MODELING INFILL AND URBAN GROWTH TO EVALUATE AGRICULTURAL CONVERSION IN LAKE COUNTY, FLORIDA

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS IN URBAN AND REGIONAL PLANNING

UNIVERSITY OF FLORIDA

2011

To Mom and Dad

ACKNOWLEDGMENTS

First, I would like to thank my committee, Dr. Paul Zwick and Dr. Andres Blanco. In class and in meetings, Dr. Zwick provided the tools and the insight for me to “vision” and model future land use, which essentially provides the basis for this paper, so it wouldn’t have been possible without him. Dr. Blanco helped me with the nuts and bolts of writing a research paper, which until now I have had little experience with, so his assistance was greatly appreciated.

Additionally, I would like to thank my parents, who provided practical support that allowed me the time and space needed to produce this research. I also thank them, and everyone else who “cheered me on” during this process, to give me the moral support I needed to finish.

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LIST OF ABBREVIATIONS

AHP	Analytic Heirarchy Process
BEBR	Bureau of Economic and Business Research
CCA	Core Commercial Area
FDOR	Florida Department of Revenue
FGDL	Florida Geographic Data Library
GIS	Geographic Information System
GUA	Gross Urban Area
GUD	Gross Urban Density
LUCIS	Land Use Conflict Idenfication Strategy
MUA	Multiple Utility Assignment
MXD	Mixed Use Development
SUA	Single Utility Assignment
TDR	Transfer of Development Rights
TOD	Transit Oriented Development
UGB	Urban Growth Boundary
USDA	United States Department of Agriculture

Abstract of Thesis Presented to the Graduate School
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December 2011

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Major: Urban and Regional Planning

In recent decades, thousands of acres of agricultural land across the United States have been destroyed by agricultural conversion, in which farms on the fringes of urban areas are sold and developed as part of expanding urban growth. This study explores whether redirecting some portion of new urban growth within urban areas, (a phenomenon known as urban infill) rather than on their fringes, can help save farmland and crop yield. This was accomplished through a series of thirty-year time horizon urban growth and infill simulations for a rapidly growing but agriculturally productive county in central Florida, Lake County.

The results showed that while increased urban infill will slow the expansion of urban sprawl in Lake County, even with intensive infill a majority of farmland and crop yield in the county faces agricultural conversion. These results are attributable to the small area available for urban infill in the county and a large projected incoming population. However, the results also suggest that an increase in new urban growth density could have a greater impact than infill in curbing sprawl and mitigating conversion.

CHAPTER 1
OVERVIEW

The issue of “urban sprawl” has long been a well known phenomenon of post-World War II America, popularly thought of as a mass of low-density suburban development extending out from established cities. It is cited as being the source of several problems that may be environmental, economic, or even social in nature (Daniels and Bowers, 1997). One of these frequently mentioned problems is the conversion of agricultural land to non-agricultural uses, usually as a result of urban expansion. Many statistics reflect that this is a very real phenomenon: In 1997, one million acres of farmland was disappearing each year in the United States as a result of “suburban sprawl”, including 150,000 acres per year in Florida, which was the fastest rate in the nation (Daniels and Bowers, 1997, p.134). By 2003, the national rate of farmland disappearance had jumped to over three million acres per year (Hoobler, et al., 2003). In addition, more of the best remaining farmland is threatened. Over half of agricultural production in America, in terms of value, comes from counties “in and around urban areas” (American Farmland Trust, 1997, p.3).

If urban sprawl is destroying farmland, it is intuitive that slowing the growth of sprawl will also slow the destruction of agriculture. However, this can’t come at the cost of halting urban growth, which is economically and politically impossible.

Growing within an existing urban area is one way of slowing outward sprawl without slowing urban growth; when this is accomplished, the result is urban infill. By making use of the gaps of land within a scattered urban landscape, or the vacant parcels within a hollowed-out urban core, a city can avoid placing all of its new growth on the urban fringe.

The aim of this study is to determine to what extent it is possible to preserve agriculture if a region pursues intensive infill as part of its future urban growth, as opposed to continuing to grow at the current gross urban density. This was accomplished through a scenario-building simulation for Lake County, Florida, set over a period of thirty years from 2010 to 2040. Lake County has grown rapidly over the past ten years and is projected to continue to do so; as such, the time horizon of thirty years provides ample time to model this growth, and determine if urban infill will indeed alleviate agricultural conversion for this region.

The study is divided into three sections. First, an infill simulation was conducted for the county, using up-to-date property records to determine where urban infill is possible. A model of both commercial and residential infill was produced, using densities that are intensive for this county, but still tempered to some degree to be compatible with the current urban landscape.

The results from this section feed into five urban modeling scenarios, using a population allocation methodology developed for LUCIS, a land-use modeling system. These scenarios model urban growth for the year 2040, and show infill implementation to varying degrees.

Finally, the urban growth in each scenario was spatially compared to current farmland in Lake County to determine which farms were eliminated by sprawl. The loss in acres, potential crop yield, and the cost of this lost crop yield were calculated.

With Lake County as an example for many similar regions around the nation, a broad goal of this study is to shed light on the degree of threat that much of America's farmland faces from urban development. More specifically, it should establish a relationship between urban infill growth and agricultural preservation that could be used to inform policy aimed at solving the conversion issue.

CHAPTER 2
LITERATURE REVIEW

The purpose of this literature review is to outline the problem of agricultural conversion, provide an overview of urban infill development and show how it connects to alleviating conversion, and then describe how land use suitability analysis is a basis for creating future land use scenarios, which can model this interaction between infill, urban growth, and agricultural conversion.

Agricultural Conversion

This first section will explore why farmland conversion is an issue worth studying, how this phenomenon typically occurs, and what solutions have been proposed to help solve this problem.

Today, the United States is the third most agriculturally productive nation in the world in dollar value (Central Intelligence Agency, 2011). Because of the incredible productivity of US farms, Americans pay “the smallest percentage of their income for food”, around 12% (Daniels and Bowers, 1997, p.9). The U.S. also produces nearly half of the world’s grain and plays a critical international role as a food exporter. Meanwhile, food production must continually increase to meet global demand, and in fact, food prices worldwide are already rising because of increasing demand (American Farmland Trust, 1997). Given these facts, preserving productive farmland is critical for the food security of both the United States as well as the rest of the world. Without an “investment strategy”, it will be difficult to respond to rising global demand for food (American Farmland Trust, 1997, p.6).

Preserving currently productive farmland is also an environmentally smart strategy that helps protect other natural resources. It is true, of course, that there are environmental concerns with any farmland, including fertilizer and pesticide runoff. However, these problems are compounded when urban development replaces farmland. Soil naturally absorbs and filters stormwater runoff, unlike the impervious surfaces of developed land, which also add their pollutants to the runoff, such as lawn fertilizer, oil leaks, road salt, and even heavy metals (American Farmland Trust, 1997). Meanwhile, additional environmental damage will occur when farms must then move to marginally suitable land. Additional fertilizers and pesticides, as well as expensive land preparation, will be required to make this land productive, and these will further serve to damage once-natural land that the farmland was pushed out to (American Farmland Trust, 1997; Berry, 1983).

Finally, keeping farms productive is an economically wise decision. Besides the nearly 1.1 million employees working in crop production and support activities in the US, (U.S. Bureau of Labor Statistics, 2008), agriculture is also an export activity – an important distinction in an age when we are struggling to find ways to balance a wide trade deficit (American Farmland Trust, 1997). Additionally, agricultural land uses are more self-supporting than the residential uses that frequently replace them. Farms “more than pay for the municipal services they require”, in contrast, tax revenues from residential uses “consistently fail to cover costs” (American Farmland Trust, 1997, p.7-8). Lastly, the best economic use of farmland may not necessarily be what the free market dictates, i.e. its “highest and best” use. Farmland on the fringe of growing residential areas can be inflated by “home mortgage deductions”, public expenditures on infrastructure, artificially low gasoline prices, and sometimes, by simply the expectation of growth (American Farmland Trust, 1997, p.7).

The replacement of farmland with urban development can occur for several reasons. First, developers seeking to build close to farms can bid up land prices higher than what surrounding farmers can pay, or tempt them to sell their land (Daniels and Bowers, 1997). In Florida, as in much of the country, farm areas close to major cities have a greater “fair market value” than they have an “agricultural value”, as a result of the profits to potentially be made on the development, even if “land prices are high”. Selling as a result of high land prices is especially attractive to farmers who are heavily in debt, and many are (Herndon, et al., 1982, p.34 – 35; Reynolds, 2001). Encroaching development can also cause tax assessments to go up, and as public expenditures increase, tax rates rise as well. This will put financial pressure on the farmer as urban development grows around them (Herndon, et al., 1982, p.34). Unfortunately, land that is most suitable for farming is also the cheapest to develop for urban uses, as it is well-drained and gently sloping, and thus, non-agricultural land uses often spread onto land with the best farming soils (Daniels and Bowers, 1997; Freedgood, et al., 1997).

Conflict between new urban emigrants and farmers can also occur, causing the sale of farmland: the non-farming neighbors may complain about the smell, noise, or other environmental effects caused by farms, while the farmers may suffer crop or livestock damage from trespassing, dog attacks, or stormwater runoff. Conflict from both sides serves to push the farmers to move, as the new immigrants living on the urban fringe gain political power and pass “nuisance ordinances” aimed at the farmers (Daniels and Bowers, 1997, p.4). Finally, competition with urban centers over water resources can leave farmers with additional hardship, giving them further motivation to sell. The growth of “urban wellfields” can lead to “saltwater intrusion into ground water supplies", which then damages agricultural water supply (Herndon, et al., 1982, p.39; Berg, 1983).

Solving Agricultural Conversion

Many solutions to mitigate farmland conversion have been attempted or proposed. Generally speaking, they fall into two categories: regulatory policies and incentivized policies.

Regulatory Policies

Regulatory policies seek to prohibit certain types of development from occurring in designated areas, or at least slow their growth. Urban growth boundaries and agricultural zoning have been two growth management tools, often used in tandem, to contain rapid urban growth and keep agricultural conversion at bay. Oregon's growth management legislation, the 1972 Land Conservation and Development Act, is one of the most proactive examples of agricultural protection through regulation (American Farmland Trust, 1997). It has required all cities and counties in the state to create urban growth boundaries, in order to contain urban growth in designated urban areas where "basic services" such as utilities, police, and fire protection can be provided (Daniels and Bowers, 1997, p.136-139). As a result of this legislation, which also required agricultural zoning, "16 million acres of agricultural land have been protected from development" (American Farmland Trust, 1997, p.30). However, the effectiveness of urban growth boundaries between cities has been uneven. A study conducted 17 years after the initial legislation indicated that while only 5% of new homes in Portland were built outside its UGB, 57% of new homes were built outside the UGB in the Bend region. In addition, threats to Oregon's farmland continue with scattered homes outside the

UGBs that have “on-site septic and well systems” as they cannot be connected to utilities within the UGBs (Daniels and Bowers, 1997, p.141).

Agricultural zoning is another regulatory strategy that is often combined with urban growth boundaries. Although Florida’s Growth Management Act doesn’t contain an agricultural protection zoning provision, APZ has been practiced locally. Martin County, for example, has designated 210,552 acres of its land as part of an APZ plan. Here, residential development is limited to “one single-family unit per gross 20-acre tract”, though exceptions are made for farmworkers’ housing. There is also a buffer zone between urban areas and the agricultural zone, to protect farmland from edge effects (Scott, 2007).

Incentivized Policies

Incentivized policies differ from regulatory policies in that they are not a steadfast prohibition on activity, but offer financial incentives for the parties involved to follow a desired course of action. Purchase of agricultural conservation easement and transfer of development rights programs are significant incentivized policies that can be used to protect farmland or natural, conservation-suitable land that is owned privately. In a PACE program, a farmer will sell their development rights to a government agency or private organization, and an easement is placed on the farmland property to prevent it from being developed later if it is sold. Transfer of development rights differs in that rights are purchased by a developer for “credit” to develop in “areas planned for growth” (American Farmland Trust, 1997, p.36-37). These areas are known as “receiving areas”, and developers are permitted to build here at increased densities, provided that they purchase development rights credits from the landowners in the areas to be protected – the “sending areas”. A permanent easement is then placed on the property in the sending area to prevent it from being developed. TDR is a major part of the North St. Lucie County Towns, Villages, and Countryside Plan, which aims to encourage growth in the “towns and villages” designated in the plan and away from “countryside” (Scott, 2010).

Infill

Urban infill is generally defined as being the development of vacant, underutilized, or abandoned land within urbanized areas. Infill development can take many forms: residential, office, retail, industrial, or a mix of uses is common. As urban land, infill parcels are generally expected to already have access to available sewer, water and other public services, but this does not always mean they are more economical to develop than land on the fringe, as often the vacant land was bypassed because of problematic “physical conditions”, “ownership problems”, or other issues (Real Estate Research Corporation, 1982; Smart, 1985). However, there are several reasons why an infill-favorable policy might be chosen. The cost of constantly expanding infrastructure to a scattered fringe could become frustratingly high, especially with gradually rising energy costs; there might be a desire to encourage transit ridership or to revitalize an aging neighborhood with new business and a broader tax base; or, any of the other problems caused by sprawl, such as agricultural conversion or environmental degradation, may give cause to grow inward instead of out (Real Estate Research Corporation, 1982).

Infill and Transit Oriented Development

Urban infill can be part of a larger vision of urban redevelopment, concentrating on transit oriented development, higher densities, and the continuous, compact urban form that infill creates. In “The Next American Metropolis: Ecology, Community, and the

American Dream", Peter Calthorpe describes a "new context and direction for the built environment" that includes compact, walkable, mixed-use, transit friendly urban form "oriented toward the public domain and human dimension rather than the private domain and auto scale" (Calthorpe, 1993, p.41). His description of the guidelines for development in a city built by these principles are quite detailed, and as he claims, they can be used for a variety of purposes: to "redirect and reconfigure" a comprehensive plan; to revise existing zoning ordinances to allow for "more mixed-use, pedestrian-oriented land plans"; to establish an urban growth boundary; and most importantly for the purposes of this study, "to designate appropriate new growth and infill areas" (Calthorpe, 1993, p.41).

Calthorpe divides his model city into two main zones: the transit-oriented development (TOD) and Secondary Areas. The TOD combines core commercial areas, office space, residential units, and public uses, all with walking distance of transit opportunities. It is compact, and development is of higher density than the rest of the city. A large infill site can provide a space for "all or a major portion of a TOD", while underutilized areas adjacent to the site can be redeveloped if additional space is required. A city may have multiple TODs, which are separated and surrounded by Secondary Areas. This development type is lower density, and primarily focused on housing. However, other uses that are too large for a TOD are found in the secondary areas, such as school campuses, parks, "large employment sites" and small corner stores. However, it is important to note that the commercial uses in secondary areas should not significantly compete with the commercial districts in TODs, so as to not lead to auto-centric "edge cities" in the secondary areas (Calthorpe, 1993, 69, 87-88).

Infill Challenges

Calthorpe's model is a rather idealistic one – there are still many challenges and particular requirements that developers and governments face in creating infill. One of the most important is that infill developments must fit within its context. This is true in terms of its use, its physical form, and even its socioeconomic and cultural attributes (Smart, 1985). The design of the infill development should "create a sense of continuity" with its surroundings, as it needs to be "part of the everyday fabric of the neighborhood" where people will work, shop, and live, and a contrasting design may evoke hostility or be rejected (Smart, 1985, p.18). This suggests that some high-density infill developments in the wrong context, such as a low-density suburb, may not be successful. However, "infill development typically implies an increase in density", and this is "often acceptable when the product creating it is superior". Design techniques such as "stepping back" the upper floors of a taller structure can alleviate its sense of height from the street. Parking solutions such as "below-grade, off street" parking and nearby off-site parking can alleviate the additional demand for parking (Smart, 1985, p.22, 25).

Besides the importance of context, infill development faces several other challenges. Though fairly obvious, it's certainly worth mentioning that a healthy economy and a steady growth rate are required for a region to have any significant infill development. If any growth is difficult for a community, infill will not be easy either, even if the city has suitably vacant, publicly serviced land available (Real Estate Research Corporation, 1985).

The size of developable vacant parcels may also be restrictive, particularly for commercial uses. The most effective retail developments are regional centers for commerce that combine many businesses, and thus require a large area to be built. Unfortunately, the median size of infill parcels is relatively small, making many unsuitable for large-scale retail development (Real Estate Research Corporation, 1982), such as what might be required in Calthorpe's (1993) TOD, which is anchored by a major commercial development.

The regulatory environment can also be an impediment to infill development. It is very important that research by the developer be conducted ahead of time to ensure that the local comprehensive plan and zoning ordinances are compatible with the type of infill development being proposed (Smart, 1985). However, if the locality has made a commitment to encouraging infill development, it can change its part of the regulatory environment to favor infill rather than hinder it.

Finally, any proponent of infill development must realize that it "can only accommodate a portion of future growth". To some degree, the urban area needs to keep expanding, as the capacity of vacant land to provide for future growth needs is limited, especially in a rapidly growing locality. Any policy to force all growth into this limited area can cause a "serious inflation of land and housing prices" (Smart, 1985, p.2). Fortunately, most urban growth boundaries take at least some future urban expansion into account.

Infill and Agricultural Preservation

Fortunately, by accommodating at least some portion of future growth, infill can function as a "method of preserving land" (Real Estate Research Corporation, 1982, p.1). It does this by diverting urban growth into already existing urban areas, which serves to "reduce pressures to expand urban and suburban areas further into the countryside" (Scott, 2010, ¶1). By acting as an inhibitor of sprawl, which as has already been discussed is a direct threat to agriculture, infill is therefore a catalyst of agricultural protection.

The relationship between agricultural preservation and infill development is also illustrated by how incentivized and regulatory agricultural preservation policies also encourage infill. Besides putting a halt to sprawl that would cause agricultural conversion, Urban Growth Boundaries also incentivize the use of vacant urban land, since the opportunity for edge development is restricted. In practice, this opportunity to fill in vacant land at higher than sprawl densities has not been missed, and as such, UGBs have not been a detriment to growth (Daniels and Bowers, 1997).

TDR programs also feed directly into urban infill. In return for buying the rights from the sending areas, the developer is allowed to build at a higher density than perhaps they otherwise would be able to in the receiving area, which serves as an incentive for them because of the additional units or square footage they are able to sell. Additionally, TDR programs give governments the ability to designate where those receiving areas should be located (Scott, 2010). They could use this power to create a receiving area for a vacant parcel in a flagging inner-city neighborhood, and the resulting high-density infill project might serve as a focal point for economic development in the neighborhood. This basic model was used in West Palm Beach to take development pressure off of areas with historic structures and create a substantial amount of higher-density residential capacity downtown (Scott, 2010). Although this program was used to preserve historic areas rather than farmland, it goes to show the potential combination of preserving land and creating infill that TDR can provide.

Land Use Suitability Modeling

Policy implementation can help guide agricultural preservation and infill development. Land use analysis is an important tool for planners to help them predict or demonstrate the effects of policies or other factors that affect land use. By using analysis techniques to create a model representing the future of a region, a planner can make better land use decisions. Land use suitability analysis is a popular modeling technique, which is, as its name suggests, is “a tool used to identify the most suitable places for locating future land uses”. By finding the interaction between “development actions”, environmental (which can include agricultural) impacts, and where these occur spatially, policy makers, officials, and the public can make better-informed decisions about land use (Collins, Steiner, and Rushman, 2001, p.611).

