)

Criteria for Utility Assignment: Euclidean distance was run on residential parcels and then zonal statistics were run to determine the mean distance of existing residential parcels from industrial parcels and the standard deviation. Land with values of 0 to the mean were designated a value of 1. Then land was designated values 2-9 in standard-deviation intervals.

Table 59: Identify lands away from existing residential development sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 408	1
409 – 1097	2
1098 – 1786	3
1787 – 2475	4
2476 – 3164	5
3165 – 3853	6
3854 – 4542	7
4543 – 5231	8
5332 – 5920	9

UG4O42SO421

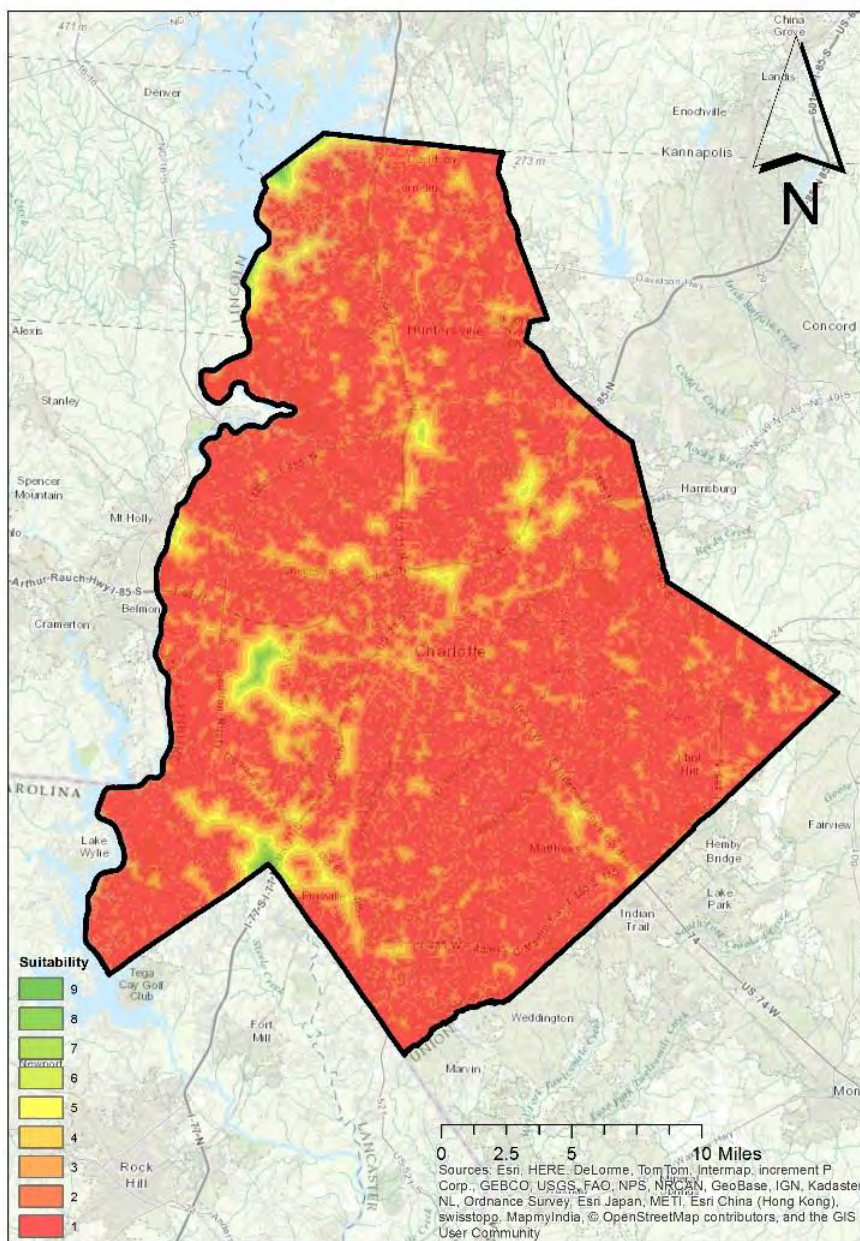


Figure 140: UG4O42SO421

Land use: Urban**Goal 4:** Identify lands suitable for industrial land use**Objective 4.2:** Determine lands economically suitable for industrial land use**Sub-objective 4.2.2:** Identify lands proximal to existing industrial land use**Input:** Parcels**Rationale:** Industrial development success increase in proximity to other industrial areas.**Output:** Industrial Proximity to Industrial SUA (UG4O42SO422)

Criteria for Utility Assignment: Euclidean distance was run on industrial parcels and then zonal statistics were run to determine the mean distance and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 60: Identify lands proximal to existing industrial land use sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 4328	9
4329 – 8237	8
8238 – 12,146	7
12,147 – 16,055	6
16,056 – 19,964	5
19,965 – 23,873	4
23,874 – 27,782	3
27,783 – 31,691	2
31,692 – all remaining	1