Overview

Land use suitability analysis has its roots in Ian McHarg’s landmark 1969 book *Design with Nature*. McHarg drew a distinction between the unplanned sprawling nature of American urban areas with a more deliberate pattern of development that takes into account many criteria from geology, ecology, and human values, to create an urban form with land uses that are more appropriate for their natural context. He used land use and land cover maps to show where different uses would be more or less appropriate – for instance, land with geologic properties that have “a capacity to bear foundations of high-density construction” would be more appropriate for high-density construction (McHarg, 1969, p.158). By overlaying relevant maps together, he created composite maps that used shades of gray to show relative suitability for a given use (McHarg, 1969). This methodology readily lent itself to computer-aided analysis when such technologies became available. Early computer mapping programs such as

SYMAP and IMGRID used grids containing varying statistical values that could be overlaid with each other, much like the grayscale maps McHarg produced. From this, Geographic Information Systems, (GIS) which are able to "store, analyze, and display spatial and nonspatial data" soon developed. The ability of GIS to perform spatial searches, automated overlays, and map algebra greatly advanced the potential of land use suitability analysis (Collins, Steiner, and Rushman, 2001, p.614).

Suitability analyses can be used in planning for the purposes of avoiding a specific impact on a land use (agricultural or environmental) by showing where that land use is most suitable, in order to prioritize preservation efforts for that land use. In Wyoming, Land Evaluation and Site Assessment (LESA), a suitability model developed by the USDA, was utilized through GIS to identify agricultural suitability in Park County, Wyoming. The land evaluation component of this methodology analyzed suitability of the land itself for agriculture, taking into account factors such as soil type and quality, crop yield, and slope. Site assessment looked at geographic features, especially those that might be harmful in proximity, such as roads, sewer lines, and other development. The result is a map showing relative suitability for agriculture in the county. This was compared to the county land use plan, and found to be generally compatible with it, so few policy changes were needed. However, if conditions were to change, the suitability map can be rapidly and easily adjusted with new data, and appropriate changes could then be made to the Park County land use plan if needed, so agriculture in Park County can continue to be protected (Hoobler, 2003).

Suitability can also be used to direct urban growth to certain areas, rather than to preserve land for certain uses, as in the above example. Multi Criteria Decision

Analysis was used with the GIS program MapInfo to create a suitability surface for housing in an area of Switzerland. Eight criteria were used to calculate suitability for every point in the study area. However, because of computational limitations, the suitability surface had to be reclassified into three categories of suitability. The areas designated as “suitable” identified where the growth of housing should be encouraged (Joerin, Thériault, and Musy, 2001).

Land Use Modeling with LUCIS

Unlike the above methodologies, which use one suitability type to direct urban development to or away from a given area of land, The Land-Use Conflict Identification Strategy, or LUCIS, is a land use analysis methodology that uses three suitability types (which become “preference” – this will be explained later) in tandem to make smart land use decisions. These include: urban, agricultural, and conservation suitability. As one would expect, suitability for these three land uses will often come into conflict for some locations – but this is a strength of the methodology, rather than a weakness. By mapping conflict, future land-use allocations can be projected, and the effects of different policies or land-use decisions can be examined (Carr and Zwick, 2007).

LUCIS follows a five-step methodology to create this conflict surface. First, goals and objectives are defined. These “become the criteria for determining suitability”, with the goals being the broadest categories of criteria for each suitability type (agricultural, urban, and conservation), while objectives become the criteria for each goal, and subobjectives become the criteria for the objectives (Carr and Zwick, 2007, p.12).

The second step is to collect relevant data that will serve as the criteria for each goal and objective. This data must fit the boundaries of the study area so a complete suitability surface can eventually be created, and it must be compatible with ESRI’s

ArcGIS software. This is important because LUCIS makes heavy use of the spatial analyst extension for ArcGIS (Carr and Zwick, 2007).

Data is converted to suitability in the third step of LUCIS. Single utility assignments (SUAs) are raster data layers created from a single layer of spatial data, and generally represent the subobjectives defined in step one (if an objective has no subobjectives, the SUA represents the objective itself). To create a SUA, the spatial data must be converted to utility values ranging from one to nine. There are many ways to do this, which depend on the data type (nominal, ordinal, interval, or ratio). The most common is simply assignment of values by the modeler, with the idea that values of nine are roughly nine times as suitable as values of one. More complex methods are possible, however, such as the Analytic Hierarchy Process (AHP), in which weights are calculated for layers based on their assigned importance. The data is then converted to raster format, if it hasn't been already. SUAs are then added together into Multiple Utility Assignments (MUAs), which represent Objectives, using Spatial Analyst. MUAs can then themselves be combined to create a raster surface representing the Goals of the project. Combining these layers requires weighting the constituent SUAs and MUAs, and there are also many ways to do this, from a simple rank sum method (dividing a layer's inverse rank by the sum of ranks) to using AHP as discussed above (Carr and Zwick, 2007).

The results are suitability layers which represent each goal. In the fourth step of LUCIS, these are then combined to create layers representing preference for the three land use types LUCIS uses. Preference differs slightly from suitability in that it captures the human partiality for a given use, as opposed to simply asking what features are more suitable for a given purpose. Stakeholders, whether they consist of a team of experts or a community, assign preference values to each goal, usually using AHP. Weighted values are calculated based on these preferences, and the goal raster datasets are add together to produce land-use preference rasters (Carr and Zwick, 2007).

The final step of LUCIS process uses the preference layers to map conflict between land uses. This requires first removing areas from the preference layers where there are land uses that are not likely to change – these include water features, urban areas, or protected land. The land left behind, that is susceptible to change, is referred to as “greenfield”. Next, the values of each preference layer are normalized so that they are on a common scale. This is done by dividing each value in the raster by the raster’s highest value, so that all values range from 0 to 1.0. The preference layers are then collapsed into three classes representing high, medium, and low preference. A number of classification methods can be used to accomplish this, including Equal Interval and Standard Deviation, among others. Finally, the preference layers are combined using the Combine tool. This does not mean that any mathematical operation is performed between the layers to produce a result, but rather that the preference layers are overlaid on top of each other, with the data from each layer forming a new field in the resulting table, and each record a unique combination of values. In this case, there are 27 separate combinations of high, medium, and low preference for agricultural, conservation, and urban use. Combinations that share preference values for multiple land uses show areas of land use conflict, while combinations in which one use is preferred above others show areas of no conflict. Major conflict occurs when all three preferences are equal (Carr and Zwick, 2007).

The resulting conflict surface produced by the LUCIS process can then be used for future land-use allocation scenarios, as one was in this study. Cells in this map without conflict can be “allocated” to simulate new urban growth (Carr and Zwick, 2007). Making infill a factor in this scenario will affect the amount of urban growth projected, changing the number of allocated new growth cells accordingly. The allocation map representing this growth can then be compared with other spatially referenced datasets, such as for farmland properties, as a way of measuring agricultural conversion. A methodology for accomplishing this is covered in much greater detail in Chapter 4.

CHAPTER 3
STUDY AREA

Overview

Despite the recent recession and resulting unprecedented outflow of population in Florida, a state that has for decades been known as one of the nation's fastest growing, the recent 2010 US Census reveals that this drop may have been only a short, insignificant drop in growth that is otherwise strong and continuous. The 2010 Census recorded an increase of 2.8 million additional residents from 2000, exactly as had been projected, by the Bureau of Economic and Business Research (BEBR) at the University of Florida.

Lake County (Figure 3-1) is likely to be no exception to this trend of continued growth. It grew 41%, from 210,528 residents to 297,052, between 2000 and 2010. This growth made it the 23rd fastest growing county in the nation between 2000 and 2006, while also experiencing a 41% growth in housing in this time period (US Census , 2010). Its growth potential is also huge; the county has a median 2040 population projection of 520,700, a 75.3% increase over its 2010 population of 297,052 (US Census, 2010; BEBR 2011).

County Characteristics

There are several factors that make Lake County a meaningful place to model future agriculture conversion. The first is the aforementioned high rate of population growth. Population growth fuels urban growth, and as discussed in Chapter 2, urban growth causes agricultural conversion. Very simply, this makes Lake County a prime candidate for the conversion of farmland. In fact, this has already occurred rapidly over the past decade. Between 2002 and 2007, farmland in the county dropped from

180,245 acres to a mere 121,422 acres. In other words, a third of all farmland in Lake County went out of operation in only five years. This includes an almost unbelievable drop from 73,958 acres to 34,681 acres of cropland in the same time period – well over half (USDA, 2007). While these statistics reflect only gross losses in agricultural land, rather than conversion, these drastic reductions in farmland came at a time when the county's population was skyrocketing, providing both the direct and indirect effects discussed earlier that lead to agricultural loss.

The county might be best characterized as a low-density suburban "bedroom community" supporting the much larger Orange County, with which it is part of the Orlando-Kissimmee-Sanford, Metropoltian Statistical Area, along with Osceola and Seminole counties. The commuting statistics for the county support this notion. Only 36.6% of working residents are employed in Lake County itself. Almost as many (34.5%) work in the other counties of Greater Orlando, with the largest proportion (27.4%) working in Orange County (On The Map, 2009).

As discussed in Chapter 2, a low density, scattered urban form such as that found in outer suburban areas tends to hasten agricultural conversion. As of 2005, the county has a Gross Urban Density (GUD) of 1.81, which is typical of other counties in Florida with suburban/exurban development on the edges of larger metropolitan areas, such as in Hernando (1.82), Santa Rosa (1.97), and Clay (2.07) counties (Zwick and Carr, 2006). The county is also profoundly decentralized – it contains fourteen separate municipalities, the largest of which, (Leesburg) contains only 6.77% of the county's population. With so many separate municipal authorities, coordination for the purposes of growth management can be difficult, increasing the risk of future sprawl.

Planning Policy

In the 387-page 2010 Lake County comprehensive plan, there is some mention of encouraging urban infill development, as well as some concern for preserving farmland. However, both of these topics are only mentioned briefly and without specifics for their implementation, and infill is never proposed as an agricultural conversion solution. Infill for “Residential uses” for example, is “encouraged” in areas that already have “adequate existing infrastructure”, but with no mention of how this is to be done, or why (King, 2010, p.32). Commercial infill is only referenced as something “allowed within designated commercial corridors”, which occur along major highways in the county (King, 2010, p.29, 52-53).

One potentially useful tool implemented in the plan is the use of a “Rural Transition Future Land Use Category”, the purpose of which is to provide a “compatible boundary that protects natural resources and the integrity of rural lands.” Land with this designation has tight restrictions on what can be built, and maximum densities are very low – “one dwelling unit per five (5) net buildable acres” (King, 2010, p.20). While these restrictions may lessen the impact of the urban fringe on adjacent agricultural land, they would do nothing to stop that edge from advancing.

Buffers aimed at protecting agricultural lands are more directly addressed in a policy section that mandates buffers a minimum of fifty feet wide between “any new subdivision of 25 acres or more and active agricultural lands”. The purpose of the buffers is to eliminate threats or nuisances for the sake of both agricultural as well as residences, “so that the long term continuance of both uses is not threatened” (King, 2010, p.44).

Actual conversion of agricultural lands into urban development is rarely addressed. The most direct control on agricultural conversion is a restriction against "residential developments" that are "premature" as a result of a list of possible factors, one of which is incompatibility with "adjacent and adjoining land uses, such as agriculture" (King, 2010, p.42). However, there is no further detail, so it is unclear what incompatibility might entail.

The county's "Economic Action Plan" (http://www.lakecountyfl.gov/...), which is a more accessible document for the general public, is somewhat more specific in its encouragement of infill development, thought it makes no mention of agricultural preservation, or even of agriculture at all. As part of a goal to "protect and improve our quality of life" as well as "maintain the proper balance between job creation and the protection of our natural resources", the plan orders that regulatory changes be explored to "to encourage small, infill residential development" as a way to "enhance our downtown districts and urbanized areas". That "protection of…natural resources" are mentioned as a motivating factor might indicate some acknowledgement of the harmful effects of sprawl, and the potential of infill to mitigate this. The rest of the plan is almost entirely devoted to economic development, which appears to be the county government's first priority (Lake County Board of County Commissioners, 2007, ¶H).

Agricultural Profile

Lake County has historically been known as a major agricultural region, with "Florida's largest peach orchard in the 1920s" and citrus production that was "second in the world" in the 1960s. However, a "series of freezes" in the 1980s caused the citrus industry to decline, and some farmers moved south (Lake County Board of County Commissioners, 2007, ¶4). However, despite these and more recent declines, Lake

County remains an agriculturally productive region. As of the 2007 USDA Agricultural Census, the county has 1,814 farms, which produced $188,519,000 worth of agricultural goods for that year. 121,422 acres of farmland remain in the county, with 34,881 acres of this in cropland. Citrus still makes up a significant part of this, with 12,381 acres of orchards. Also significant are the 20,010 tons of hay and grass silage produced on 6,738 acres. Minor crops include vegetables, with 274 acres; non-citrus fruit (besides berries) with 238 acres; berries, 128 acres; and nuts, 180 acres. Animal products are also an important part of Lake's agricultural output, with 21,319 head of cattle on 767 farms, with 9,137 sold in 2007 (USDA, 2007).

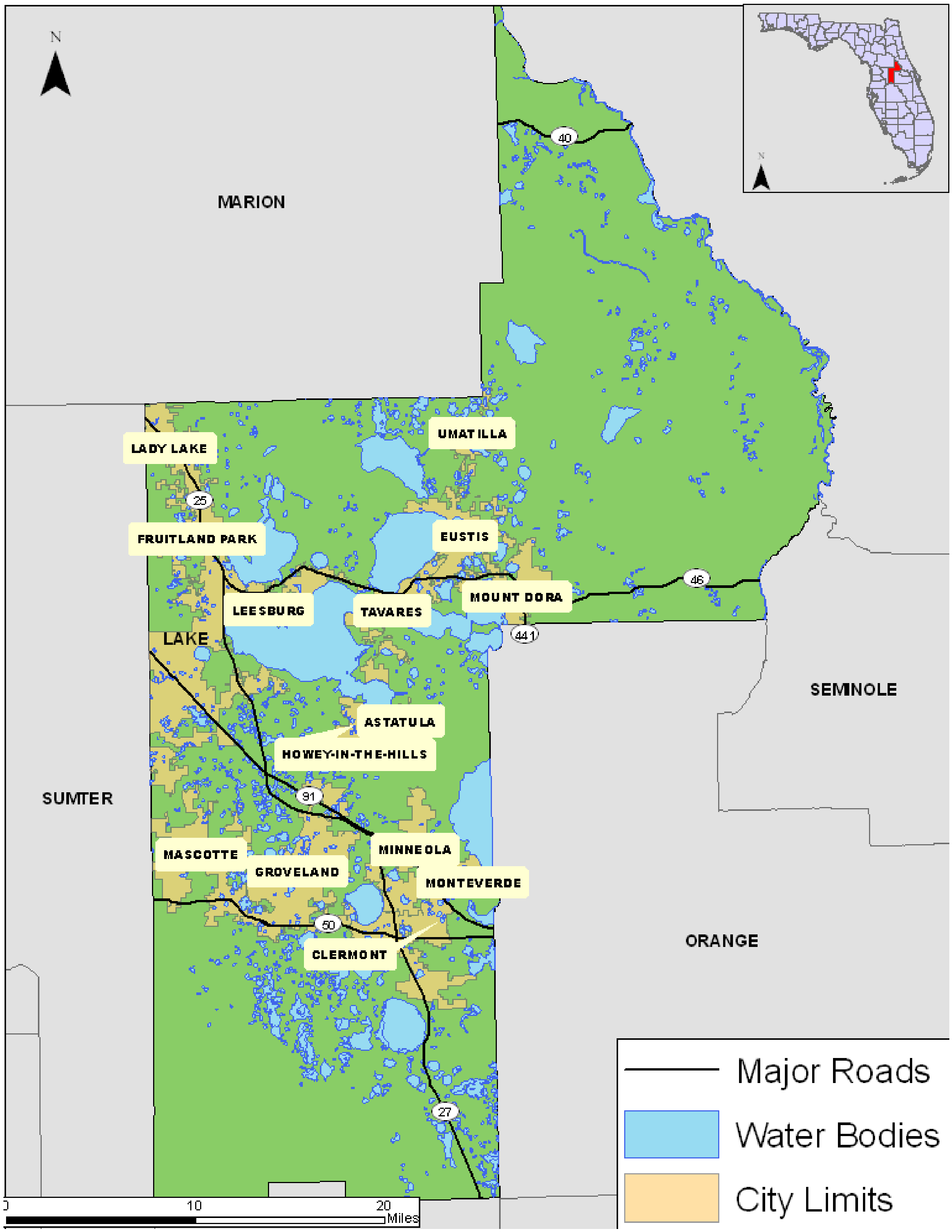

Figure 3-1. Lake County

CHAPTER 4
METHODOLOGY

Overview

The aim of this study is to identify opportunities for urban infill development in Lake County, and assess whether the use of those opportunities by a designated horizon year (2040) can lead to a reduced need for new growth in greenfield areas of the county, thus reducing the need for agricultural conversion. The quantifiable product of the study will indicate the potential agricultural value of pursuing infill development in Lake County, versus growing at status quo, or “trend” densities. This will be accomplished through the use of several urban growth scenarios that use suitability analysis and LUCIS methodology. Broadly speaking, the methodology can be separated into three main sections: first, an allocation of urban infill development, using principles from Calthorpe’s Transit-Oriented Development (TOD) model from *The Next American Metropolis* (1993), but with respect to current land use patterns and densities in Lake County. The results of this section inform the next, which uses LUCIS methodology to create growth scenarios, based on the 2040 population projection and using two variables, new growth density and infill population. The final section of analysis uses the results from the LUCIS scenarios to calculate potential losses in agricultural productivity.

Infill Analysis

The first section of the study aims to create a model of urban infill development for Lake County, the purpose of which is to make a realistic calculation of the amount of incoming population that can be accommodated by this development. This model requires several criteria: the designation of areas in the county that are suitable for infill development, the selection of the various land uses that will make up this new development, and the average densities of development that are expected to occur. These criteria were determined by the Transit-Oriented Development principles outlined in Peter Calthorpe's *The Next American Metropolis* (1993), as well as densities of land uses, patterns of development, and transportation facilities currently present in the county. The principles and guidelines from *The Next American Metropolis* are aimed at creating a workable model that fully takes advantage of the opportunities compact development can afford, such as better accessibility to transit options, and retail and employment centers. The model works by creating a spatial pattern of land uses and densities that encourage transit and walkability, while at the same time not significantly contrasting with existing urban development (Calthorpe, 1993).

It is true that transit oriented development is not a synonym for urban infill, but TOD can serve as a purpose for infill development, and more importantly, it establishes some "rules" for infill allocation. This is critical for the creation of a relevant infill model. If the model had no guidelines, and high-density infill was allocated to every vacant parcel in the county, there would be situations where large residential or commercial developments were modeled in exurban or rural areas. This is an example of sprawl, rather than urban infill. Designating boundaries and density criteria was essential to maintaining an actual infill model.