UG4O42SO422

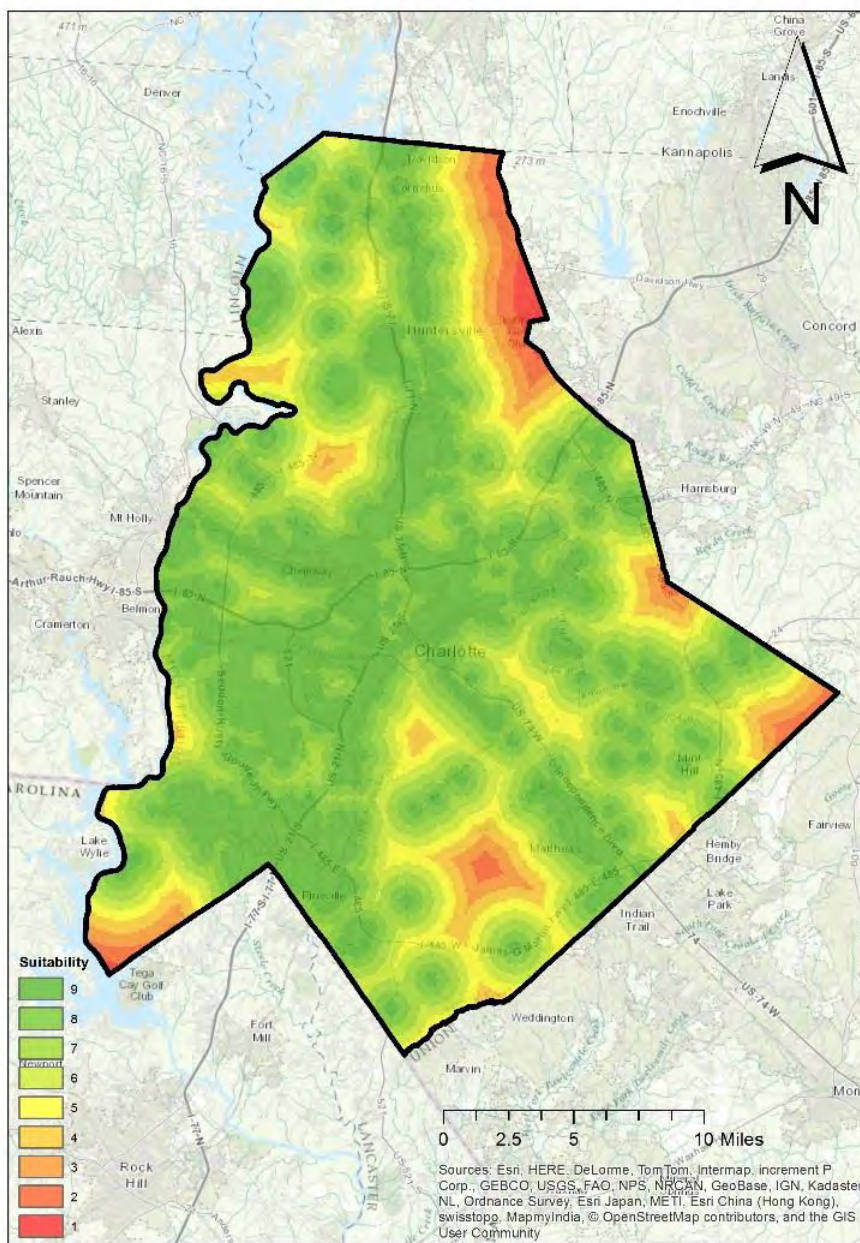


Figure 141: UG4O42SO422

Land use: Urban**Goal 4:** Identify lands suitable for industrial land use**Objective 4.2:** Identify lands economically suitable for industrial use**Sub-objective 4.2.3:** Identify lands proximal to roads**Input:** Euclidean Distance from Major Roads**Rationale:** It is convenient to be close to major roads.**Output:** Industrial Proximity to Major Roads SUA (UG4O42SO423)

Criteria for Utility Assignment: Euclidean distance was run on major roads and then zonal statistics were run to determine the mean distance of existing residential parcels from major roads and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 61: Identify lands proximal to roads sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 3875	9
3876 – 7515	8
7516 – 11,155	7
11,156 – 14,795	6
14,796 – 18,435	5
18,436 – 22,075	4
22,076 – 25,715	3
25,716 – 29,355	2
29,356 – all remaining	1

UG4O42SO423

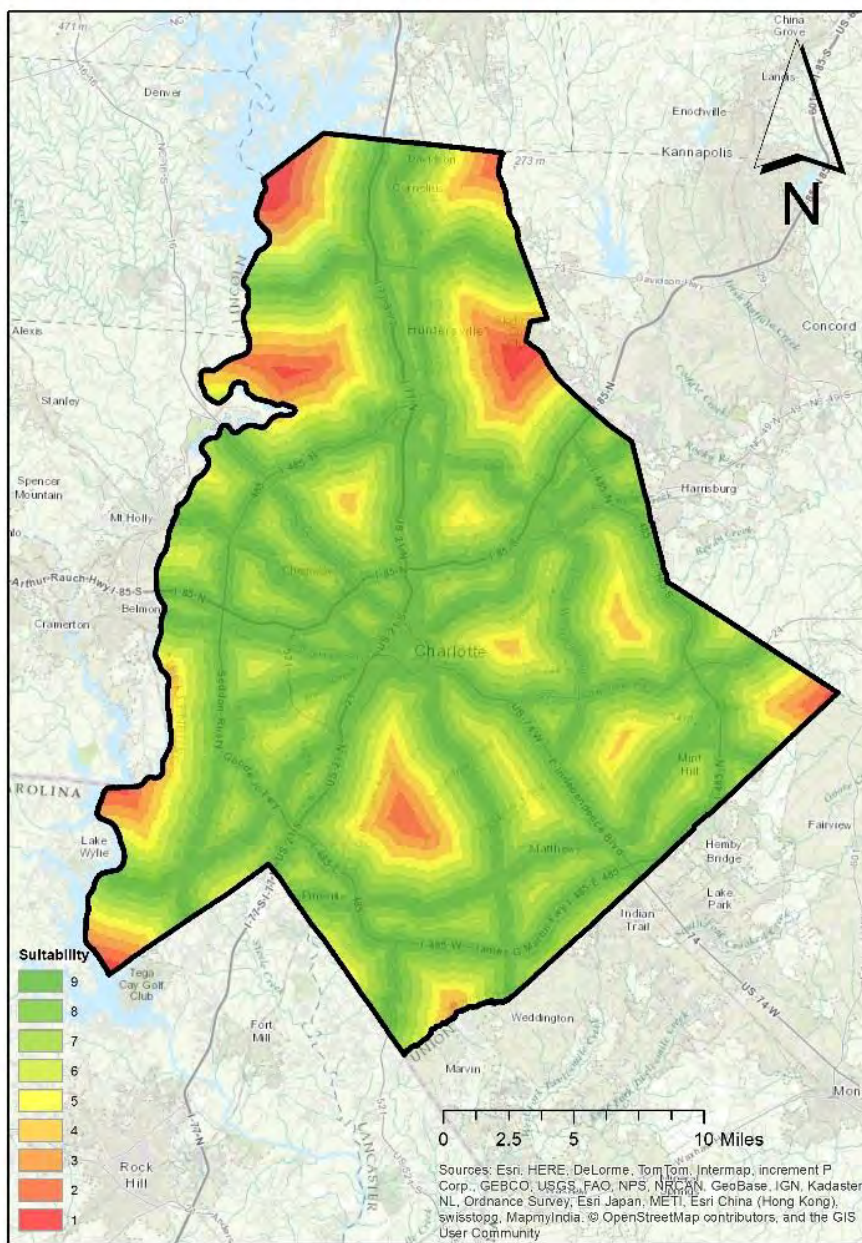


Figure 142: UG4O42SO423

Land use: Urban**Goal 4:** Identify lands suitable for industrial land use**Objective 4.2:** Identify lands economically suitable for industrial use**Sub-objective 4.2.4:** Identify lands proximal to railroads**Input:** Distance from Railroads**Rationale:** It is convenient to be close to railroads in order to transport goods.**Output:** Industrial Proximity to Railroads SUA (UG4O42SO424)

Criteria for Utility Assignment: Euclidean distance was run on railroads and then zonal statistics were run to determine the mean distance of existing industrial parcels from major roads and the standard deviation. Land with values of 0 to the mean were designated a value of 9. Then land was designated values 8–2 in standard-deviation intervals. The remaining land was assigned the value of 1.

Table 62: Identify lands proximal to railroads sub-objective data ranges and UA values

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
0 – 9604	9
9605 – 17,523	8
17,524 – 25,442	7
25,443 – 33,361	6
33,362 – 41,280	5
41,281 – 49,199	4
49,200 – 57,118	3
57,119 – 65,037	2
65,038 – all remaining	1

UG4O42SO424

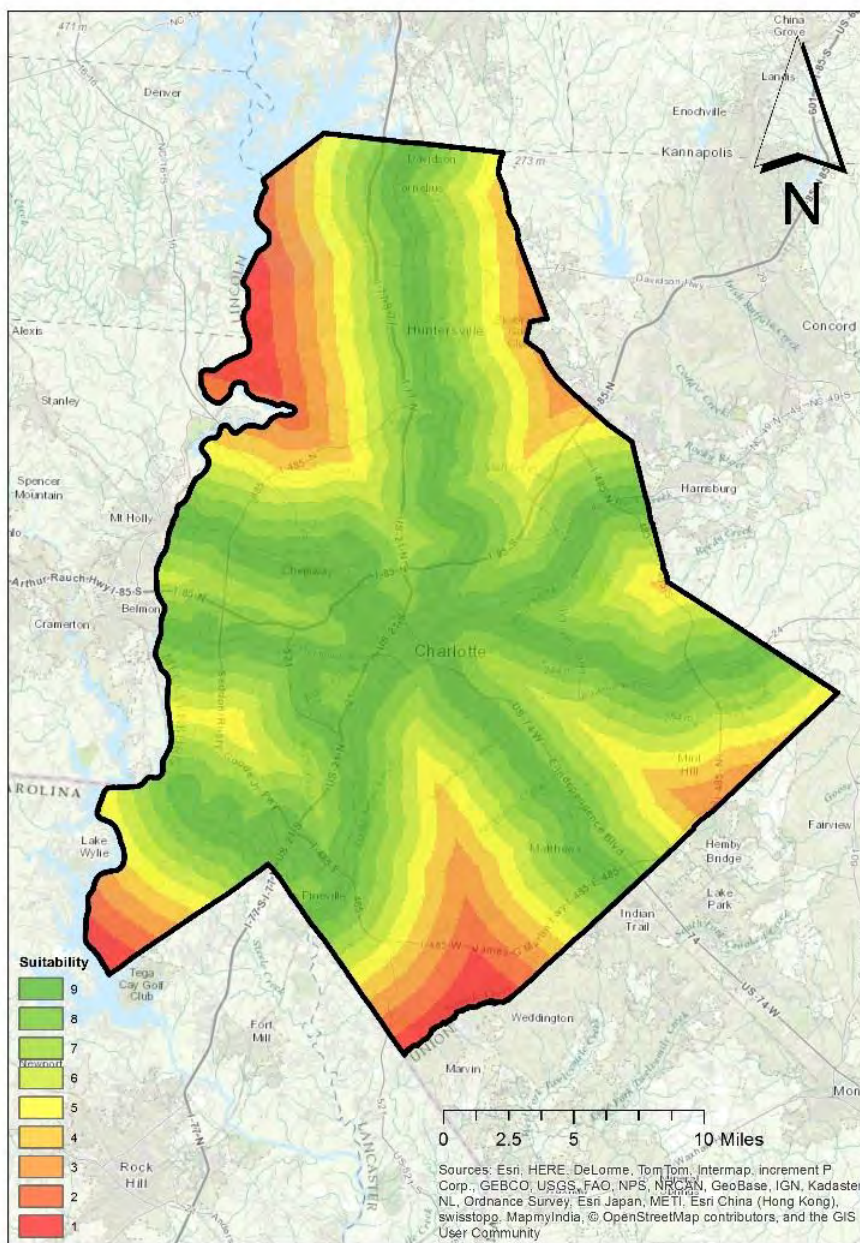


Figure 143: UG4O42SO424

Land use: Urban**Goal 4:** Identify lands suitable for industrial land use**Objective 4.2:** Identify lands economically suitable for industrial use**Sub-objective 4.2.5:** Identify lands proximal to airports**Input:** Airports**Rationale:** It is convenient to be close to airports in order to transport goods.**Output:** Industrial Proximity to Railroads SUA (UG4O42SO425)**Criteria for Utility Assignment:** Euclidean distance was run on the airport. The results were then reclassified using the Reclassify tool at natural breaks, with the closest interval to the airport being designated a value of 9 and the furthest a value of 1.*Table 63: Identify lands proximal to airports sub-objective data ranges and UA values*