Data Preparation

The source of data that formed the basis of this analysis is the Florida Department of Revenue 2010 Property Parcel dataset, as an ESRI ArcGIS feature class. This dataset provided the quantity of available vacant land for infill development, as well as current land uses in the county, and the density of those uses. However, spatial data for property parcels, though a valuable resource is notoriously ridden with erroneous data as a result of faulty digitizing. This takes the form of multiple “slivers” for one parcel. These slivers will contain duplicate records of data for a single parcel in the table, but spatially will make up only a section of that parcel. These sliver sections usually make up only a tiny percentage of the overall parcel, but they can skew an analysis of parcel data greatly. The duplicate records can make more parcels appear to exist than actually do in reality, and these slivers create enormous outliers in any density calculation, as the sliver’s acreage is only a fraction of the parcel’s actual area, while all other attributes (such as residential units or square footage of usable space) remain the same.

Correcting these data errors was relatively simple. In ArcGIS, the summary statistics tool from ArcToolbox was used to sum the area of every record containing the same parcel ID number. The resulting table contained a field for each unique parcel ID and a field for the correct area of that parcel, being a sum of all of its slivers. Using the “join” function, this table was joined to the original parcel table, with parcel ID as the connecting field. A new field was created in the table to calculate the proportion of each sliver’s area to its total area, and all slivers that made up less than 50% of the total parcel’s area were deleted, although most slivers made up less than 1% of the total parcel area. This made every record in the parcel dataset unique by parcel ID. Area was not recalculated – instead the total acreage of all “pieces” of each parcel was used, as this is the correct area of the entire parcel.

Creating Transit-Oriented Developments

The heart of any TOD is its Core Commercial Area. This is a concentration of commercial, particularly retail, development, where residents of the TOD and the suburbs beyond do most of their shopping, and where many of them are employed. It sustains the TOD by providing a mixed use destination for the community, while being close enough to all area residents that it can easily be reached. This is also where the main transit hub of the TOD is located, which provides access to the Core Commercial Area for the surrounding region as well. Without this economic center, there is little incentive to pursue compact growth, and thus little reason to infill.

The first step in choosing the location for TODs in Lake County was to find and designate these core commercial areas. The most promising areas for TOD selection already had something like a core commercial area yet also had potential for new infill development. It is these areas where infill development would be most viable and effective.

Criteria were established for identifying core commercial areas. The first and most important attribute for a CCA was retail density. This entails not only the physical proximity of retail locations to each other, but the density of retail floor space inside each location, which is measured by Floor Area Ratio (FAR). FAR was calculated by dividing the Total Living Area (floor space) for each parcel by the total acreage of that parcel. A low FAR for a retail location can be less than .3; a high FAR can be more than 1.0 (Calthorpe, 1993).

The data used for measuring this density was 2010 Florida Department of Revenue (FDOR) property parcel data, obtained from the Florida Geographic Data Library (FGDL, www.fgdl.org). FDOR provides classifications of property types in the “DESCRIPT” field of its GIS data. Through this classification, retail properties were selected. The criteria for this selection can be seen in Table 4-1. By default, this data is available in polygon format. However, to create a density map, it was necessary to convert these polygons to points. In the property parcel data table, two new fields were added to store the x and y coordinates of each polygon's centroid. Using the "Calculate Geometry" tool, these centroids were calculated, and the table's data exported. The "Add XY Data" option was selected from ArcMap's Tools menu to reopen this table as a temporary points file. Finally, this temporary file was saved permanently as a feature class.

The "Kernel Density" tool could then be used to calculate the spatial distribution of retail density. This tool uses distance between points and FAR to calculate density. It displays concentric rings for each categorical level of density calculated. Using Kernel Density, it was possible to visually identify retail nodes throughout Lake County, as these were marked by the highest density rings, where there are both clusters of retail locations, and high FARs within these locations.

It was also important to choose established urban areas for CCAs, as opposed to edge developments. Retail densities are often high in suburban or exurban strip malls, but choosing these areas for intense development could not be considered urban infill, because it would only serve to push new development further out from city centers, and into agricultural areas. Data for this criterion included GIS layers for city limits, to show whether intense retail development occurred within city centers or in edge or even unincorporated areas. Additionally, parcel data was again used to show existing office uses (Table 4-2), single family residential uses (Table 4-3), multi-family residential uses (Table 4-4), in addition to retail uses. Areas with a greater mix of uses (as opposed to the single-use strip mall) were considered to be located in more established urban areas that would be suitable for TOD development. Finally, aerial imagery obtained from

ESRI (http://www.esri.com/software/...) was used to visually confirm that prospective CCAs were located within urban areas, and not on the edge of development.

Additional criteria for CCAs included placement on an existing transit line – the only one for Lake County being Lake Xpress, (http://www.ridelakexpress.com/...) a regional bus service. This was preferred, but not a requirement, as service is limited. An abundance of nearby vacant parcels was of course important; otherwise, infill development would not be possible. Lastly, areas that were close, but not directly adjacent to major highways were preferred. This was to make transportation to CCAs convenient; however, placement directly next to or surrounding a major highway would make CCAs less walkable and would encourage auto-centric development.

Once CCAs were chosen, and their locations stored via a points feature class, the boundaries of TODs were designated around them. This was done with the Buffer tool, with a 2000 foot buffer around each point. 2000 feet is roughly the maximum distance required to maintain a 10 minute walking distance – the CCA should easily be reachable by foot from all parts of the TOD (Calthorpe, 1993).

An additional buffer was created around the TODs, to create Secondary Areas. These extend from the edge of the TOD to one mile from the CCA. These areas are designed to be essentially compact suburbs that support the TOD. They are primarily meant to be residential in nature, and while more compact and dense than typical suburban development found in Lake County, residential densities are not as intense as they are in the TOD. Figure 4-1 shows all infill areas (TODs and Secondary Areas) in relation to existing city limits.

Preparing the Infill Dataset

At this point, the vacant parcels to be used for urban infill could be selected. Because infill in this case consists of residential and commercial development, vacant commercial and vacant residential property parcels were selected in TOD and Secondary zones. Any parcels of less than .1 acre in total area were discarded, as this was considered to be too small for worthwhile redevelopment. This final selection represented the total number of available parcels for potential infill.

Vacant parcel data is in vector format, so using the Convert to Raster tool, this data was converted to raster format, using a relatively high resolution of nine meters per cell– this was needed in order to capture all vector data, such as the small .1 acre parcels.

In this analysis, suitability values were used for many decisions about infill land use. Suitability data, in raster format, was used for four land uses: single family residential, multi-family residential, retail, and commercial. Commercial suitability served as criteria for developing office uses, as a specific "Office" suitability layer was no available. All of the above suitability layers were provided courtesy of Dr. Paul Zwick and the GeoPlan center.

Using the ModelBuilder tool**,** a model was developed that combines the suitability and parcel data into one allocation raster (Figure 4-2). Any record in this layer contained attribute data for suitability, acres available for infill, and an FID number that acted as a unique ID number for each parcel.

However, before infill allocation could commence, a major problem remained with this data. Frequently, multiple suitability values existed for each parcel, since these values vary between each cell of data in the raster surface, and all but the smallest parcels consisted of multiple cells.

The best way to solve this issue was to use a single, normalized suitability value for each parcel. This was accomplished by taking the average of the parcel's weighted suitability values. As described above, a single parcel may have several suitability values. Each of these suitability values within the parcel has a given number of cells that represent it.

As a first step to find each parcel's "weighted" suitability values, all records with a suitability value of 0 were deleted from the table. These did not actually represent "zero suitability", but rather the lack of available suitability data for that area, so including these values would skew the eventual averages. The Summary Statistics tool was then used to find the sum of remaining suitability cells that were contained within each parcel, and create a new table with this data. Note that this was not a sum of suitability values, but merely the total number of cells that *contained* any suitability values in the parcel. A field, "CountSum" was added to the summary statistics table, to list this sum for each parcel. "Count", the sum of cells of a given suitability value within each parcel, was then divided by "CountSum" in order to calculate the proportion of each suitability value within the parcel. This was stored in field "Proportion". To illustrate this: if a parcel contains 10 suitability cells, ("CountSum") and four of them ("Count") have a suitability value of 500, the proportion of value 500 to the whole parcel would be 0.4 ("Proportion").

To find the weighted suitability of each suitability value inside each parcel, yet another field was added to the summary statistics table, “WeightSuit”. This was calculated by multiplying any given suitability value with its “Proportion”.

At this point, Summary Statistics were used once again, this time to sum weighted suitability values by parcel ID. This was the final, single suitability value used for each parcel.

The above process was repeated for each of the four suitability types. The final suitability values for each parcel were joined to the same table with the selected vacant parcels (the “allocation” raster dataset), along with new fields for future land use type, residential units, commercial space, residential density, commercial density, estimated residents, and estimated jobs generated.

Allocation

In the context of infill development, allocation refers to the simulated placement of new land uses onto selected vacant parcels. This was accomplished through a combination of suitability analysis, an assessment of compatible land uses and development densities, and guidelines from Calthorpe’s TOD model. These tasks were accomplished within the data table of the allocation raster, with new land use and density conditions recorded for the vacant parcels being allocated to.

The first task was to set aside parcels deemed unsuitable for infill development. These included parcels that were unconnected to infrastructure, adjacent to farmland, on the outer edge of development, or over open water. Once again, aerial imagery from ESRI was used **(**http://www.esri.com/...) to make these determinations. With one exception of a large, forested parcel in Tavares with low suitability values, all of these occurred in Secondary Areas – the outer infill zones that are between 2000 feet and one mile from Core Commercial Areas. These parcels were designated “Open Space” as their new land use.

Different land use and density allocation criteria were used by type of development area. The primary types of development area were TODs and Secondary Areas. However, TODs were further split into Urban TODs and Neighborhood TODs. Of the 12 designated TODs in Lake County, five are Urban TODs and seven are Neighborhood TODs. Urban TODs, as their name might suggest, are developed more intensely, with higher densities than other development areas. They have an emphasis on retail and other job generating land uses, which are patronized by residents across the region, from both Neighborhood TODs and Secondary Areas. Because of this, it is important that they serve as hubs in the regional transit network (Calthorpe, 1993).

Neighborhood TODs have lower development densities than Urban TODs, but serve mainly the same purpose. Their shopping and employment opportunities benefit mainly just the TOD residents and those in the immediate surrounding secondary area. Neighborhood TODs can be in close proximity to each other, and serve a common Urban TOD in the same city (Calthorpe, 1993).

Secondary Areas are, again, suburban areas that support TODs. Infill in these areas should be mostly focused on moderate-density residential development. Indeed, it is important that large-scale commercial development not be pursued in Secondary Areas, as it is likely to encourage dispersed, auto-oriented sprawl, and pull economic activity, as well as transit ridership, away from Core Commercial Areas (Calthorpe, 1993).

Residential allocation

Residential land uses were allocated first. Because the dominant existing land use in the designated TODs, as well as in most urban areas of Lake County, is single family residential, all infill residential development (using vacant residential parcels) in both Urban and Neighborhood TODs was allocated as multifamily residential. This choice was made to increase residential densities and encourage walkability, which is crucial to the success of TODs.

Choosing average densities for residential infill required compromise between the need to create densities that are high enough for transit and a walkable community to be viable, yet low enough, for infill to be context-sensitive to the surrounding, existing development. Calthorpe (1993) suggests minimum average residential densities of 10 units per acre in Neighborhood TODs and 15 units per acre in Urban TODs. Because of the dominance of low-density single family housing, these densities are virtually unobtainable in Lake County without massively increasing the density of development relative to existing land use patterns. Therefore, the average densities of infill housing were made to be greater than existing averages without being greater than existing maximums (Table 4-5, multifamily housing densities), as an effort to move towards TOD densities. For Urban TODs, this meant allocating at a density of 35 units per acre, which is generally much more than the average multifamily housing density for Urban TODs, but well less than the maximum for most of them. As with all density allocations, this was meant to represent an average, rather than a flat density across the board. If such an infill project were actually pursued, some multifamily units would be close to or exceeding the densest housing there today, while others would be closer to the current average.

The density of multifamily units in Neighborhood TODs was made much lower. This is to reflect the “neighborhood” character of this type of development area, where high rise apartments would be less desirable. In addition, the maximum existing multifamily densities in these areas were much lower than in the Urban TODs. For most Neighborhood TODs, an allocation density of 20 units per acre was used, except for some in which the existing maximum densities for this use were less – in these cases, the maximum density was used.

Suitability was used for allocating residential land uses to Secondary Areas. Here, continuing to develop a mix of single-family and multi-family residential units is more acceptable than in TODs, given the more suburban nature of Secondary Areas. Therefore, suitability values were used to make choices about the best use for vacant residential land. Whichever suitability value for each parcel was higher (single or multifamily) determined its use for these areas. A density of 20 units per acre was once again used for multifamily parcels, unless the existing maximum for that Secondary Area was less than 20. In this case, that maximum density was used instead. Single-family parcels were given a density of 10 units per acre. This density is higher than the average existing density for single-family homes in most Secondary Areas, (about three to four units per acre) but as with the higher infill densities in TOD, this development density is an effort to push these suburban areas to higher, more walkable, and transit friendly densities. A density of 10 units per acre would perhaps consist of a mix of single homes on a moderate lot size, duplexes, and townhouses (Calthorpe, 1993).

Commercial infill

Suitability values were also used for allocation of commercial land uses. In all TODs, roughly two-thirds of vacant commercial acreage was allocated to retail usage.

These were selected through retail suitability values – more suitable parcels were allocated first, until two-thirds of the commercial acreage had been designated retail. This preference of retail over office land uses in TODs stems from the importance of retail development for the economic “health” of a TOD, and the more sensitive nature of locating retail uses. As important as it is to locate retail centrally to encourage transit use, it is equally important not to disperse it to avoid encouraging autocentric land-use patterns.

As with residential infill, commercial infill was made to be denser in Urban TODs than in Neighborhood TODs. Again, this was measured by Floor Area Ratio (FAR). A FAR of 0.6 was used for commercial development (both office and retail) in Neighborhood TODs, and 1.0 in Urban TODs. Of course, commercial space with a FAR of 1.0 has full floor space coverage for the area of the parcel, so a two-story building, or structured parking for a one-story building, would be required. However, as with residential densities, in the real world this allocation density would be an average rather than a homogenous number all commercial properties in the TOD should adopt. Thus, an average FAR of 1.0 would likely represent a mix of properties with structured parking, some with two stories, and those with more traditional, albeit smaller, lots. The average FAR of 0.6, for Neighborhood TODs, represents a mix of these types of commercial developments with a higher proportion of one-story properties with ground level parking (Calthorpe, 1993).

Commercial infill for Secondary Areas presented new challenges. As previously mentioned, it is important that large retail centers are prevented from forming in suburban areas, if a policy of compact development is being pursued. Therefore, commercial allocation in Secondary Areas was generally pursued in regard to parcel size. Commercial parcels less than two acres in size were designated retail, unless their suitability value for this use was below 600. Parcels between two and five acres were allocated to office use, as office parks of moderate size are acceptable in Secondary Areas. Those with commercial suitability of less than 600 were excluded from office use. Large vacant commercial parcels of more than five acres in size (of which there were several in the town of Minneola's Secondary Area arranged along US Highway 27, likely to become "box" retail developments which are incompatible with transit oriented development) were converted to single or multi-family residential use, whichever suitability was higher, provided one of them was greater than 600. Owing to the suburban nature of Secondary Areas, the average FAR of all commercial infill for these areas was set at 0.6.

All other commercial parcels in Secondary areas that infill development was not allocated to were left as open space. This could be reserved as space for parks, public facilities such as police or fire stations, schools, or future infill projects.

Mixed use

The final step of infill allocation consisted of creating a single mixed use development for each TOD. The purpose of this was to create a centerpiece for the Core Commercial Area of each TOD, combining residences, offices, retail uses, and possibly also structured parking. A large mixed use project can act as a "flagship" of sorts for redevelopment in the area, encouraging higher density residential and commercial growth around it, and acting as a central attractant to retail patrons and other transit riders arriving to the CCA.

Of course, there were several criteria for the location of each mixed use development. Preferred site size was between one and four acres, and this could include the combination of several smaller parcels. All parcels needed to have high suitability values – over 700 for commercial, retail, and multi-family suitability. To take advantage of existing high density development, locations as near as possible to the CCA were preferred, which will serve to add to the economic “gravity” of these hubs and make additional high density development feasible. Other desirable attributes, such as waterfront locations, or walkable accessibility to nearby residential areas, were also preferred, if the geography of the TOD allowed them.

Density of mixed use developments was made higher than surrounding land uses, as each development would likely be a multi-level structure, even for Neighborhood TODs. Commercial FAR in the Urban TOD mixed use developments was given a FAR of 3.0, while residential density was allocated at 50 units per acre. In Neighborhood TODs, commercial density was 2.0, and residential density was 30 units per acre. Once again, since the health of CCAs depends so much on retail usage, two-thirds of the commercial area in mixed use developments was made retail space, with the other third reserved for office usage.

Infill Population and Jobs Generated

At this point, the total new residential infill population could be estimated, along with the total new jobs generated by commercial infill. New fields were added to the allocation table for residential units per parcel, commercial space per parcel, employees per parcel, and residents per parcel. Units and space per parcel were calculated by simply multiplying the density (either residential or commercial) of the parcel by its acreage, and converting this to square feet. To calculate jobs per parcel, statistics for square feet of commercial space per worker (387 square feet for office workers, and 945 for retail workers) were gathered from the U.S. Energy Information Administration (Energy Information Administation, 1995). These were then multiplied by parcel floor space for retail and office uses to calculate the number of workers per commercial parcel (and thus new jobs).

Similarly, the average household size for Lake County (2.34) was obtained from the US Census Bureau (2009), and this was multiplied by residential units per parcel to obtain total residents per residential parcel. This estimate would inform the next section of the methodology, which creates future urban growth scenarios using infill development as a variable.

Urban Growth Scenarios

Urban growth modeling makes up the second phase of the methodology. It uses the results of the infill modeling section, population projections created by the Bureau of Economic and Business Research for 2040, and a “conflict surface” created with suitability data using LUCIS methodology, to create several scenarios showing future urban growth in Lake County. These scenarios, in turn, were used to calculate future agricultural losses in the county.

Five scenarios were created. The first is a “trend” scenario that shows future conditions in Lake County if minimal urban infill occurs and new development continues to be built at current densities to accommodate the projected 2040 population. The next three scenarios assume infill development is pursued as described in the previous section, which reduces the need for new growth areas because of the amount of intensive urban infill. Each of these uses a different urban density factor for modeling new growth. Finally, the fifth scenario shows the effects of all new urban growth being entirely restricted to infill areas (TODs and Secondary Areas).

Data Collection and Preparation

The dataset used as the basis for spatially allocating new growth areas was a raster dataset showing land use conflict, created using LUCIS methodology, as described in Chapter 2. As previously described, with LUCIS, land uses that are unlikely to change are removed from the dataset. As such, this raster did not cover water features, urban areas, or protected land in Lake County, and so only covered "greenfield" areas.

Using the Combine tool, another raster was added to this data, to allow a greater level of detail in creating urban growth scenarios. This was an urban preference raster, with values ranging from 100 to 900, which indicate preference for new urban development. It, along with the conflict raster, were also provided by Dr. Paul Zwick and the GeoPlan Center.