<i>Data Range (in feet)</i>	<i>Suitability Value Assignment</i>
<i>0 – 11,321</i>	9
<i>11,322 – 22,643</i>	8
<i>22,644 – 33,964</i>	7
<i>33,965 – 45,286</i>	6
<i>45,287 – 56,608</i>	5
<i>56,609 – 67,929</i>	4
<i>67,930 – 79,251</i>	3
<i>79,252 – 90,573</i>	2
<i>90,573 – all remaining</i>	1

UG4O42SO425

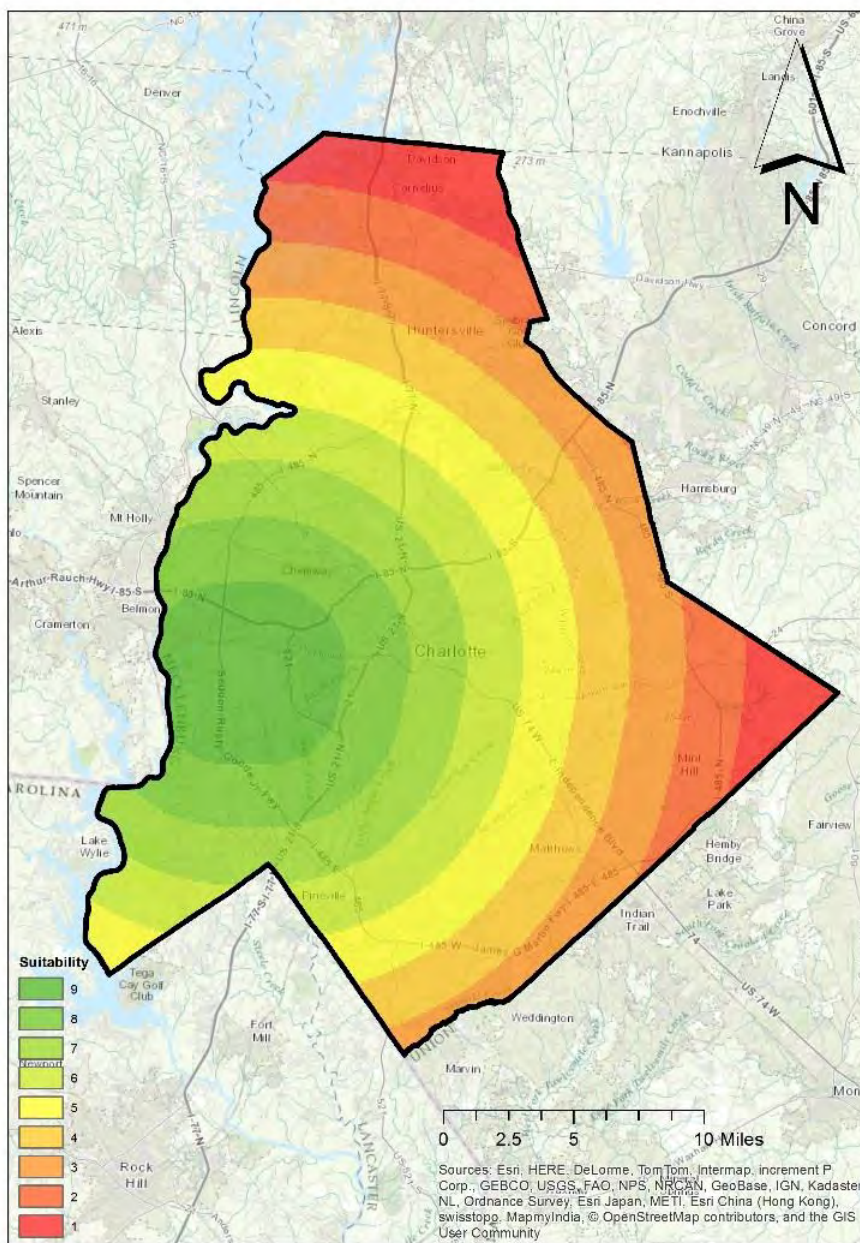


Figure 144: UG4O42SO425

Land use: Urban

Goal 4: Identify lands suitable for industrial land use

Objective 4.2: Identify lands economically suitable for industrial use

Input: Industrial Distance from Residential SUA (UG4O42SO421), Industrial Proximity to Industrial SUA (UG4O42SO422), Industrial Proximity to Major Roads SUA (UG4O42SO423), Industrial Proximity to Railroads SUA (UG4O42SO424), Industrial Proximity to Airports SUA (UG4O42SO425)

Rationale: Areas economically suitable for industrial development are close to major roads, shipping points, existing industrial areas, and at a distance from residential areas.

Output: Industrial Economic Suitability MUA (UG4O42)

Criteria for Utility Assignment: The input SUAs and MUAs were weighted and combined using the Raster Calculator tool.

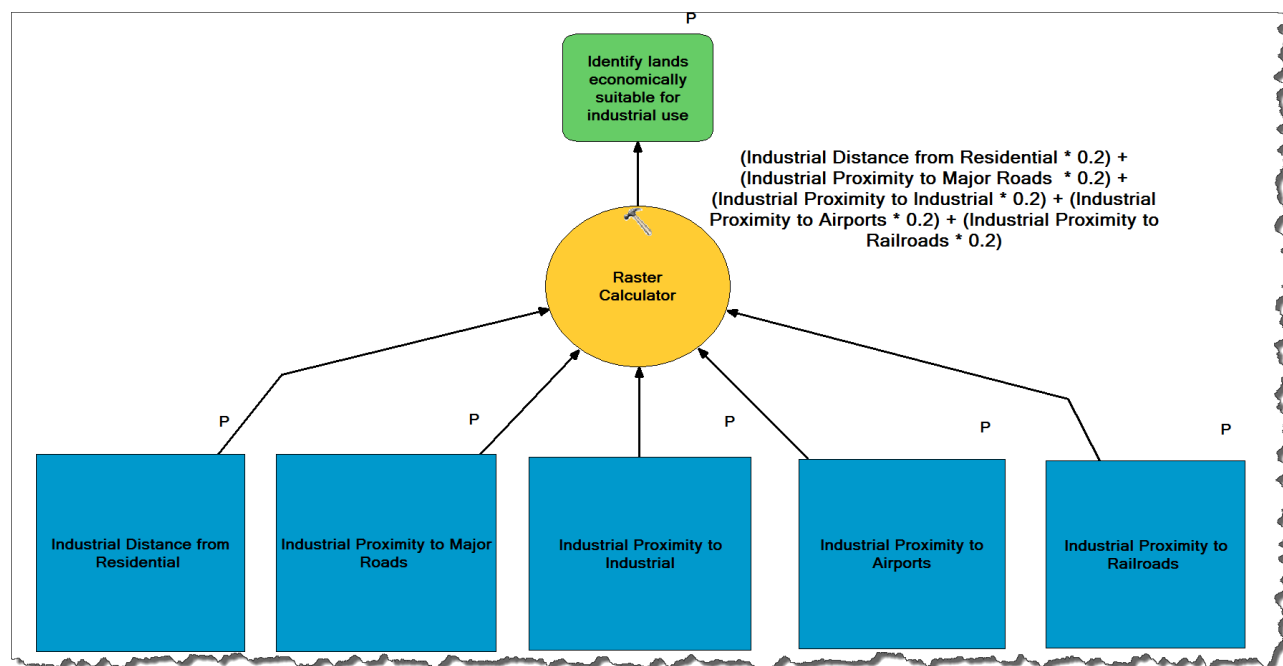


Figure 145: Identify lands economically suitable for industrial use model

UG4042

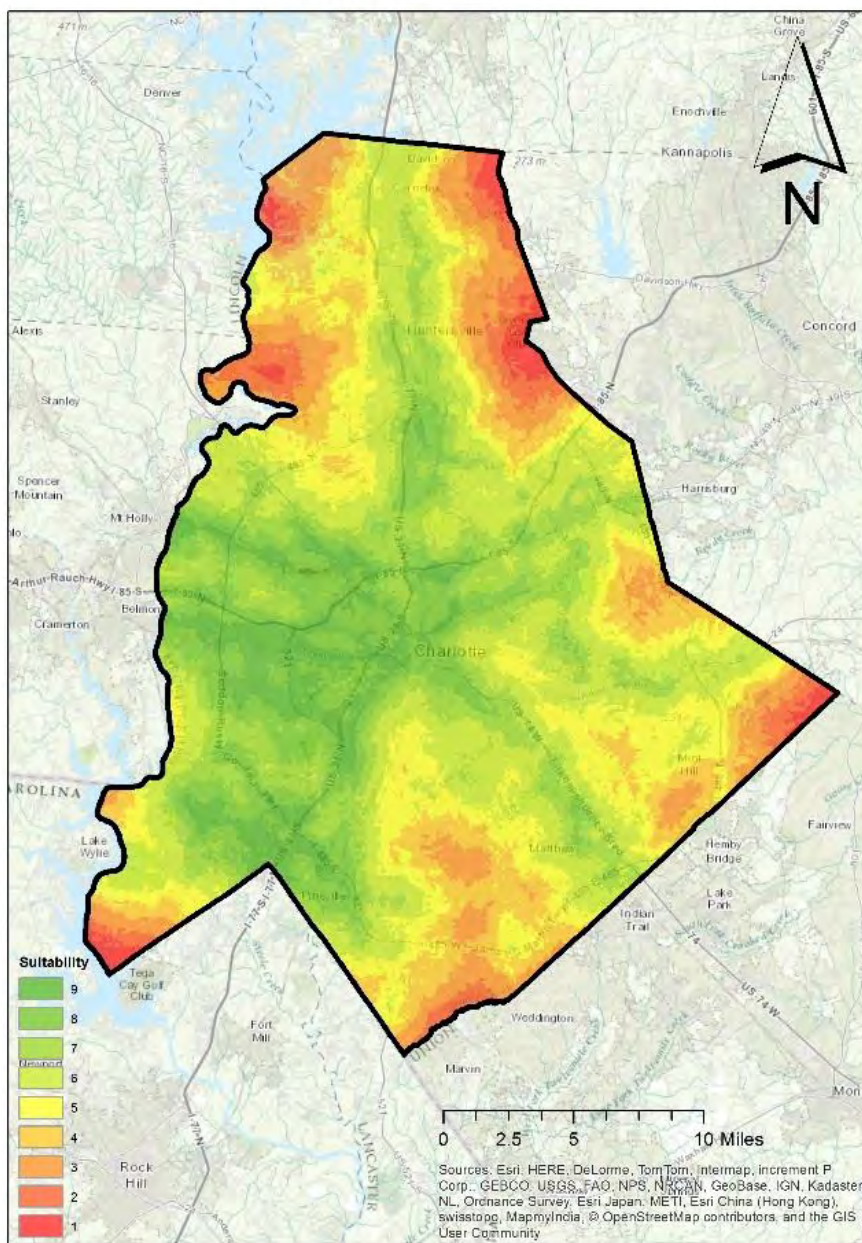


Figure 146: UG4042

Land use: Urban

Goal 4: Identify lands suitable for industrial land use

Input: Industrial Physical Suitability MUA (UG4O41), Industrial Economic Suitability MUA (UG4O42)

Rationale: Both physical and economic criteria are important in determining industrial suitability.