Two more rasters were combined with the above. These represented the TOD and Secondary Areas used in the infill analysis section of this methodology. With these, new growth could be restricted from or made exclusive to infill areas in a given scenario. Finally, a field was added to measure the area for each record in the raster table, which aided in population allocation later in this process. The resulting raster dataset was known as "Conflict Raster".

Population projections created by the Bureau of Economic and Business Research (BEBR) were used as the input that would drive the future urban growth modeled in these scenarios. The "Medium" projection for Lake County in the year 2040 was used. BEBR creates county-level projections for the intermediate future (5 to 30 years) using five different projection methods and three historical base periods from which to derive data. The first of these methods is “Linear”, in which the population of the county is modeled to increase “by the same number of persons in each future year as the average annual change” for one of the given historical base periods. An “Exponential” method is also used, which uses an average percentage rate of increase or decrease instead of number of persons. The third method is “Share-of-growth”, which keeps as a constant the county’s ratio of population to the state population. The fourth method, “Shift-share”, uses an average annual change of the county’s share of the state population. Finally, the “Constant population” method keeps the county’s population constant at the level of the present year (Smith and Rayer, p.2-3, 2010).

All three historical base periods, extending five, ten and fifteen years out from the present year, are used to create three different projections for the linear and share-of-growth methods, while only the ten year period is used for the exponential and shift-share methods. Of course, the constant population method only produces one projection, for a single year. In all, this produces nine different projections. For most counties, including Lake, these projections are then averaged, except for the two highest and two lowest projections, which are excluded (Smith and Rayer, 2010). The results are the medium level county projections BEBR produces, including the 2040 medium projection for Lake County that was used in this study.

Gross Urban Density

The “fundamental land-use equation” (Equation 4-1) is used to create an urban growth scenario (Carr and Zwick, 2007, p.166):

$$\textit{Population} \div \textit{gross urban density} = \textit{acres of land needed to support human settlement} \quad (4\text{-}1)$$

Population is the first part of Equation 4-1. As these scenarios use 2040 as the horizon year, population projections from the Bureau of Economic and Business Research (BEBR) were used, for Lake County, using the “Medium” projection for 2040. This projection shows a population of 520,700 in Lake County for this year, a 57% increase over the 2010 population of 297,052 (Smith and Rayer, 2011).

Next, gross urban density (GUD) needed to be calculated. In Chapter 3, a 2006 calculation of GUD was cited for Lake County (1.81). However, a more up to date figure was required to keep the study relevant, especially in such a rapidly changing county as Lake. Since GUD is equivalent to gross urban area (GUA) multiplied by population, finding GUA was the first step to calculating GUD. Once again, the conflict raster consisted of the only greenfield land: the land that is left when water features, urban areas, and protected areas are removed. Therefore, by creating a map of greenfield, water features, and protected areas, the remaining land could be inferred to be the urban area. For water features, USGS 1:100,000 Hydrography data were obtained from the Florida Geographic Data Library (FGDL, www.fgdl.org). For protected areas, a dataset of Florida Managed Areas, also available from FGDL, was used. This dataset is a comprehensive collection of protected areas in Florida, on a local, state, and federal basis. The conflict raster, as described above, was used for greenfield.

Using the Features to Raster tool, the water and protected areas datasets were converted to raster format, and all three, including the conflict data which was already in raster format, were summed together using the Raster Calculator. The area not taken up by any of the above three data sources was considered to be the urban area. Gross urban area was then calculated by converting the raster’s cell resolution (31 meters) to acres (using a factor of .237) for all urban lands. This was converted to gross urban density (GUD) by dividing the current population of Lake County (297,052) by this gross urban area**.**

Scenario Modeling

With the base gross urban density calculated, urban growth scenarios could be created. Table 4-6 provides a summary of the key variables included in each scenario.

The first scenario, as described above, is a trend scenario showing the next thirty years of growth in Lake County at the current gross urban density. This scenario is merely an extrapolation of current conditions in the county, and in this sense acts as a “base” or “control” scenario. As such, it does not take into account the infill analysis completed previously. However, since growth was not restricted from occurring in infill areas, some “infill” development was possible within them, though at the “low” gross urban density. Using the “fundamental land use equation”, 131,094.59 new acres of urban growth were needed to accommodate the 2040 population of Lake County.

As in all five scenarios, this growth was spatially allocated using the “Conflict Raster” table. Each combination of agricultural-conservation-urban preference, urban suitability, and presence in a TOD or Secondary area (for a total of 6,318 combinations) produced a record in the table and had a given area within Lake County. The goal in building each scenario was to choose relevant land-use combinations until the required number of acres was reached.

A “hierarchy” of land use conflict combinations was created, based on which combinations had less conflict with urban uses, and were therefore more likely to be developed first. With 1 representing low preference, 2 representing medium preference, and 3 representing high preference, the first combination chosen was 1(Agricultural)-

1(Conservation)-3(Urban) because it was least preferred for agricultural and conservation uses, and most preferred for urban uses. A combination of 1(Agricultural)-3(Conservation)-3(Urban), however, is much lower on this hierarchy. Inevitable conflict between conservation and development interests on this land will slow its eventual development. The full hierarchy can be seen in Table 4-7.

Using the “Select by Attributes” dialog, a selection was created with each combination in this hierarchy being selected in order (from highest to lowest) until the requisite area was exceeded. However, with only 27 different land use combinations, a “match” between the area required and the area reached is unlikely. Splitting these 27 combinations into thousands was the purpose of including an urban preference level in the raster, as each resulting combination had a small land area that allowed for the level of subtlety required for the analysis. Once enough conflict combinations were used to exceed the area required by the scenario, the selection of the last conflict combination was refined by using urban preference levels.

In this first (“trend”) scenario, the lowest preference combination on the hierarchy used was 3(Agricultural)-2(Conservation)-2(Urban), which exceeded the number of acres needed for the scenario. The urban suitability level was used to refine this selection, wherein only 3-2-2 land that had an urban suitability of 467 or higher was used. By this method, the nearest number of acres to the target number that were possible to select, were selected. An additional field, “TREND”, was created in the “Conflict Raster” table to record these results, with a “Y” if the record was included in the scenario as new growth and an “N” if it was not.

The next scenario utilized the results of the infill analysis – that the population of the infill areas (TODs and Secondary Areas) will increase by a set number as a result of intensive infill development. As a result, in this scenario new growth was not modeled in the infill areas, while the calculated infill population was subtracted from the projected increase in population for Lake County. As a result, less people than in the trend scenario were allocated to new growth areas. However, the same gross urban density was used for new growth, as in the trend scenario. Using the same methodology as in the first scenario, the lowest land use preference combination required was 3(Agricultural)-2(Conservation)-2(Urban), using land with urban suitability values of 544 or higher. Again, the results were recorded in the "Conflict Raster" table, in a new field "INFILL1", as "Y" or "N".

The same methodology was followed for the next two scenarios, which only differ from the above in that the density of new growth was increased – in the second infill scenario, by a factor of 1.5, and in the third infill scenario, by a factor of 2.0. The density of new growth would likely be increased if infill policies are pursued, as the dense, transit-oriented development practiced in the infill areas would be repeated to varying degrees on the urban fringe. However, since new growth density is not part of the research question, these scenarios were created only for the sake of comparison and "realism".

The final scenario was different. The object of this scenario was to model growth only in the infill areas, while restricting it anywhere else. The purpose of this was to measure agricultural conversion in the case, however unlikely, that new urban growth is halted in Lake County, and only development in infill areas is permitted. In this sense, it is an assessment of the infill areas' ability to prevent conversion.

However, unlike the previous scenarios, this one did not use the results of the infill analysis. Instead, it used the assumption that all greenfield land in the infill areas, (TODs and Secondary Areas) would be used for new urban growth, with no growth permitted outside of these areas. Thus, the fundamental land use equation had different variables here: The area of land required for development was set to be the total greenfield acreage in all TODs and Secondary Areas. Since the incoming population to be allocated in the infill areas was also set, this left new urban density as the variable, rather than a set parameter as in the other scenarios.

The final step in this urban modeling process was to convert the raster dataset into vector data for each scenario, so that it may be more easily analyzed for the next section of the methodology, the agricultural analysis. Most of the data used for this section, such as soil data was in vector format. Using Spatial Analyst, each of the scenario fields in “Conflict Raster” were converted into vector features, such that a “Y” in the field was generated as vector data (where urban growth occurred) and “N” did not. Lines were not generalized so as to maintain spatial integrity.

Agricultural Analysis

The goal of the final section of this methodology was to quantify potential agricultural losses as a result of the new urban growth modeled in the previous section. This section uses three data sources for analysis: the results of the scenario modeling, in five vector feature classes, one for each scenario; farm property parcel data; and soils data that shows potential crop yields by soil type.

By first calculating agricultural conversion in terms of the area of farmland lost, soils and yield data could be used to show the total potential loss of yield for a number of agricultural products.

Which agricultural products were included in the analysis depended on which crops were actually grown in Lake County, and which soils/yield data were available. Lake County's agricultural output data was gleaned from the 2007 U.S. Agricultural Census (http://www.agcensus.usda.gov/...). In all, 10 different crops were used, with six of these consisting of field crops, though these are comparatively minor economically compared to citrus, timber, and grazing land; they do exhibit the most variety, however.

These crops were matched with four different farm types: field cropland, citrus cropland, timberland, and grazing land (see Table 4-8 for a list of farms and crop types). As with most property data in this study, the data for these farms were from the 2010 FDOR property parcel feature class, and the farm types were divided via their FDOR description.

Once again, soils data were provided by Dr. Paul Zwick and GeoPlan. Each layer of this data contained the expected yield for a given crop in every soil region provided. Every data layer contained the same spatial information and soil types, but different crop data. These data were merged by relationally joining the tables together by soil type and reproducing the crop information in new fields for one layer.

Farm property conversion could now be calculated. Using the Select by Location tool, farm properties were selected that fell under the same location as new urban growth from one of the five scenarios. The Clip tool was used to extract the land area of these selected farm properties from the soils/yield data, to produce a new feature class.

This provided the yield per acre for relevant crops on the converted farmland. This process was repeated for every combination of the four farm types and the five urban growth scenarios. Also, each complete farm feature class (without losses from the urban growth scenario) was clipped with the soils/yield data, in order to calculate 2010 potential yield, so that this could be compared to the losses.

The tables from these feature classes were exported out of ArcGIS to be used in a spreadsheet. To calculate losses in yield, the yield per acre for each soil type (bushels per acre, for example) was multiplied by the acres of lost farmland in that soil type. Percentage of yield loss per crop type (between 2010 and 2040) was calculated by dividing loss in yield by the current potential yield for that crop.

The yield for a particular crop was calculated for all farms that would potentially be growing the crop. For example, the yield of peanuts and soybeans, as field crops, were calculated for all farms classified as “cropland” (but not for timberland or citrus cropland). This had the effect, particularly for field crops (of which there were six used in this study) of different crop yields being calculated for the same location. This was not a problem in itself, as this method measures the potential yield for each crop, in all farms and soil types where it can potentially be grown, and the reduction of this yield is a good measure of agricultural conversion. However, summing these losses is not possible, if they are mutually exclusive to each other. Therefore, an “agricultural scenario” was designed, wherein different crop yields were divided equally in each soil type where they overlapped. This was only done for field crops; for citrus crops, oranges and grapefruit were proportionally split 90% to 10% respectively, as this reflects the proportion of land they are grown on in Lake County (USDA, 2007). Wood and grass did not need to be altered, as each one of these crops was calculated for a single farm type (timberland and grazing land).

Without the problem of mutual exclusivity, agricultural losses could be summed for each urban growth scenario, which was useful in comparing results between scenarios.

To see the financial impact of agricultural conversion, yield losses were also calculated in dollars, by multiplying crop price by yield loss. Current prices (as of 8/31/2011) per yield unit (i.e. tons, bushels, boxes) were found for most crops through the National Agricultural Statistics Service (http://usda.mannlib.cornell.edu/...). Watermelon prices, not available through NASS, were found through the USDA Economic Research Service (http://usda.mannlib.cornell.edu/MannUsda/...), and represent the average price for 2010. Additionally, wood prices were obtained through the Summer-Fall 2011 edition of *The Florida Forest Steward* (http://www.sfrc.ufl.edu/...), which prints quarterly stumpage prices for Florida. These are provided in cords, which were converted to cubic meters, which are the units for timber in the yield data. Finally, because grass forage is not a market item (as it is consumed directly by the animal), grass yields in grazing lands were priced for grass hay, for which current prices are available through NASS in units of tons. These were converted to animal unit months (AUM) which are the units for grass in the yield data.

Table 4-1. Retail selection

FDOR Description
Community Shopping Centers
Department Stores
Mixed Use - Store and Office
Regional Shopping Malls
Stores One-Story
Supermarket

Table 4-2. Office selection

FDOR Description
Financial Institutions
Insurance Company Offices
Multi-Story Non-Professional Offices
Professional Service Buildings

Table 4-3. Multi-family housing

FDOR Description
Multi-Family
Multi-Family Less than 10 Units
Homes for Aged

Table 4-4. Single-family housing

FDOR Description
Single-Family
Condominia

Table 4-5. Existing densities for multi-family properties in Lake County TODs

Location	Mean Residential Density (Units per Acre)	Maximum Residential Density (Units per Acre)
Clermont	10.56	42.02
Eustis North	15.17	59.70
Eustis South	11.80	34.29
Leesburg Central	16.46	47.62
Leesburg North	11.74	15.77
Leesburg South	8.76	14.29
Minneola	8.76	17.09
Mt. Dora East	12.37	36.20
Mt. Dora West	7.92	14.12
Tavares North	12.17	13.42
Tavares South	14.55	31.32

Table 4-6. Urban growth scenario parameters

Scenario	Density in New Growth (persons/acre)	2010 Pop	2040 Pop	Difference	Area Available for New Growth	Population to Allocate	New Acres Needed	Infill Population
Trend	1.87				All	223,648	119365	1,598
Base GUD and Infill	1.87				outside infill	188,475	100592	35,173
1.5 x GUD and Infill	2.81	297,052	520,700	223,648	outside infill	188,475	67062	35,173
2 x GUD and Infill	3.75				outside infill	188,475	50296	35,173
Infill Only	67.09				inside infill	223,648	3333	223,648

Table 4-7. Conflict combination order of preference

Conflict Value		Conflict Description
1)	113	Urban high preference
2)	112	Urban medium preference
3)	123	Urban high preference
4)	213	Urban high preference
5)	223	Urban high preference
6)	313	Agriculture-Urban high conflict
7)	323	Agriculture-Urban high conflict
8)	212	Agriculture-Urban medium conflict
9)	122	Conservation-Urban medium conflict
10)	222	All medium conflict
11)	133	Conservation-Urban high conflict
12)	233	Conservation-Urban high conflict
13)	333	All high conflict
14)	312	Agriculture high preference
15)	322	Agriculture high preference

Table 4-8. Crop yields with matched farm property types

Farm Type	Crop Type
Field Cropland	Peanuts (pounds) Soybeans (bushels) Corn (bushels) Sweet Corn (tons) Watermelon (tons) Cucumber (tons)
Citrus Cropland	Orange (boxes) Grapefruit (boxes)
Grazing land	Grass (animal unit months)
Timberland	Wood (sawtimber, cubic meters)