Output: Industrial Suitability MUA (UG4)

Criteria for Utility Assignment: The MUAs were combined and weighted equally using the Raster Calculator tool. Existing industrial parcels were reclassified using the Reclassify tool to designate a value of 9, and all other areas assigned a value of 1. Then a conditional statement was ensured that all existing industrial land retained their value of 9 and that all other land was assigned the weighted value resulting from the Raster Calculator equation.

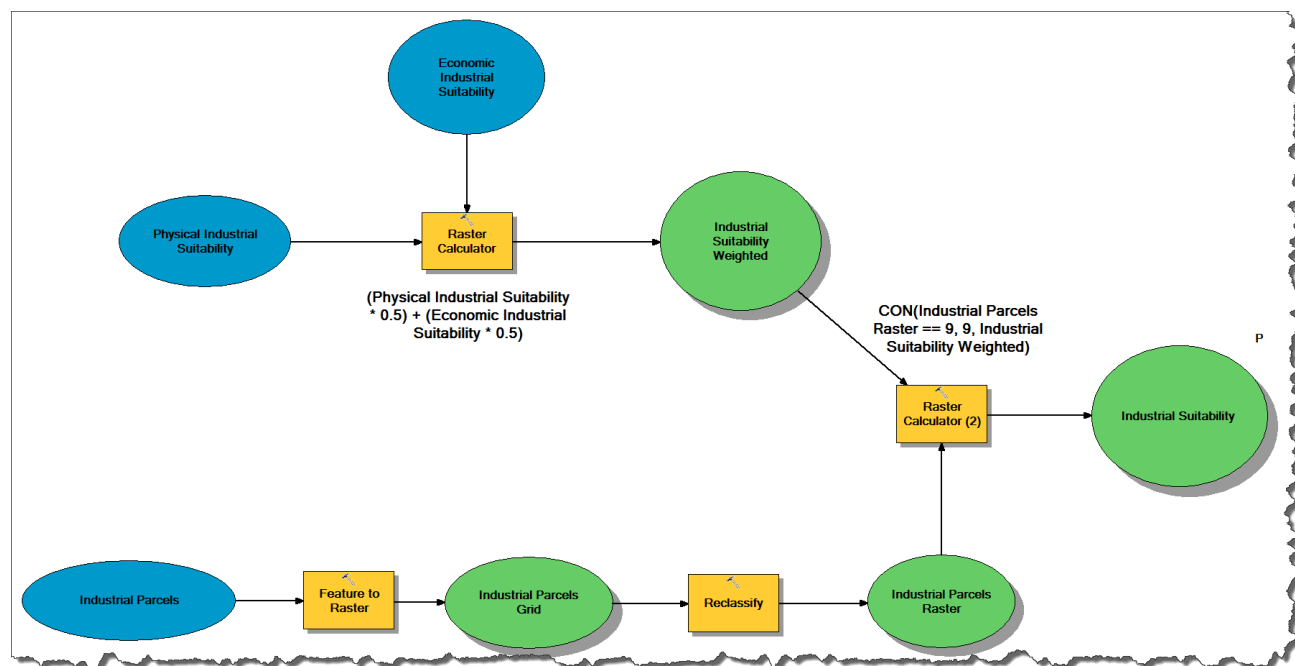


Figure 147: Identify lands suitable for industrial land use model

UG4

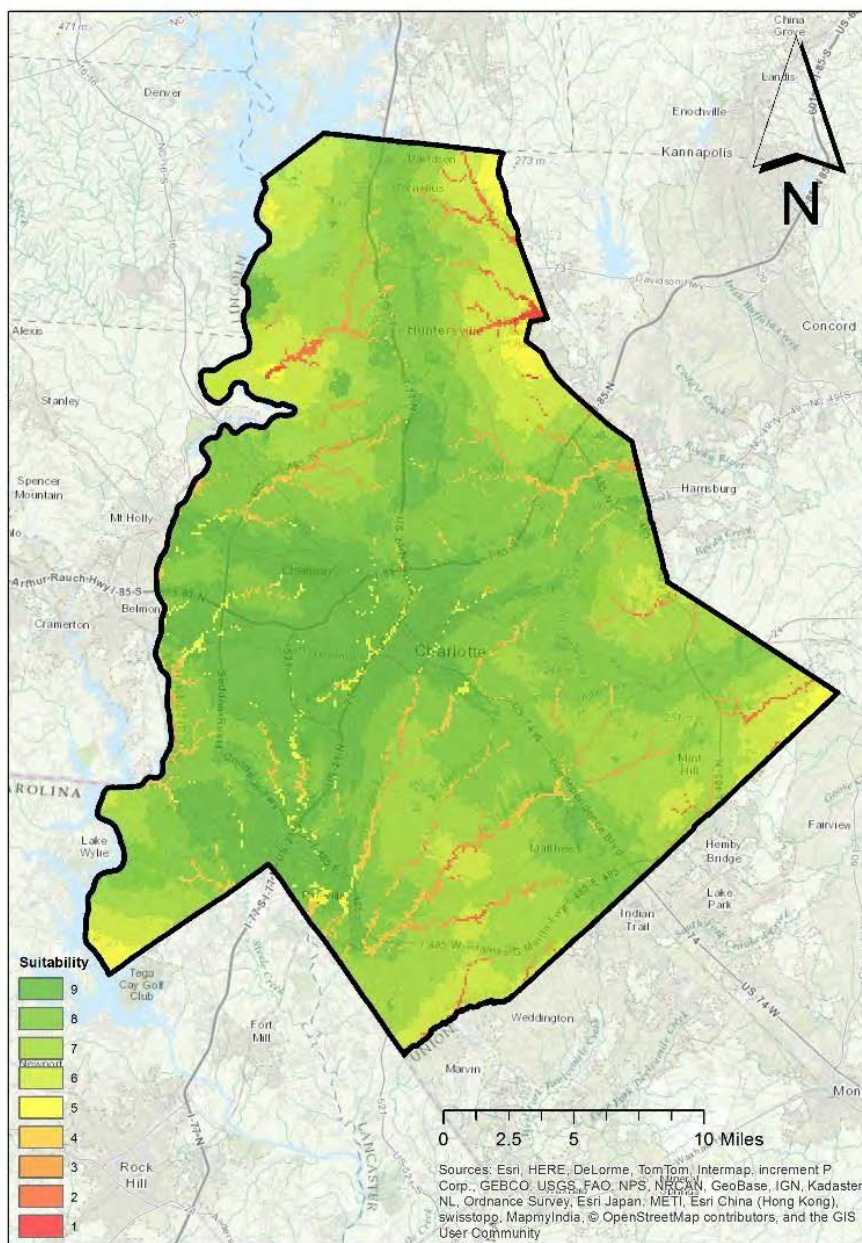


Figure 148: UG4

APPENDIX B

This appendix provides a description of each land-use code, its description, and the equivalent collapsed land-use category

Table 64: Collapsed land-use classification process designations

<u>Collapsed Land-Use Classification Process</u>		
Land-Use Code	Description	Collapsed Land-Use
1000	Rural Homesite	Agriculture
5000	Use Value Homesite	Agriculture
5310	Agricultural - Commercial Production	Agriculture
6100	Forest - Commercial Production	Agriculture
6210	Woodland - Excess on AG PCL	Agriculture
6711	Horticultural - Commercial Production	Agriculture
7000	Institutional	Urban Commercial
7100	Church	Urban Residential
7200	School, College, Private	Urban Residential
7300	Hospital, Private	Urban Commercial
7400	Home for the Aged	Urban Residential
7401	Nursing Home	Urban Residential
7500	Orphanage	Urban Residential
7600	Funeral (Mortuary, Cemetery, Crematorium, Maus)	Urban Commercial
7700	Club, Lodge, Union Hall, Swim Club	Urban Commercial
7800	Country Club	Urban Commercial
7801	Par '3' Golf Courses	
7802	Miniature Golf Courses	Urban Commercial
7803	Public Golf Course – Regulation	Conservation
7900	Airport	Urban Commercial
8000	Marina	Urban Commercial
8100	Military	Urban Industrial
8200	Recreation Area	Conservation
8300	School – Public	Urban Residential

Collapsed Land-Use Classification Process

<i>Land-Use Code</i>	Description	Collapsed Land-Use
8400	College – Public	Urban Residential
8500	Hospital – Public	Urban Commercial
8600	Other County Property	Other