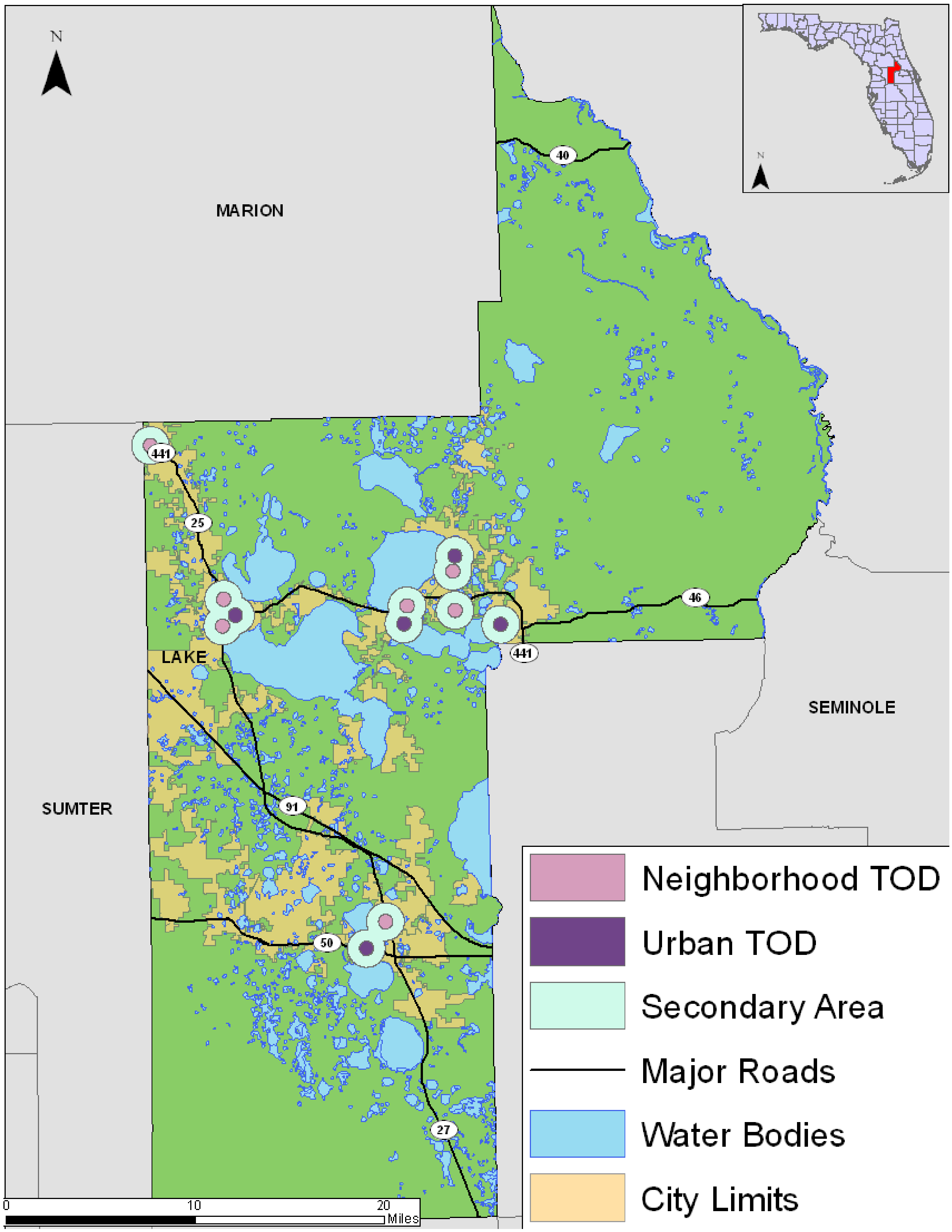

Figure 4-1. Designated infill areas in Lake County

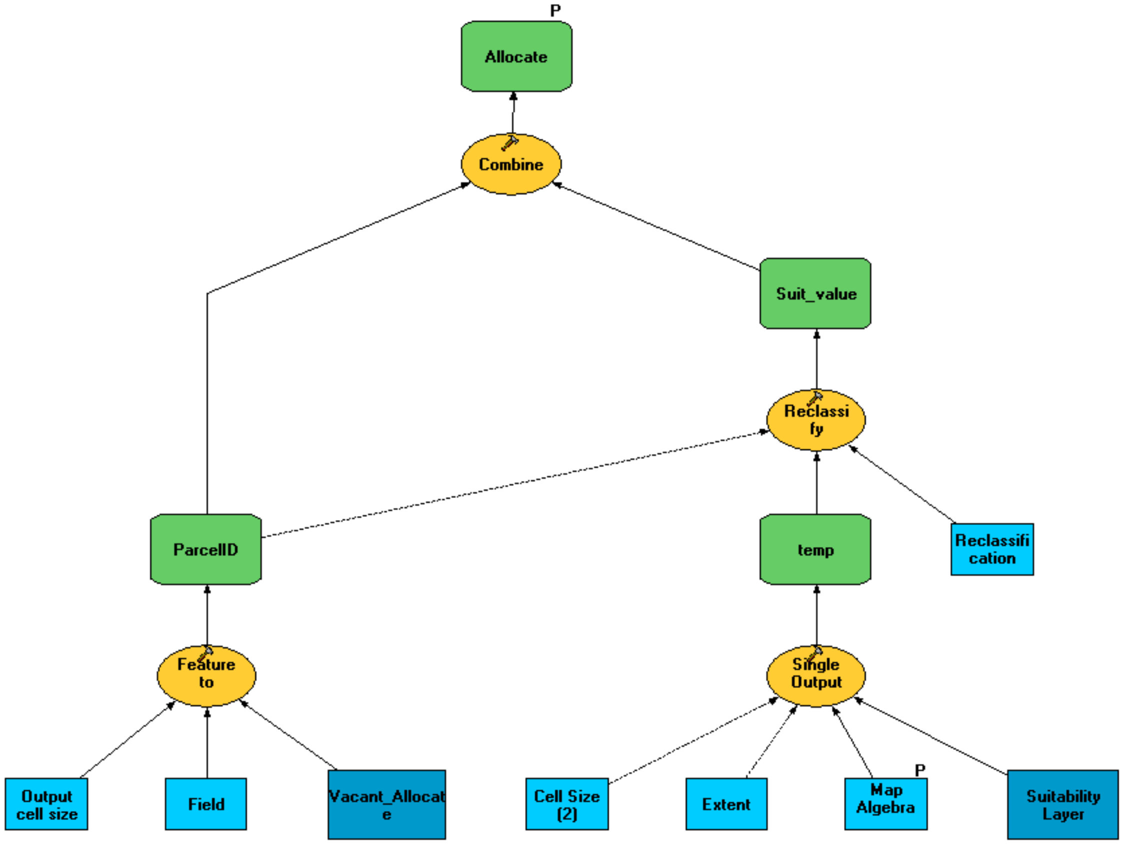

Figure 4-2. Infill allocation raster model

CHAPTER 5
RESULTS

Though the final results of this study consist of the losses of agriculture in the trend and infill scenarios, the results of all three main sections of the methodology (Infill Analysis, Urban Growth Scenarios, and Agricultural Analysis) are important in their own right for understanding how the final results were produced. These findings will be discussed in this section of the study, beginning with the results of the infill analysis.

Infill Results

In total**,** 1,347.0 acres of currently vacant land was used for future infill. Of the 266.0 acres of infill in all Transit Oriented Developments (TODs), 165.0 acres were in Neighborhood TODS. Of this area, 11.84 acres consisted of mixed use developments; 76.8 acres in multifamily housing, a 126% increase over current acreage of this use in Neighborhood TODs; 41.1 acres in new office acreage, a 48% increase; and 35.2 acres in retail infill, a 19% increase. Of the 101.0 acres of infill in Urban TODs, 12.9 acres were in mixed use developments (MXDs); 31.3 new acres of multifamily housing were added, a 38% increase in acreage; 24.1 acres of office use, a 32% increase; and 32.7 acres of new retail locations, a 54% increase. Finally, of the 1081.2 acres of infill that were modeled in Secondary Areas, 502.0 of these were acres of single family residences, which is a 14% increase of acreage in these areas. Multifamily units consisted of 340.3 acres of infill in Secondary Areas, 67% more than currently exists. Retail infill was 121.5 acres, a 25% increase over the present area, while new offices consisted of 117.3 acres, up 44%. See Table 5-1 for full results for infill land use changes. Figures 5-1 to 5-6 show all new infill land uses in each infill area in Lake County.

In total, the infill model included 15,001 new residential units, an increase of 75% from 2010 in the infill areas. 5,030 (an increase of 38%) of these were single family residences in Secondary Areas. A total of 8,981 (134% increase) units were in multifamily housing. Of these, 1,157 were in Neighborhood TODs (a 178% increase), 1,092 were in Urban TODs (a 106% increase), 6,732 were in Secondary Areas (a 133% increase). The remaining 990 units were part of MXDs, 357 in Neighborhood TODs and 633 in Urban TODs. See Table 5-2 for full residential units results.

These new residential units allowed for an incoming population of 35,173 into all of Lake County's infill development areas. The great majority of these (27,548) were accommodated in Secondary Areas, with 15,744 of these in multifamily housing, and 11,804 in single family housing. Of the 7,625 new persons in TODs 3,590 were in Neighborhood TODs, with 2,754 of those in multifamily housing and 836 housed in mixed use developments. In Urban TODs, 2,554 persons were allocated to multifamily housing, with a further 1,481 in mixed use developments for a total of 4,035. In all infill areas, new multifamily housing had a population of 21,052, mixed use developments had 2,317 new inhabitants, and 11,804 persons going to new single family dwellings. See Table 5-3 for full new infill population results.

Retail, office, and mixed use infill added a combined total of 13,398,776 square feet of commercial floor space, an increase of 153% from current floor space within infill areas, as per 2010 parcel data. In Neighborhood TODs, this consisted of 1,612,496 square feet of retail space, a 104% increase, and 1,414,279 of office square feet, an increase of 230%. 691,280 square feet of this retail and 340481 square feet of the office space were in mixed use developments. In Urban TODs, retail space increased by

2,532,649 square feet, or 255%, office space by 1,596,795 square feet (204% increase), with 1,108,717 square feet of retail space and 546,084 square feet of office space in mixed use. New retail locations within Secondary Areas came with 3,175,968 square feet of new floor area (an 97% increase), and offices included 3066588 square feet, which is a 198% increase over 2010 office space in Secondary Areas. See Table 5-4 for full infill commercial floor space results.

In total, these new businesses generated 23,455 jobs in the model. For the 15,703 office jobs created, 3,654 were in Neighborhood TODs (878 of these in MXDs); 4,124 were in Urban TODs (1,412 in MXDs); while 7,925 office jobs were created in Secondary Areas. Of the 7,752 retail jobs, 1,709 were in Neighborhood TODs (735 in MXDs); 2,684 were in Urban TODs (1,173 in MXDs); and finally, in Secondary Areas, 3,359 retail jobs were generated. See Table 5-5 for full infill new jobs results.

Urban Growth Scenario Results

As explained in Chapter 4, before the five urban growth scenarios used in this study could be modeled, Lake County's 2010 gross urban density (and thus gross urban area) needed to be calculated, and this necessitated creating a land-cover map of the county including urban areas, water features, protected areas, and greenfield. In this map, greenfield was 267,180.5 acres, there were 133,085.1 acres of protected lands, 181,787 acres of water features, leaving 158,541.7 acres of urban area. Based on the 2010 population of 297,052, this produced a GUD of 1.874. Table 5-6 shows these results. Figure 5-7 shows a map of this land cover in Lake County.

With this calculation completed, scenario creation could commence. In the trend scenario, the urban area grew by 119,497.5 acres for 2040, which is a 75% increase over the 2010 urban area. For the first infill scenario, (using the base GUD as a new growth density and assuming an infill population of 35,173) 100,800.4 acres of urban growth occurred, a 64% increase. In the second infill scenario, (using 1.5 times the GUD) there were 67,223.9 acres of new urban growth, a 42% increase. The third infill scenario (doubling the GUD) produced 50,279.8 acres of new urban growth, a 32% increase. Finally, in the “infill only” scenario, which built out the infill areas but used no other land for new urban growth, all 3,333.4 acres of available land in these areas was used, which produced only a 2% increase in the gross urban area. Table 5-7 shows all results for the urban growth scenarios. Figures 5-8 through 5-12 show the spatial results of each scenario.

Agricultural Losses Results

As of 2010, there are 193,248.1 acres of agricultural land in Lake County divided into the following types: Field Cropland (5,663.7 acres), Grazing Land (115,048.7 acres), Timberland (45,519.7 acres), and Citrus Cropland (27,016.0 acres).

Farmland Losses

Urban growth from the five 2040 scenarios reduced this amount of farmland by varying amounts. The Trend scenario reduced the total amount of farmland by 133188.9 acres (a 69% loss of area from 2010), including 2988.2 acres of field crops (a 53% loss), 75752.0 acres of grazing land (66%), while timberland was reduced by 32236.2 acres (71%), and 22212.5 acres of citrus cropland (82%).

For the first infill scenario, using base GUD for new growth, total farmland was reduced by 115485.2 acres (a 60% loss), field cropland by 2506.3 acres (44%), grazing land by 64558.1 (56%), timberland by 29652.0 (65%), and citrus cropland by 18769.0 (69%).

In the GUD times 1.5 infill scenario, total farmland was reduced by 81828.4 acres (42%), field cropland by 1664.2 acres (29%), grazing land by 45490.7 (40%), timberland by 22971.3 (50.5%), and citrus cropland by 11702.0 (43%).

Total farmland area was reduced by 59432.4 acres in the double GUD infill scenario (30.8%). Additionally, field cropland lost 1351.0 acres (24%), grazing land by 34426.4 (30%), timberland by 14205.3 (31%), and citrus cropland by 9449.8 (35%).

Finally, in the infill only scenario, overall farmland area was reduced by 522.4 acres (0.27%), no field cropland was lost, 233.3 acres of grazing land was lost (0.20%), timberland by 171.5 (0.38%), and citrus cropland by 117.7 (0.44%). Refer to Tables 5.8 and 5.9 for all farmland acreage losses results, and Figures 5-13 through 5-17 for maps of converted and remaining farmland in each scenario.

Losses in Potential Crop Yield

The loss of farmland incurred losses of potential crop yield for the 10 different agricultural products in the study. Once again, this varied between the different urban growth scenarios used.

In the trend scenario, losses in potential yield for field crops included: peanuts, with a loss of 3,008,540 pounds, which is 69% of the 2010 potential yield, and is worth a total of $691,964; soybeans, for a loss of 62,989 bushels (66% of the 2010 potential yield), worth $812,553; corn, which lost 70,115 bushels (59%), worth $464,164; 4358 tons of sweet corn lost (38%), worth $2,762,586; 22,561 tons of watermelon (62%), worth $5,414,610; and 1840 tons of cucumber (89%), worth $1,115,047. Losses in the trend scenario for citrus crops included 8,505,989 boxes of oranges (84.3% of the 2010 potential yield), worth $77,404,502; and 12,569,973 boxes of grapefruit (84.2%) worth $95,280,400. For grazing land, there were potential yield losses of 564,294 animal unit months of grass (64%), worth $42,999,191, while timberland experienced losses of 4,024,600 cubic meters of wood (77%), worth $63,175,858. The average loss in potential yield for this scenario was 69%, while the median loss was 68%.

In the first infill scenario, using base GUD for new growth, losses in potential yield for field crops included: peanuts, with a loss of 2,946,134 pounds, which is 68% of the 2010 potential yield, and is worth a total of $677,610; soybeans, for a loss of 58,997 bushels (62% of the 2010 potential yield), worth $761,068; corn, which lost 65,223 bushels (55%), worth $431,776; 2643 tons of sweet corn lost (23%), worth $1,675,872; 21,931 tons of watermelon (60%), worth $5,263,499; and 1,585 tons of cucumber (77%), worth $960,579. Losses in this scenario for citrus crops included 7,187,896 boxes of oranges (71% of the 2010 potential yield), worth $65,409,860; and 10,594,821 boxes of grapefruit (71%) worth $80,308,748. For grazing land, there were potential yield losses of 470,821 animal unit months of grass (53%), worth $35,876,592, while timberland experienced losses of 3,115,434 cubic meters of wood (72%), worth $58,566,491. The average loss in potential yield for this scenario was 61%, while the median loss was 65%.

In the second infill scenario, using 1.5 times the base GUD for new growth, losses in potential yield for field crops included: peanuts, with a loss of 1,950,671 pounds, which is 45% of the 2010 potential yield, and is worth a total of $448,654; soybeans, for a loss of 38812 bushels (41% of the 2010 potential yield), worth $500,674; corn, which lost 41,717 bushels (35%), worth $276,171; 1,826 tons of sweet corn lost (16%), worth $1,157,876; 14,512 tons of watermelon (40%), worth $3,483,016; and 1,093 tons of cucumber (53%), worth $662,628. Losses in this scenario for citrus crops included

4,481,951 boxes of oranges (44% of the 2010 potential yield), worth $40,785,761; and 6,609,740 boxes of grapefruit (44%) worth $50,101,829. For grazing land, there were potential yield losses of 331,749 animal unit months of grass (38%), worth $25,279,291, while timberland experienced losses of 2,257,533 cubic meters of wood (56%), worth $45,779,037. The average loss in potential yield for this scenario was 41%, and the median loss was 43%.

Losses in potential yield for the third infill scenario, which used double the base GUD for new growth areas, included: peanuts, with a loss of 1,653,152 pounds, which is 38% of the 2010 potential yield, and is worth a total of $380,225; soybeans, for a loss of 30,755 bushels (32% of the 2010 potential yield), worth $396,740; corn, which lost 34,035 bushels (29%), worth $225,315; 1,444 tons of sweet corn lost (12%), worth $915,437; 12,217 tons of watermelon (33%), worth $2,932,306; 651 tons of cucumber (32%), worth $394,640; 3,713,864 boxes of oranges (37% of the 2010 potential yield), worth $33,796,164; and 5,470,367 boxes of grapefruit (37%) worth $41,465,379. For grazing land, there were potential yield losses of 248,644 animal unit months of grass (28%), worth $18,946,644, while timberland experienced losses of 1,633,648 cubic meters of wood (41%), worth $33,127,674. The average loss in potential yield for this scenario was 32%, while the median loss was 33%.

In the infill only scenario, as there were no acres of cropland lost, no potential yield for field crops were lost. However, there were potential yield losses of 50,004 boxes of oranges, (0.50% of the total potential yield for this crop), which is worth a total of $455,038; 73,536 boxes of grapefruit (0.49%), worth $557,400; 1,633 animal unit months of grass (0.19%), worth $431,953; and 21,301 cubic meters of wood (0.53%), worth $1,568,818. The average loss in potential yield for this scenario was 0.17%, while the median loss was 0%, as a result of there being no loss of yield for cropland. Refer to Tables 5.10, 5.11, and 5.12 for a full tabular summary of all yield losses.

“Agricultural Scenario” Losses

Finally, in the “agricultural scenario”, designed to show a potential total of yield costs for each urban growth scenario (by proportionally dividing up overlapping yields), the 2010 total yield value was calculated to be $248,618,049. The total of yield losses in the trend scenario amount to $189,654,997, or a 76% loss. In the first infill scenario, this loss drops to $165,463,388, a 67% loss of yield value. This is followed by a $119,304,716 loss in the second infill scenario (48%), and a $89,796,050 loss (36%) in the third infill scenario. The infill build-out only scenario sees only a $1,021,655 loss, which is only 0.41% of the total yield value. Table 5-13 shows the full results of the agricultural scenario.

Table 5-1. Infill areas: change in land uses (acres)

	Single family	% Inc.	Multi family	% Inc.	Office	% Inc.	Retail	% Inc.	Mixed Use	Sum
Neighborhood TOD	0	0%	76.8	126%	41.1	48%	35.2	19%	11.84	164.9
Urban TOD	0	0%	31.3	38%	24.1	32%	32.7	54%	12.90	101.0
Secondary Area	502	14%	340.3	67%	117.3	44%	121.5	25%	0.0	1081.1
Sum	502	14%	448.4	68%	182.5	43%	189.4	26%	24.74	1347.0

Table 5-2. New infill residential units

	Single family units	% Inc.	Multi family units	% Inc.	Mixed Use units	Sum
Neighborhood TOD	0	0%	1157	178%	357	1514
Urban TOD	0	0%	1092	106%	633	1725
Secondary Area	5030	38%	6732	133%	0	11762
Sum	5030	38%	8981	134%	990	15001

Table 5-3. New infill population estimate

	Single Family	Multi family	Mixed Use	Sum
Neighborhood TOD	0	2754	836	3590
Urban TOD	0	2554	1481	4035
Secondary Area	11804	15744	0	27548
Sum	11804	21052	2317	35173

Table 5-4. New infill commercial floor area (square feet)

	Total Office Floor Area	*(In MXDs only)*	% Increase	Total Retail Floor Area	*(In MXDs only)*	% Increase	Sum Space
Neighborhood TOD	1414279	*340481*	230%	1612496	*691280*	104%	3026775
Urban TOD	1596795	*546084*	204%	2532649	*1108717*	255%	4129444
Secondary Area	3066588	*0*	198%	3175968	*0*	97%	6242557
Sum Space	6077662	*886566*	206%	7321113	*1799997*	126%	1.3E+07

Table 5-5. Infill commercial job estimate

	Total Office Jobs	*(In MXDs only)*	Total Retail Jobs	*(In MXDs ony)*	Sum Jobs
Neighborhood TOD	3654	*878*	1709	*735*	5363
Urban TOD	4124	*1412*	2684	*1173*	6808
Secondary Area	7925	*0*	3359	*0*	11284
Sum Jobs	15703	*2290*	7752	*1908*	23455

Table 5-6. Lake County land cover

Land Cover Type	Acreage
Water Features	181,787.0
Managed Lands	133,085.1
Greenfield	267,180.5
Gross Urban Area	158,541.7

Table 5-7. Urban growth scenarios

Scenario	Acres of New Growth	Urban Area Increase
Trend	119497.5	75%
Base GUD and Infill	100800.4	64%
1.5 x Infill	67223.9	42%
2 x Infill	50279.8	32%
Total Infill	3333.4	2%

Table 5-8. 2040 farmland acreage losses in Lake County

		Losses in each Scenario				
Farm Type	2010 Acreage	Trend	Base GUD and Infill	1.5 x GUD and Infill	2 x GUD and Infill	Infill Build-Out
Field Crops	5662	2988	2506	1664	1351	0
Grazing Land	114977	75752	64558	45491	34426	233
Timberland	45473	32236	29652	22971	14205	171
Citrus Crops	27012	22212	18769	11702	9450	118
Sum	193124	133189	115485	81828	59432	522

Table 5-9. 2040 farmland percentage losses in Lake County

		Losses in each Scenario				
Farm Type	2010 Acreage	Trend	Base GUD and Infill	1.5 x GUD and Infill	2 x GUD and Infill	Infill Build-Out
Field Crops	5662	52.77%	44.26%	29.39%	23.86%	0.00%
Grazing Land	114977	65.88%	56.15%	39.57%	29.94%	0.20%
Timberland	45473	70.89%	65.21%	50.52%	31.24%	0.38%
Citrus Crops	27012	82.23%	69.48%	43.32%	34.98%	0.44%
Sum	193124	68.97%	59.80%	42.37%	30.77%	0.27%

Table 5-10. 2040 potential crop yield losses in Lake County

		2010 Total Potential Yield	Losses				
			Trend	Base GUD and Infill	1.5 x GUD and Infill	2 x GUD and Infill	Infill Only
Field Crops	Peanuts (pounds)	4356078	3008541	2946134	1950672	1653152	0
	Soybeans (bushels)	95079	62989	58998	38812	30755	0
	Corn (bushels)	117922	70115	65223	41718	34035	0
	Sweet Corn (tons)	11588	4357	2643	1826	1444	0
	Watermelon (tons)	36586	22561	21931	14513	12218	0
	Cucumber (tons)	2063	1840	1585	1093	651	0
Citrus Crops	Orange (boxes)	10085869	8505989	7187897	4481952	3713864	50004
	Grapefruit (boxes)	14926507	12569974	10594822	6609740	5470367	73536
Grazing	Grass (animal unit months)	881871	564294	470821	331749	248644	1633
Timber	Wood (cubic meters)	4024600	3115435	2888130	2257533	1633648	21301

Table 5-11. 2040 potential crop yield losses in Lake County (percentage)

	-	2010 Potential Yield	Losses: Trend	Base GUD and Infill	1.5 x GUD and Infill	2 x GUD and Infill	Infill Only
Field Crops	Peanuts (pounds)	4356078	69.07%	67.63%	44.78%	37.95%	0.00%
	Soybeans (bushels)	95079.31	66.25%	62.05%	40.82%	32.35%	0.00%
	Corn (bushels)	117922.1	59.46%	55.31%	35.38%	28.86%	0.00%
	Sweet Corn (tons)	11587.93	37.60%	22.81%	15.76%	12.46%	0.00%
	Watermelon (tons)	36586.16	61.67%	59.94%	39.67%	33.39%	0.00%
	Cucumber (tons)	2063.285	89.18%	76.82%	53.00%	31.56%	0.00%
Citrus Crops	Orange (boxes)	10085869	84.34%	71.27%	44.44%	36.82%	0.50%
	Grapefruit (boxes)	14926507	84.21%	70.98%	44.28%	36.65%	0.49%
Grazing	Grass (animal unit months)	881871	63.99%	53.39%	37.62%	28.20%	0.19%
Timber	Wood (cubic meters)	4024600	77.41%	71.76%	56.09%	40.59%	0.53%
	Average		69.32%	61.20%	41.18%	31.88%	0.17%
	Median		67.66%	64.84%	42.55%	32.87%	0.00%

Table 5-12. 2040 potential crop yield losses in Lake County (in US dollars)

		Dollars per unit, August 2011	2010 Potential Yield	Losses				
				Trend	Base GUD and Infill	1.5 x GUD and Infill	2 x GUD and Infill	Infill Only
Field Crops	Peanuts (pounds)	0.23	1001898	691964	677611	448654	1001898	0
	Soybeans (bushels)	12.90	1226523	812554	761069	500674	1226523	0
	Corn (bushels)	6.62	780644	464164	431777	276172	780644	0
	Sweet Corn (tons)	634.00	7346747	2762586	1675873	1157876	7346747	0
	Watermelon (tons)	240.00	8780678	5414610	5263499	3483016	8780678	0
	Cucumber (tons)	606.00	1250351	1115047	960579	662628	1250351	0
Citrus Crops	Orange (boxes)	9.10	91781412	77404502	65409861	40785761	33796164	455038
	Grapefruit (boxes)	7.58	113142924	95280400	80308749	50101829	41465379	557400
Grazing	Grass (animal unit months)	76.20	67198571	42999191	35876593	25279291	18946644	124427
Timber	Wood (sawtimber, cubic meters)	20.28	81612227	63175858	58566492	45779037	33127674	431953

Table 5-13. Crop yield losses in 2040 "agricultural scenario" (in US dollars)

		Dollars per unit, August 2011	2010 Total Yield	Losses				
				Trend	Base GUD and Infill	1.5 x GUD and Infill	2 x GUD and Infill	Infill Only
Field Crops	Peanuts (pounds)	0.23	246796	172991	169403	448654	112164	0
	Soybeans (bushels)	12.90	303987	222017	203039	500674	132581	0
	Corn (bushels)	6.62	187030	129570	115503	276172	71620	0
	Sweet Corn (tons)	634.00	2346212	1841713	1802810	1157876	1605233	0
	Watermelon (tons)	240.00	2446919	1584640	1539545	3483016	1030092	0
	Cucumber (tons)	606.00	358745	336924	290254	662628	206959	0
Citrus Crops	Orange (boxes)	9.10	82603270	69664052	58868874	36707185	30416547	409534
	Grapefruit (boxes)	7.58	11314292	9528040	8030875	5010183	4146538	55740
Grazing	Grass (animal unit months)	76.20	67198571	42999191	35876593	25279291	18946644	124427
Timber	Wood (sawtimber, cubic meters)	20.28	81612227	63175858	58566492	45779037	33127674	431953
	Sum		248618049	189654997	165463388	119304716	89796050	1021655
	Percentage Loss		0%	76.28%	66.55%	47.99%	36.12%	0.41%