8601	Water Plant	Urban Industrial
8602	Fire Department	Urban Commercial
8603	Recycling	Urban Industrial
8604	Disposal	Urban Industrial
8700	Other State (Marshland)	Conservation
8701	State Port	Urban Commercial
8800	Other Federal	Other
8900	Other Municipal	Other
8901	Municipal Education	Urban Residential
8902	Municipal Airport	Urban Commercial
8903	Municipal Housing Authority	Urban Residential
9000	Leasehold Interest	Other
9010	No Land Interest	Other
9100	Utility (Gas, Electric, Telephone, Telegraph, Rail)	Urban Industrial
9101	Utility	Urban Industrial
9200	Mining	Urban Industrial
9300	Petroleum and Gas	Urban Industrial
9400	Right of Way	Other
9401	Roadway Corridor	Conservation
9402	Utility Easement	Other
9500	Submerged Land, Rivers and Lakes	Conservation
9501	Island	Conservation
9600	Wasteland, Slivers, Gullies, Rock Outcrop	Conservation
9610	Buffer Strip	Other
9611	Wetland	Conservation
9612	100 Year Flood Plain – AC	Conservation

Collapsed Land-Use Classification Process

<i>Land-Use Code</i>	Description	Collapsed Land-Use
9613	100 Year Flood Plain – LT	Conservation
9614	FLUM/SWIM Floodway (No Build Zone)	Conservation
9699	Unsuitable for Septic	Other
9700	Mineral Rights	Other
9710	Less Mineral Rights (Taxed Elsewhere)	Other
9800	Owner Unknown	Other
9900	New Parcel	Other
9901	Transfer, Corrections	Other
9902	AC Change Only	Other
9904	Combination	Other
9905	Split	Other
9910	Deleted Parcel	Other
A500	Multi Family	Urban Residential
A501	Multi Family Common Area	Urban Residential
A503	Multi Family River	Urban Residential
A510	Multi Family Rural Acreage	Urban Residential
A512	Multi Family Water Frontage	Urban Residential
A513	Multi Family Golf Course Frontage	Urban Residential
A514	Multi Family Water Access	Urban Residential
A560	Multi Family Garden	Urban Residential
A561	Multi Family Townhouse	Urban Residential
A562	Multi Family Duplex/Triplex	Urban Residential
A563	Multi Family High Rise	Urban Residential
C700	Commercial	Urban Commercial
C701	Commercial Water Frontage	Urban Commercial
C703	Commercial Common Area	Urban Commercial
C711	Convenience Store	Urban Retail
C712	Car Wash	Urban Industrial
C713	Department Store	Urban Retail