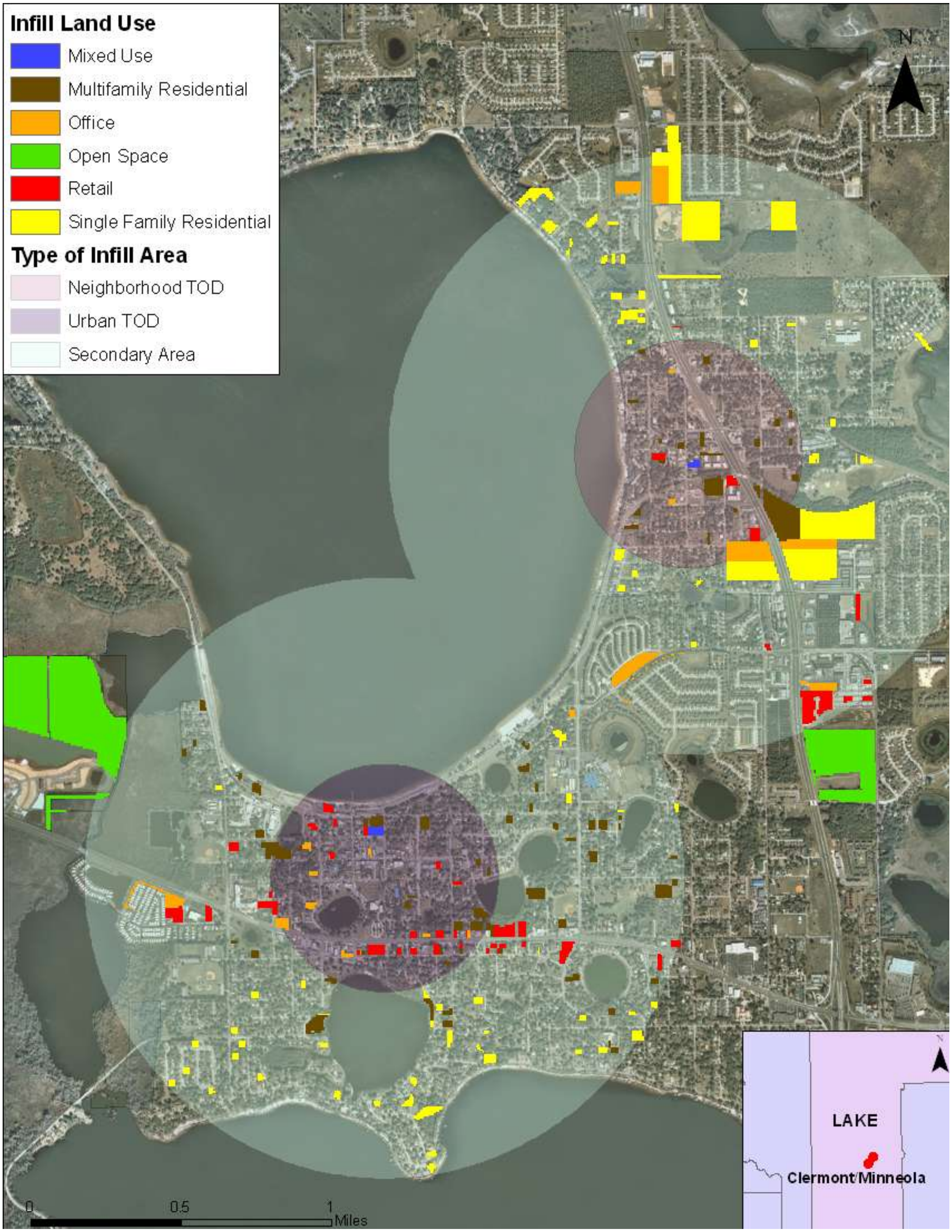

Figure 5-1. New urban infill: Clermont/Minneola area

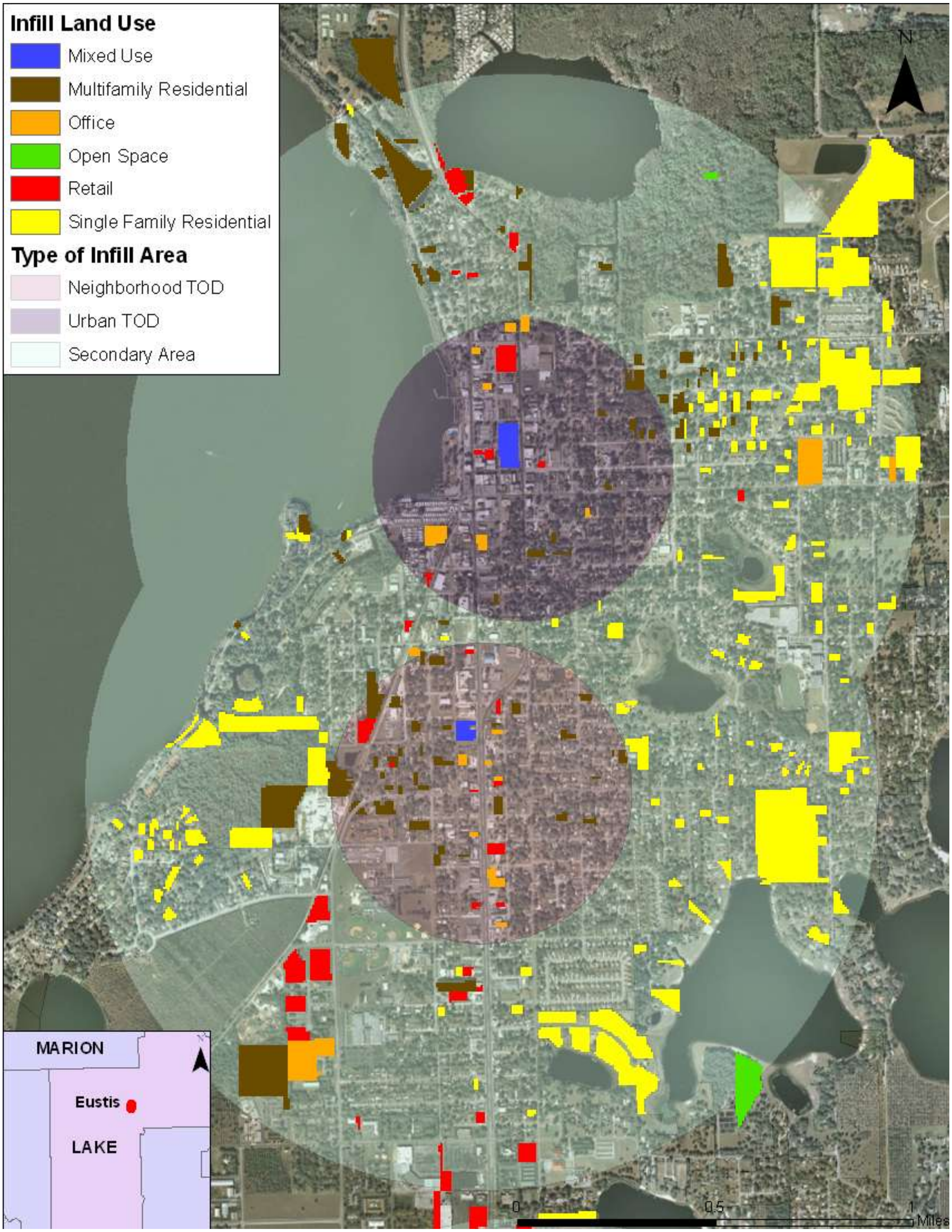

Figure 5-2. New urban infill: Eustis

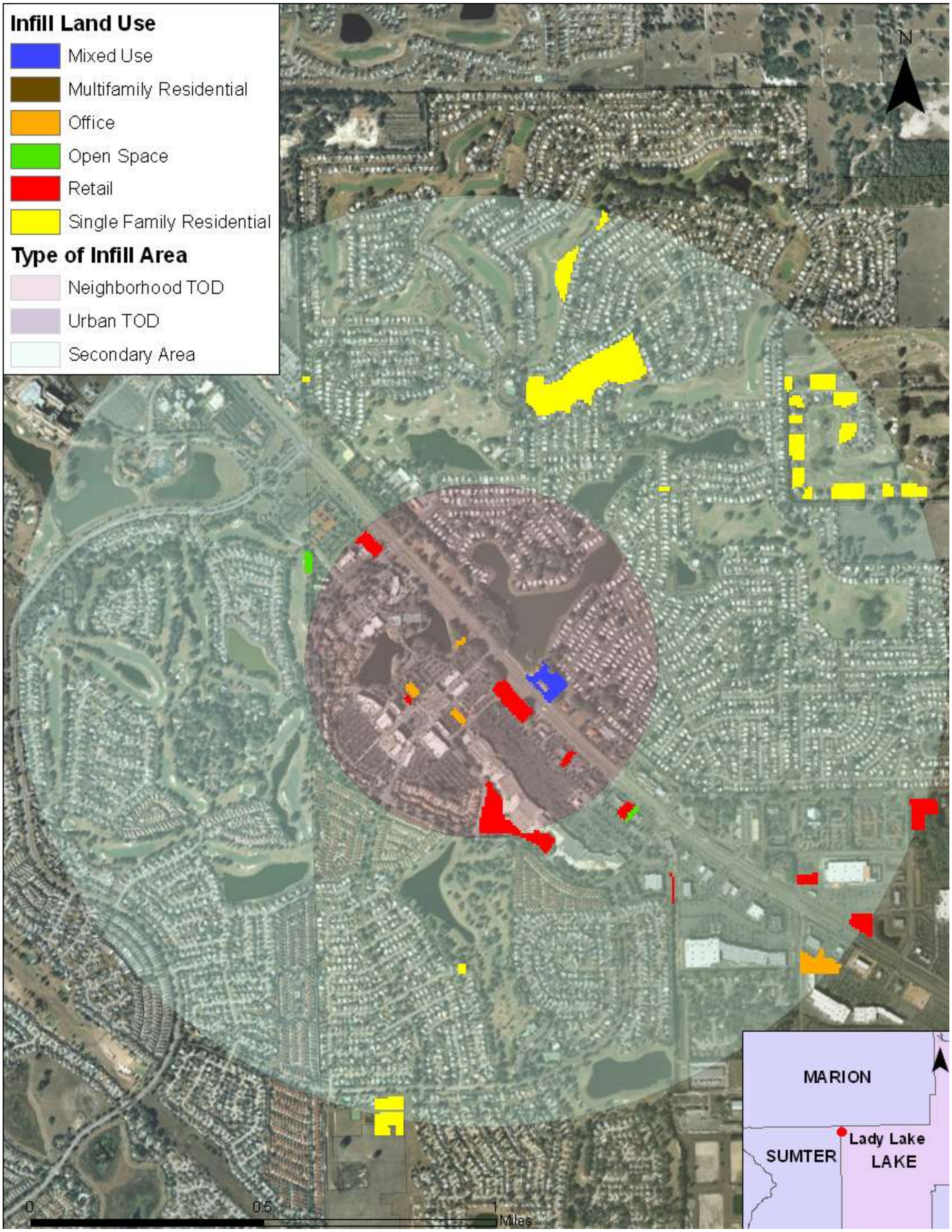

Figure 5-3. New urban infill: Lady Lake

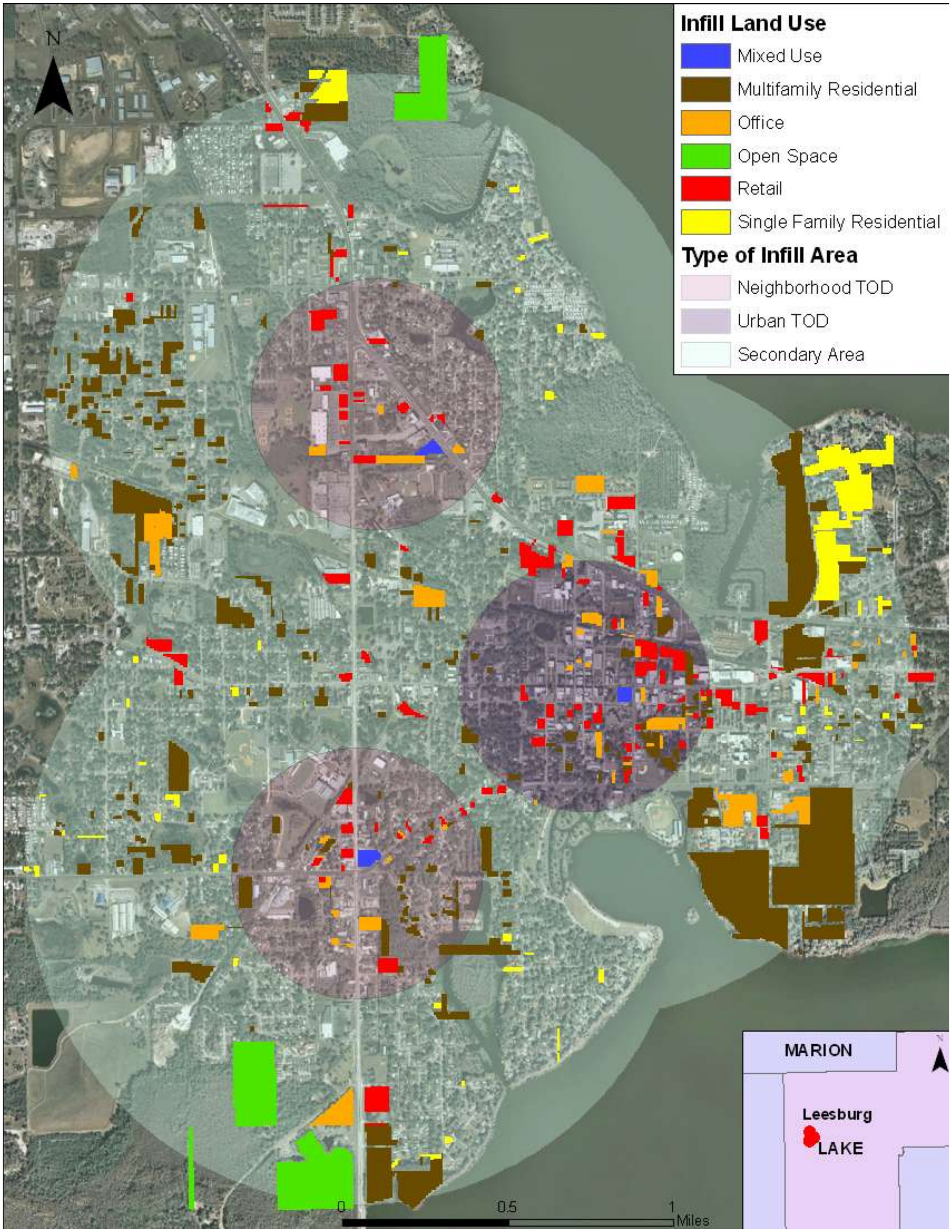

Figure 5-4. New urban infill: Leesburg

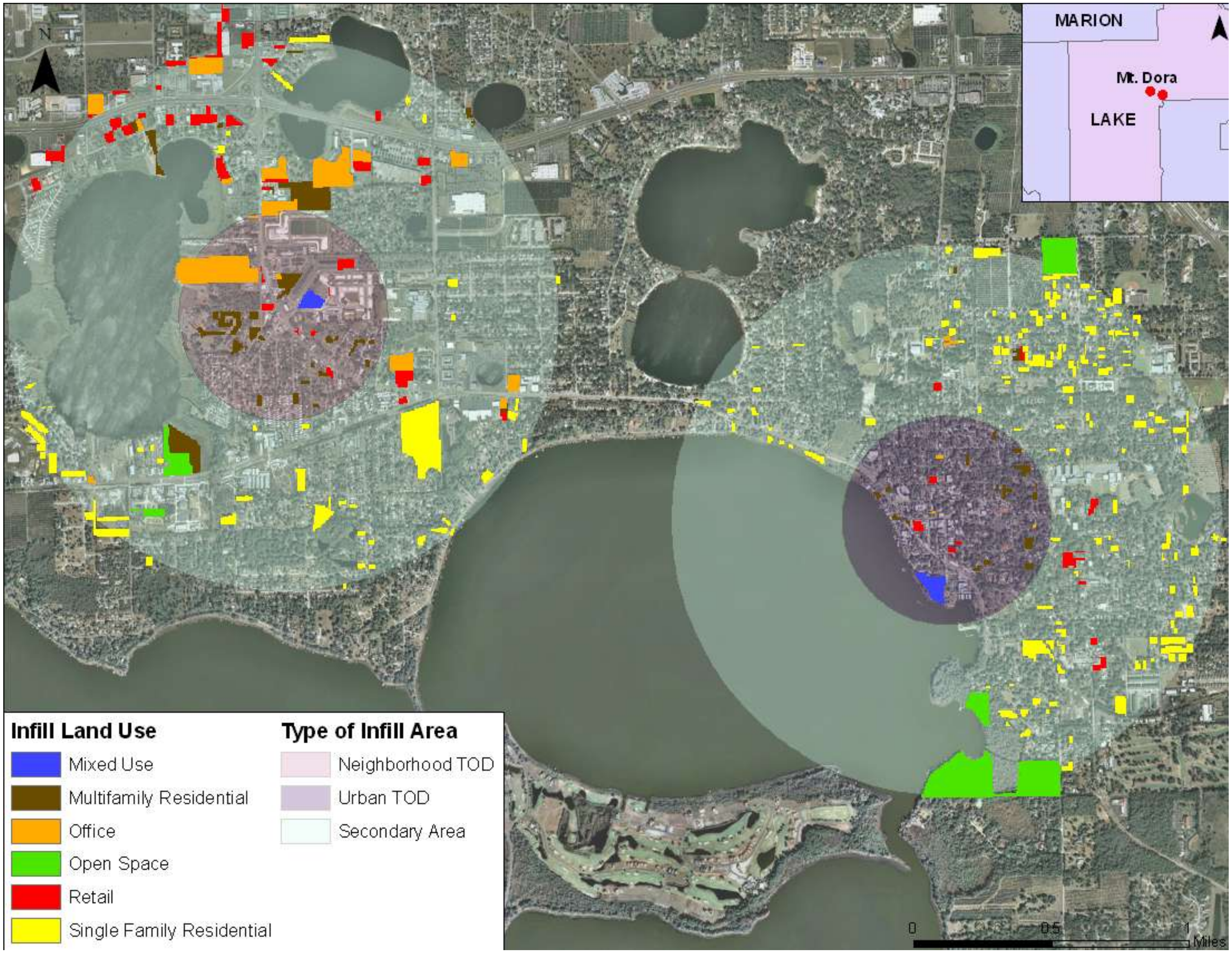

Figure 5-5. New urban infill: Mt. Dora

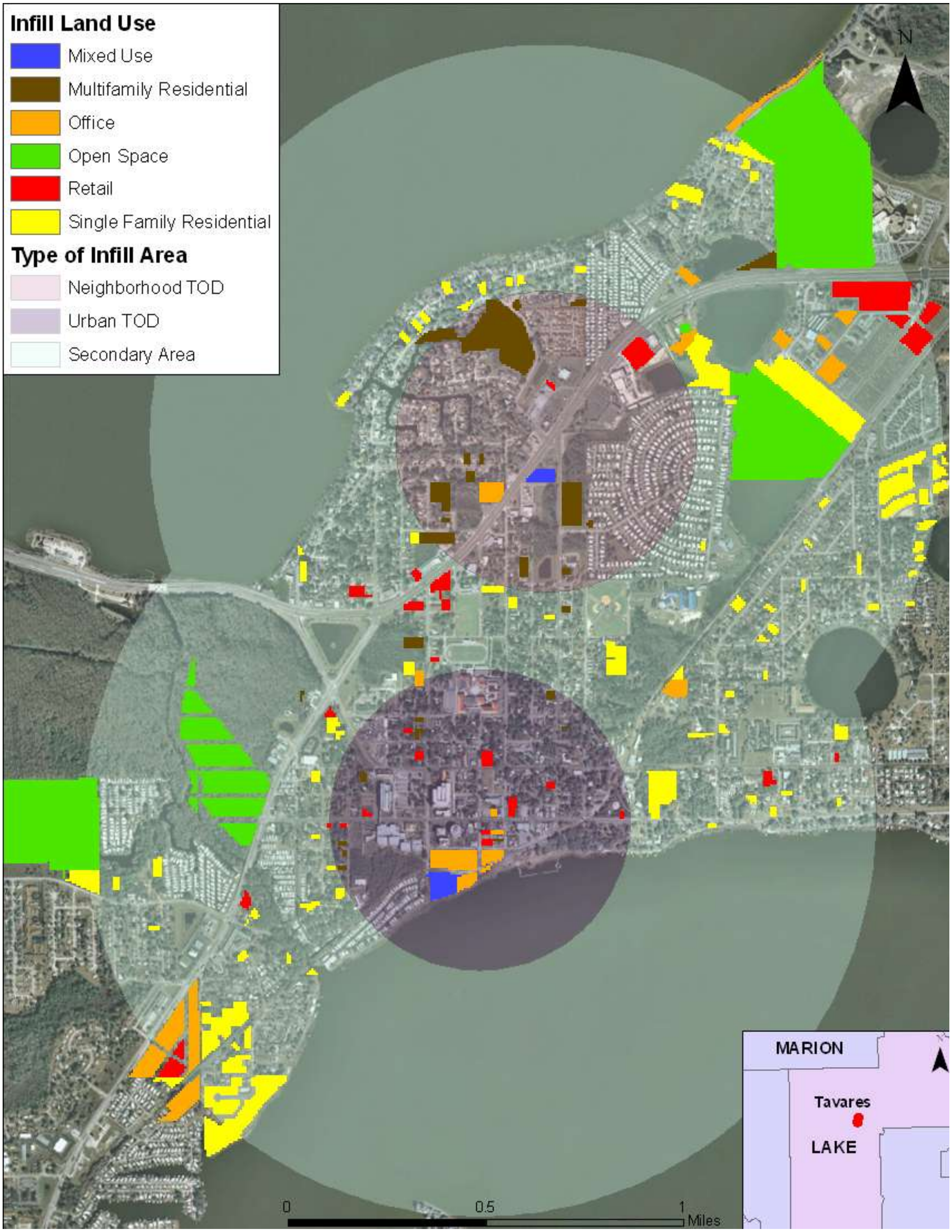

Figure 5-6. New urban infill: Tavares

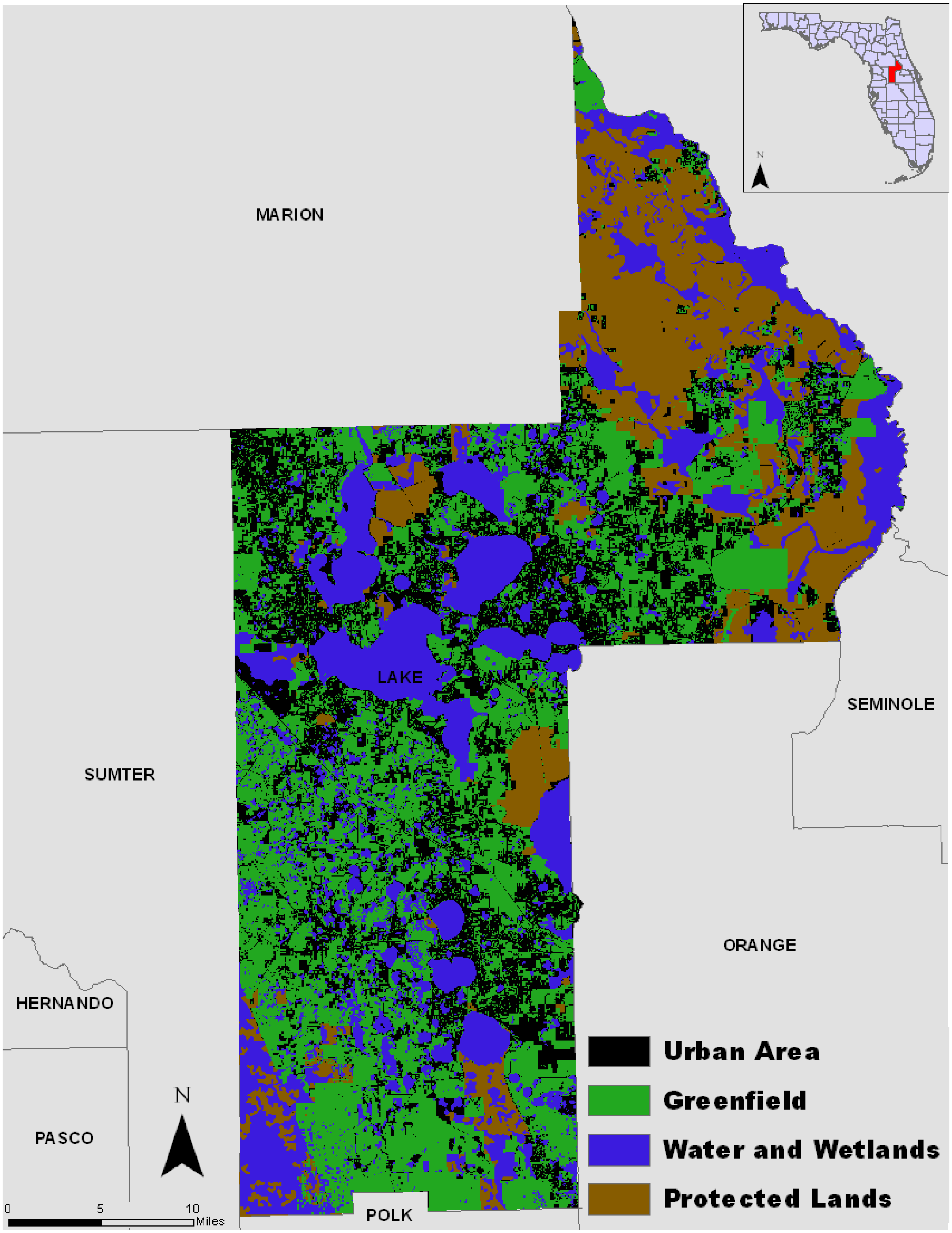

Figure 5-7. Lake County land cover map

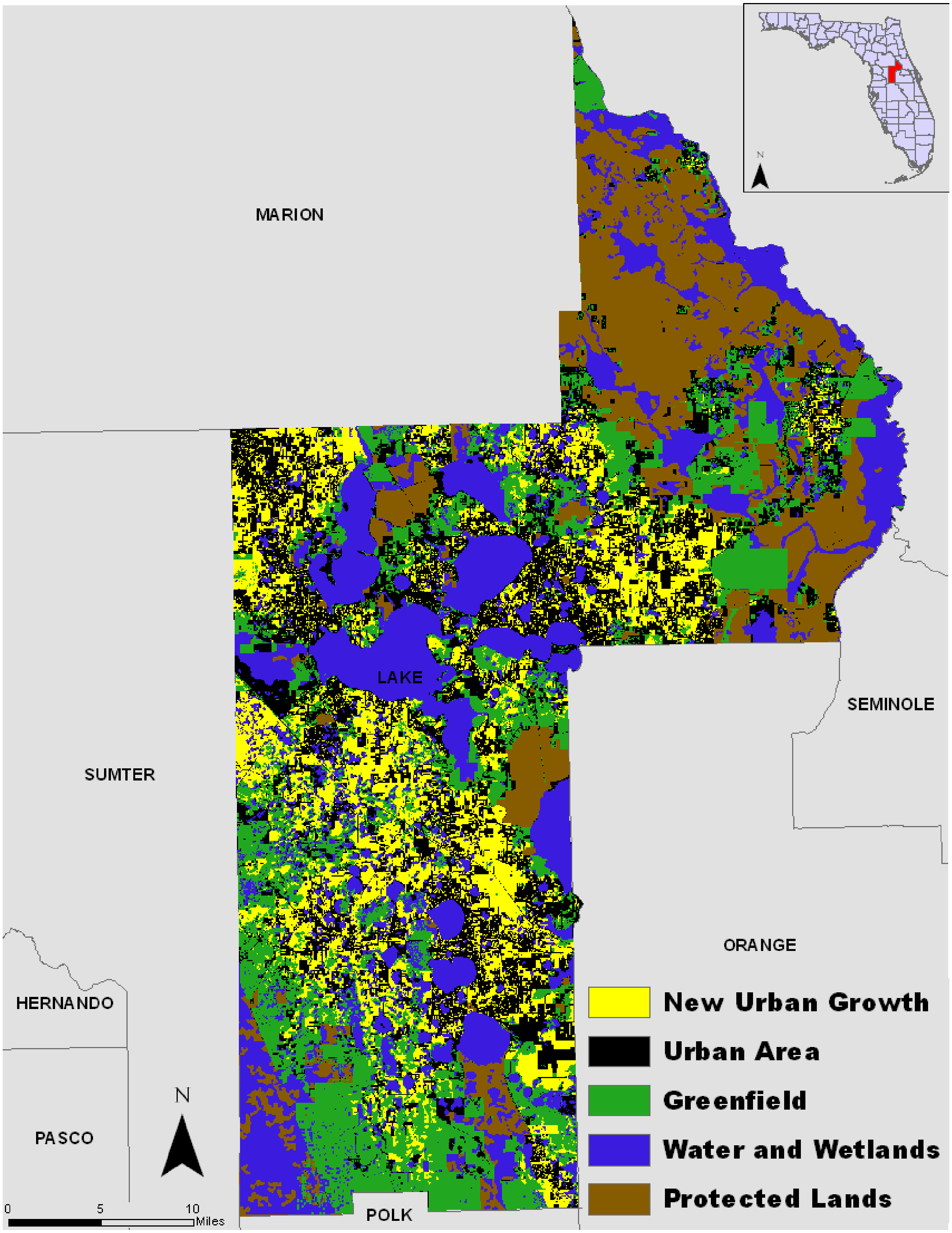

Figure 5-8. Lake County 2040 – trend scenario (using a GUD of 1.87 for new growth areas)

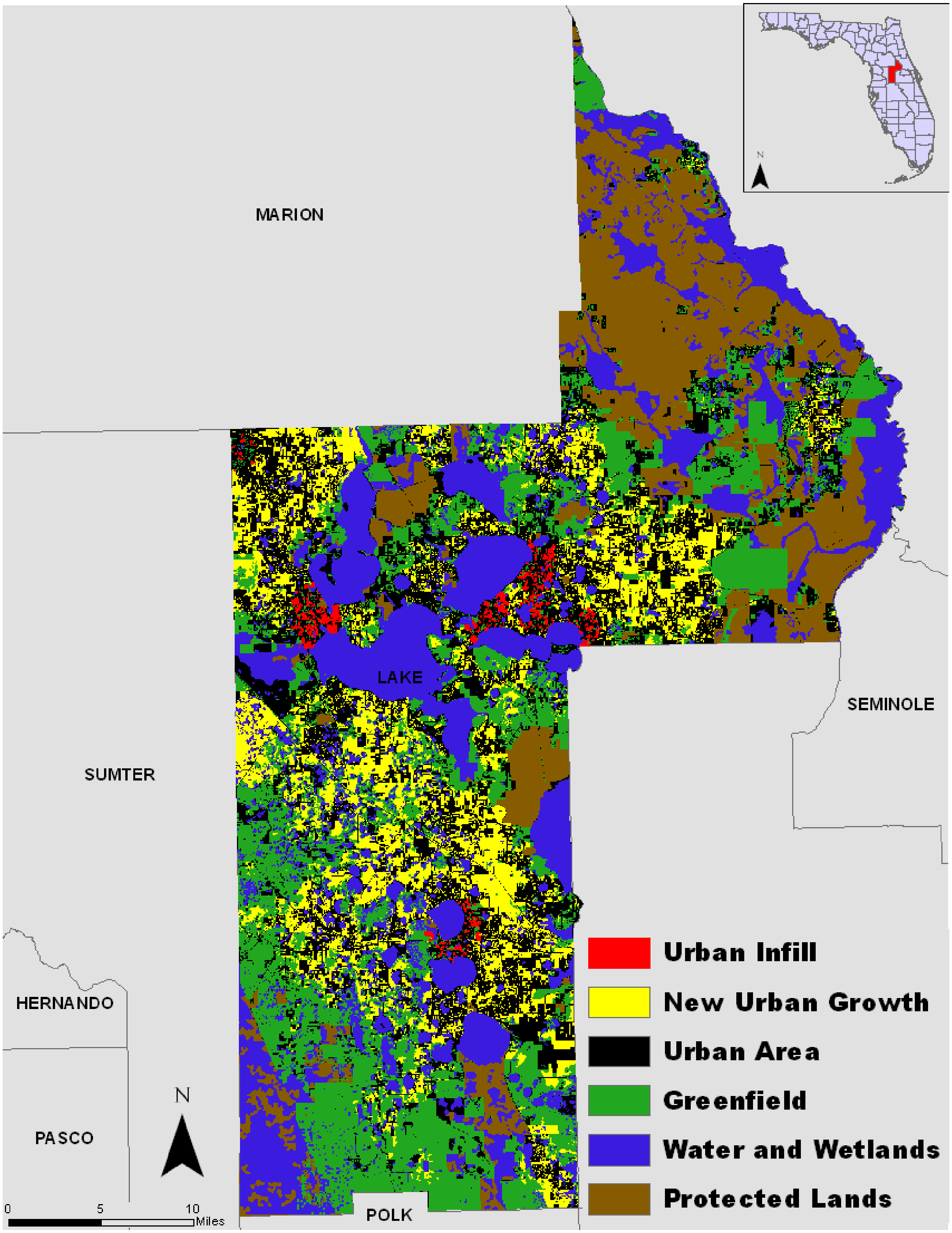

Figure 5-9 Lake County 2040 – first infill scenario (using infill results and a GUD of 1.87 for new growth areas)