Collapsed Land-Use Classification Process

<i>Land-Use Code</i>	Description	Collapsed Land-Use
<i>C714</i>	Supermarket	Urban Retail
<i>C715</i>	Shopping Center – Mall	Urban Retail
<i>C716</i>	Shopping Center – Strip	Urban Retail
<i>C721</i>	Restaurant	Urban Retail
<i>C722</i>	Fast Food	Urban Retail
<i>C723</i>	Bank	Urban Retail
<i>C725</i>	Commercial Service (Laundry, TV, Radio, Etc.)	Urban Commercial
<i>C726</i>	Service Station	Urban Commercial
<i>C727</i>	Auto Sales and Service	Urban Retail
<i>C728</i>	Parking	Urban Industrial
<i>C731</i>	Commercial Condominium Common Area	Urban Commercial
<i>C732</i>	Theatre	Urban Commercial
<i>C733</i>	Lounge, Night Club, Bar	Urban Commercial
<i>C734</i>	Bowling Alley, Skating Rink	Urban Commercial
<i>C735</i>	Commercial Condominium	Urban Commercial
<i>C736</i>	Business Park	Urban Commercial
<i>C737</i>	Hotel/Motel >6 Floors	Urban Commercial
<i>C738</i>	Furniture Store	Urban Retail
<i>C739</i>	Hotel/Motel <7 Floors	Urban Commercial
<i>C780</i>	Marina Land	Urban Commercial
<i>GC01</i>	Golf Course Class 1 - Championship	Conservation
<i>GC02</i>	Golf Course Class 2 - Private Club	Conservation
<i>GC03</i>	Golf Course Class 3 - Semi-Private & Municipal	Conservation
<i>GC04</i>	Golf Course Class 4 - Minimum Quality	Conservation
<i>I600</i>	Industrial	Urban Industrial
<i>I601</i>	Fertilizer Plant	Urban Industrial
<i>I602</i>	Seafood Processing	Urban Industrial
<i>I603</i>	Industrial Common Area	Urban Industrial
<i>I628</i>	Mini Warehouse	Urban Industrial

Collapsed Land-Use Classification Process

<i>Land-Use Code</i>	Description	Collapsed Land-Use
<i>I630</i>	Laboratory / Research	Urban Industrial
<i>I640</i>	Warehouse Condominium Common Area	Urban Industrial
<i>I641</i>	Light Manufacturing	Urban Industrial
<i>I642</i>	Heavy Manufacturing	Urban Industrial
<i>I643</i>	Lumber Yard	Urban Industrial
<i>I644</i>	Packing Plant	Urban Industrial
<i>I645</i>	Cigarette Manufacturing	Urban Industrial
<i>I646</i>	Brewery, Bottler, Cannery, Winery	Urban Industrial
<i>I647</i>	Warehouse Condominium	Urban Industrial
<i>I648</i>	Warehousing	Urban Industrial
<i>I649</i>	Steel Frame Warehouse	Urban Industrial
<i>I651</i>	Cold Storage	Urban Industrial
<i>I652</i>	Truck Terminal	Urban Industrial
<i>I653</i>	Service Garage	Urban Industrial
<i>I655</i>	Stadium	Urban Commercial
<i>NEW</i>	New Parcel	Other
<i>O400</i>	Office	Urban Commercial
<i>O418</i>	Office High Rise > 6 Stories	Urban Commercial
<i>O419</i>	Medical Office	Urban Commercial
<i>O420</i>	Medical Condominium	Urban Commercial
<i>O421</i>	Medical Condominium Common Area	Urban Commercial
<i>O424</i>	Office Condominium	Urban Commercial
<i>O425</i>	Office Condominium Common Area	Urban Commercial
<i>O431</i>	Day Care Center	Urban Commercial
<i>R100</i>	Single Family Residential	Urban Residential
<i>R111</i>	Single Family Residential – Common	Urban Residential
<i>R113</i>	Single Family Residential – River	Urban Residential
<i>R120</i>	Single Family Residential - Rural Acreage	Urban Residential
<i>R122</i>	Single Family Residential – Waterfront	Urban Residential

Collapsed Land-Use Classification Process

<i>Land-Use Code</i>	Description	Collapsed Land-Use
<i>R123</i>	Single Family Residential – Golf	Urban Residential
<i>R124</i>	Single Family Residential - Water View	Urban Residential
<i>R150</i>	Patio Home	Urban Residential
<i>R151</i>	Patio Home – Common	Urban Residential
<i>R153</i>	Patio Home – River	Urban Residential
<i>R160</i>	Patio Home - Rural Acreage	Urban Residential
<i>R162</i>	Patio Home – Waterfront	Urban Residential
<i>R163</i>	Patio Home – Golf	Urban Residential
<i>R164</i>	Patio Home - Water View	Urban Residential
<i>R200</i>	Mobile Home Subdivision	Urban Residential
<i>R201</i>	Mobile Home HS	Urban Residential
<i>R210</i>	Mobile Home Park	Urban Residential
<i>R220</i>	Recreational Vehicle Park	Urban Residential
<i>R300</i>	Condominium	Urban Residential
<i>R306</i>	Condominium High Rise	Urban Residential
<i>R309</i>	Town House SFR	Urban Residential
<i>R311</i>	Condominium Common Area	Urban Residential
<i>R313</i>	Condominium River	Urban Residential
<i>R320</i>	Condominium Rural Acreage	Urban Residential
<i>R322</i>	Condominium Water Frontage	Urban Residential
<i>R323</i>	Condominium Golf Course Frontage	Urban Residential
<i>R324</i>	Condominium Water View	Urban Residential
<i>R371</i>	Town House Common Area	Urban Residential
<i>R382</i>	Town House Water Frontage	Urban Residential
<i>R383</i>	Town House Golf Course Frontage	Urban Residential
<i>R384</i>	Town House Water Access	Urban Residential
<i>RSVD</i>	Reserved	Other