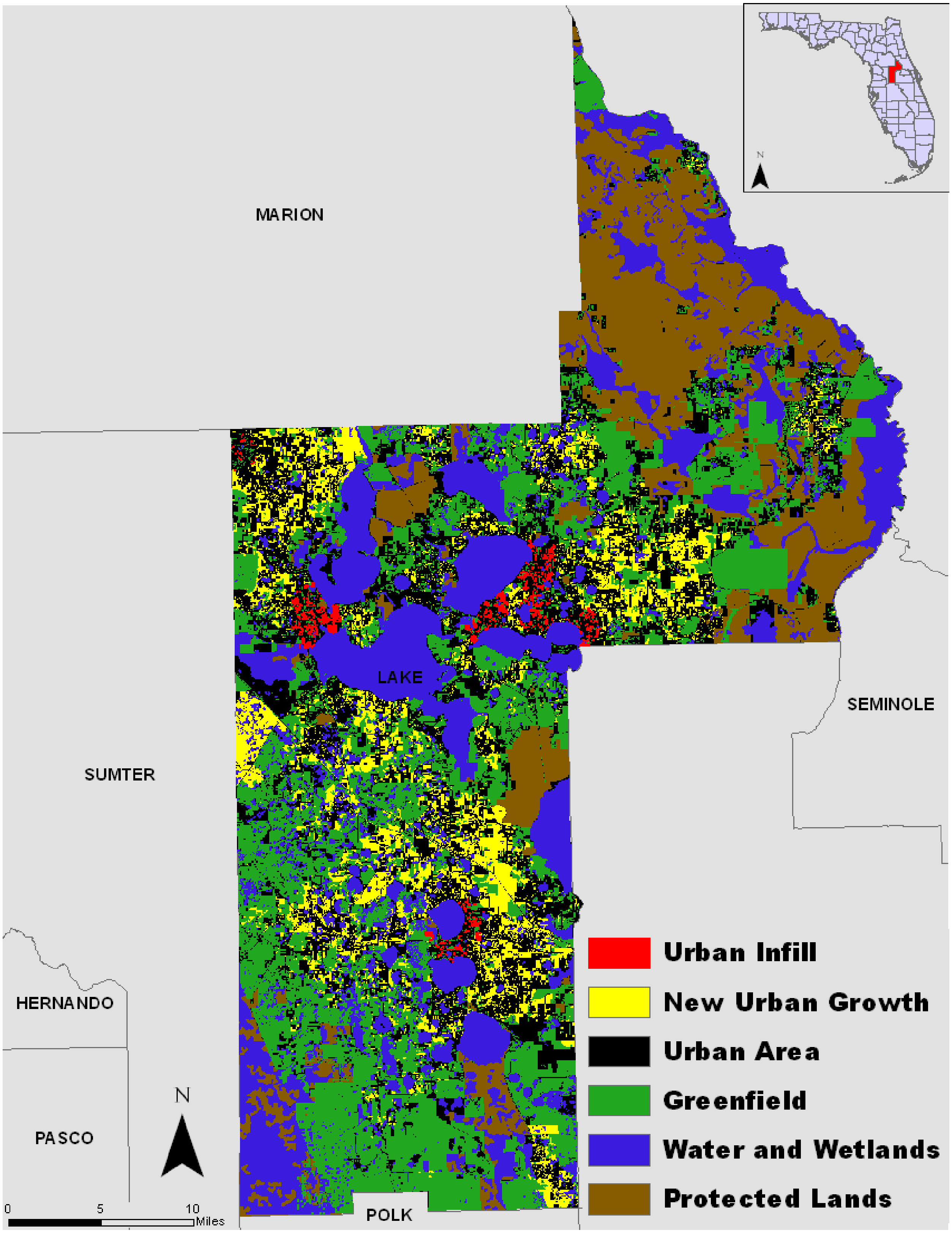

Figure 5-10. Lake County 2040 – second infill scenario (using infill results and a GUD of 2.81 for new growth areas)

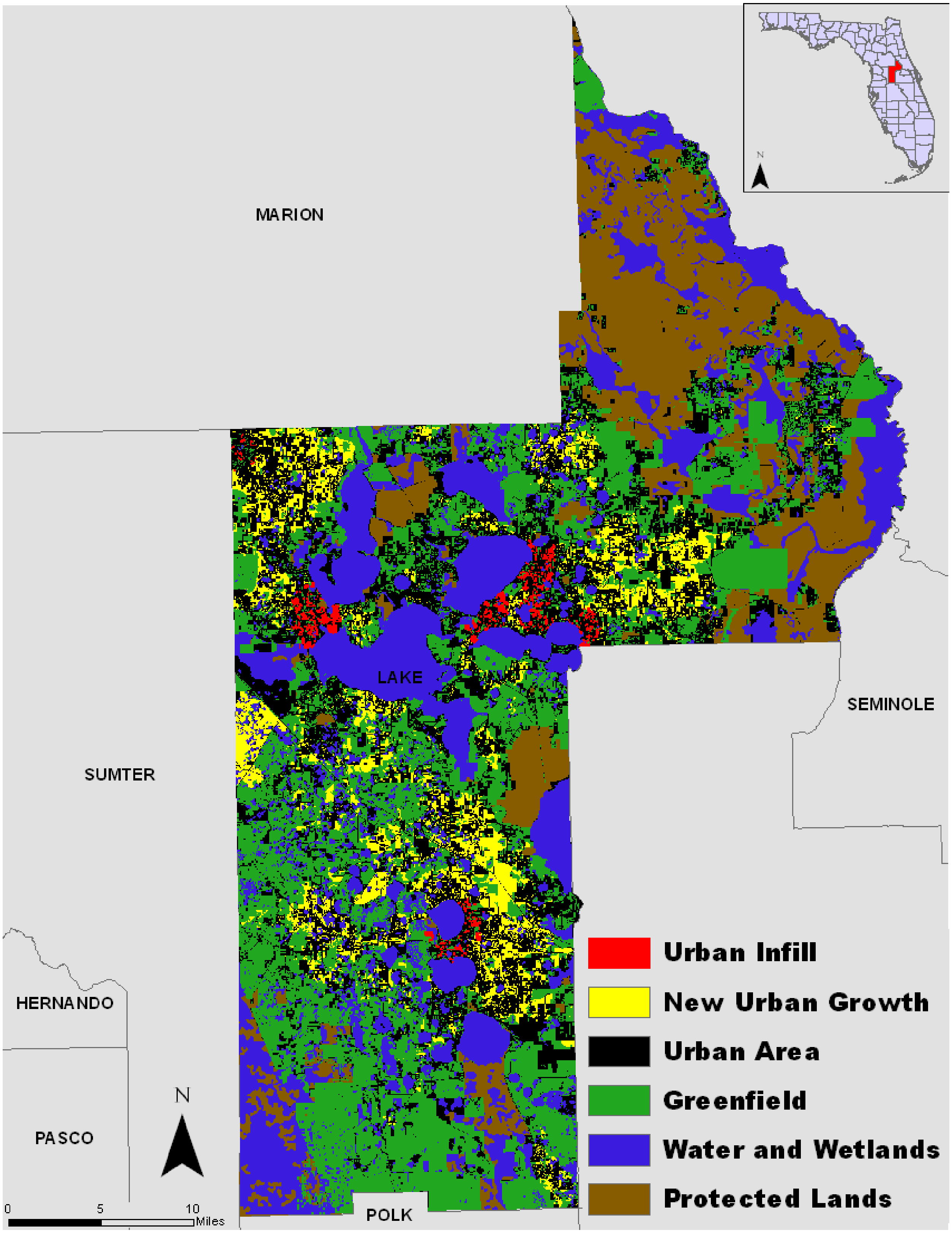

Figure 5-11. Lake County 2040 – third infill scenario (using infill results and a GUD of 3.75 for new growth areas)

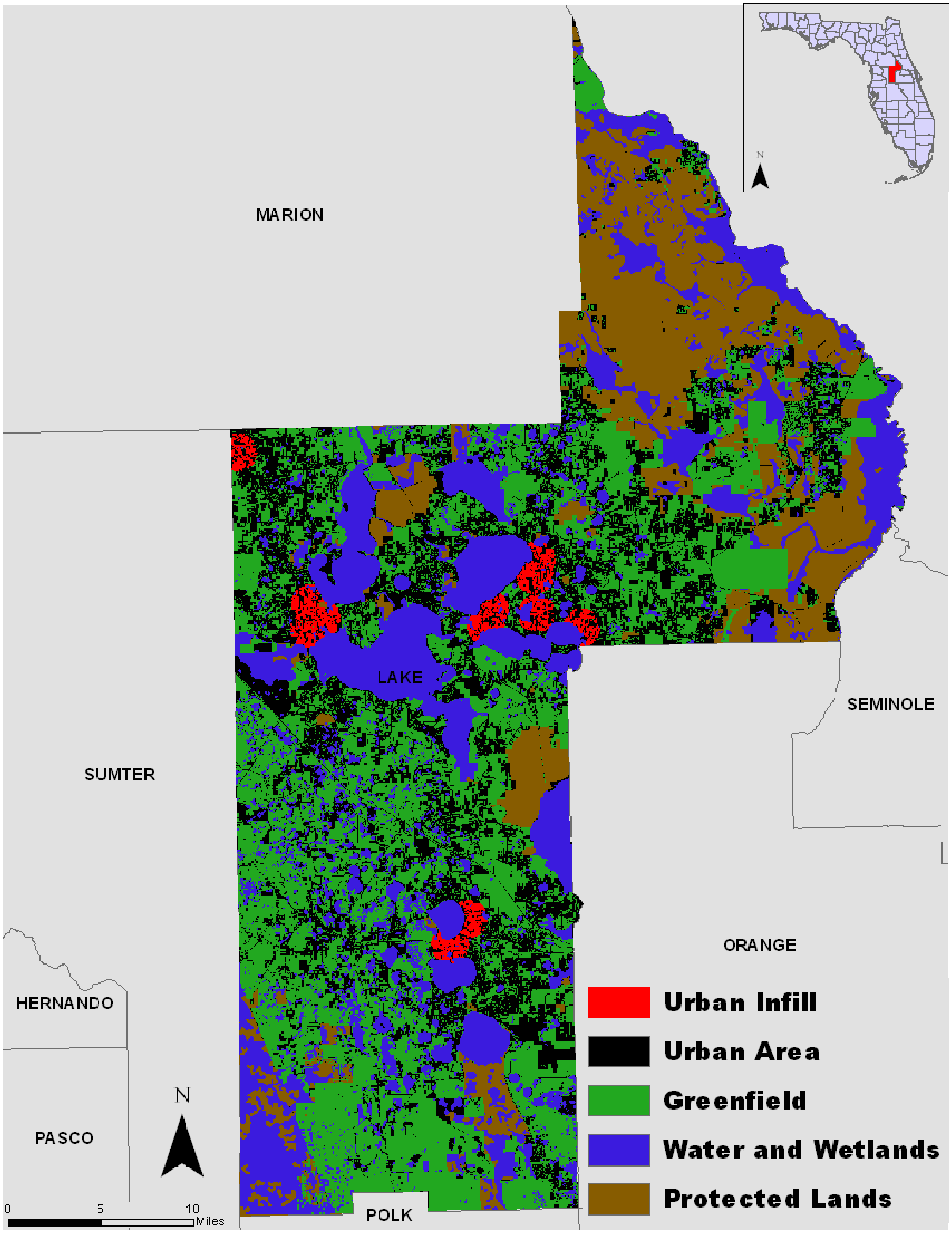

Figure 5-12. Lake County 2040 – "infill only" scenario (all new development restricted to infill areas)

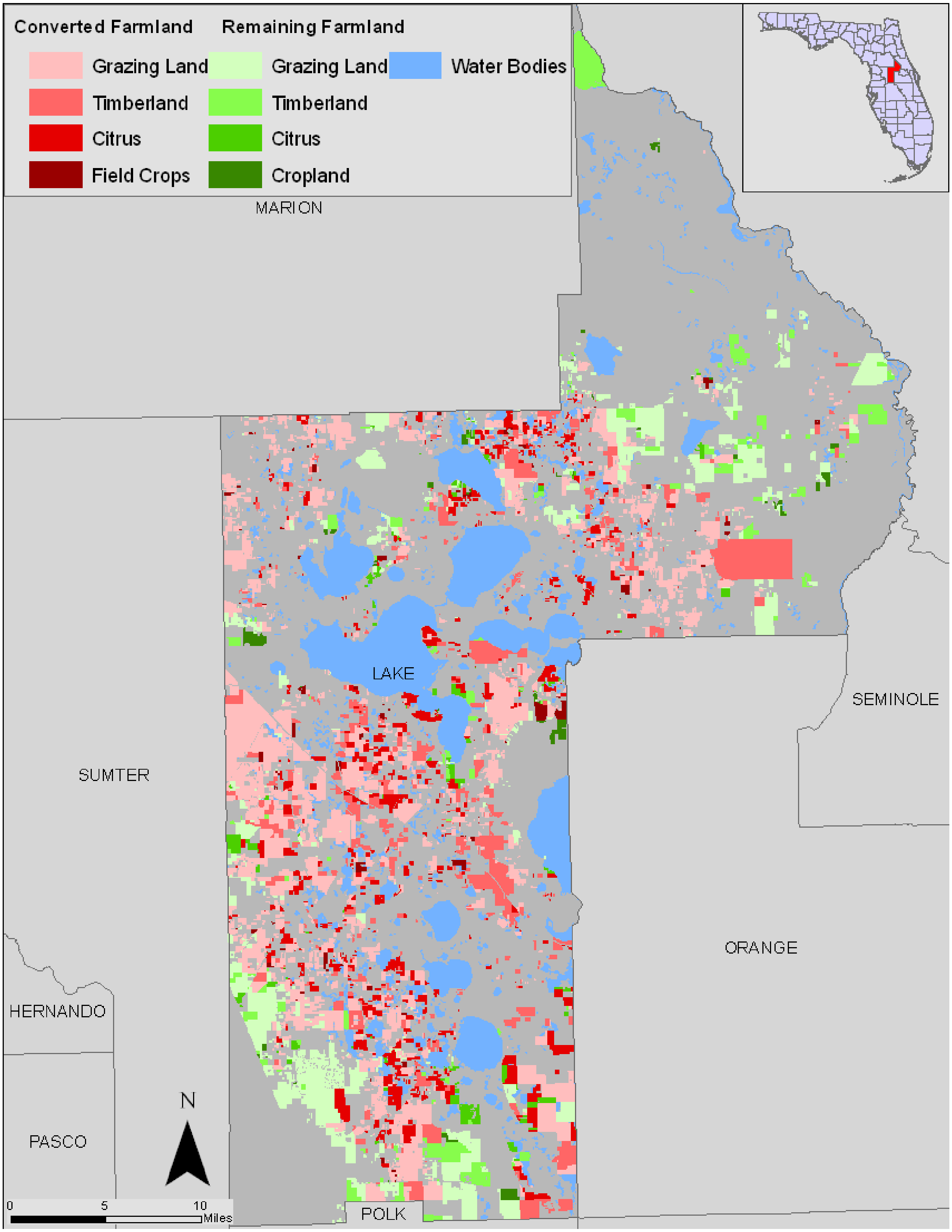

Figure 5-13. Converted and remaining farmland in the Lake County 2040 trend scenario (using a GUD of 1.87 for new growth areas)

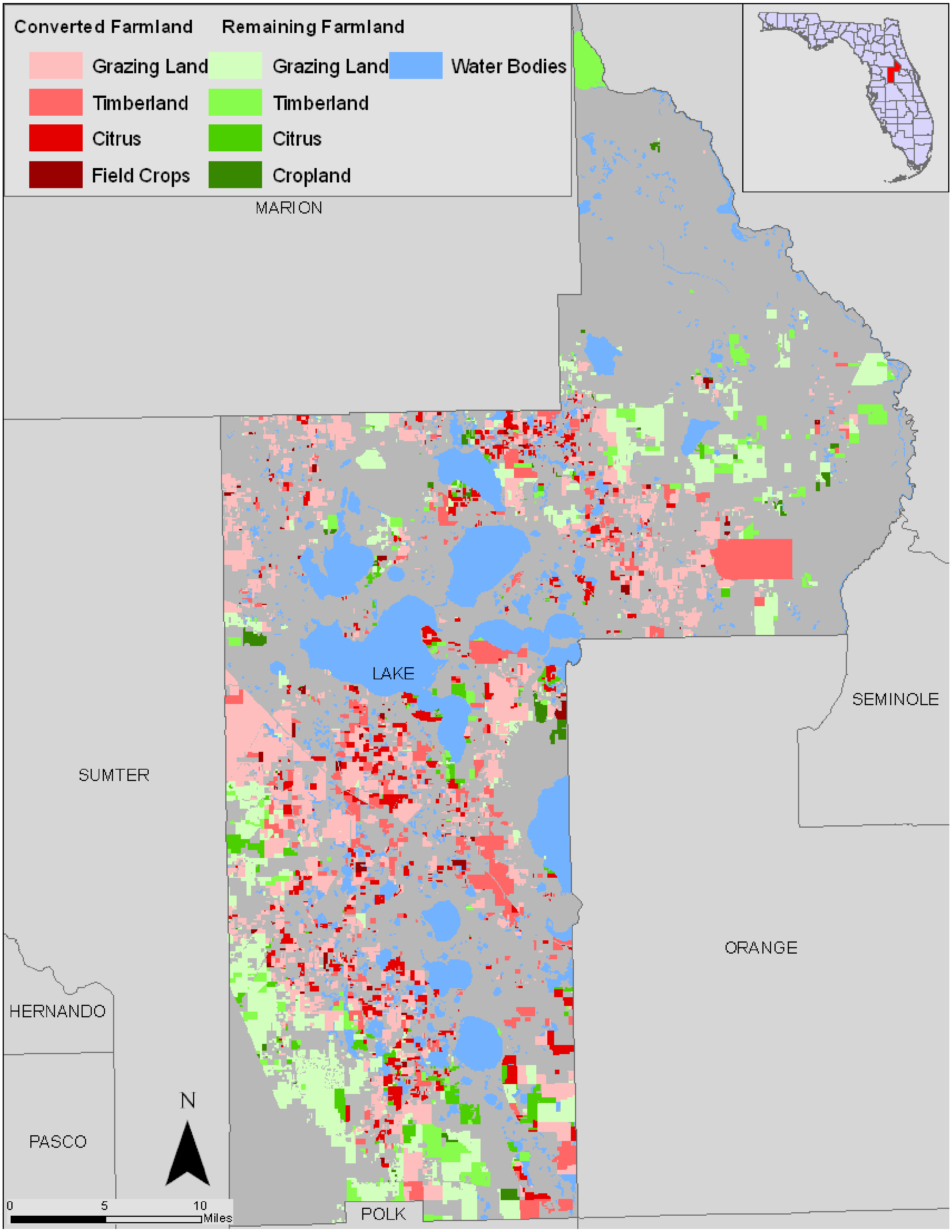

Figure 5-14. Converted and remaining farmland in the Lake County 2040 first infill scenario (using infill results and a GUD of 1.87 for new growth areas)

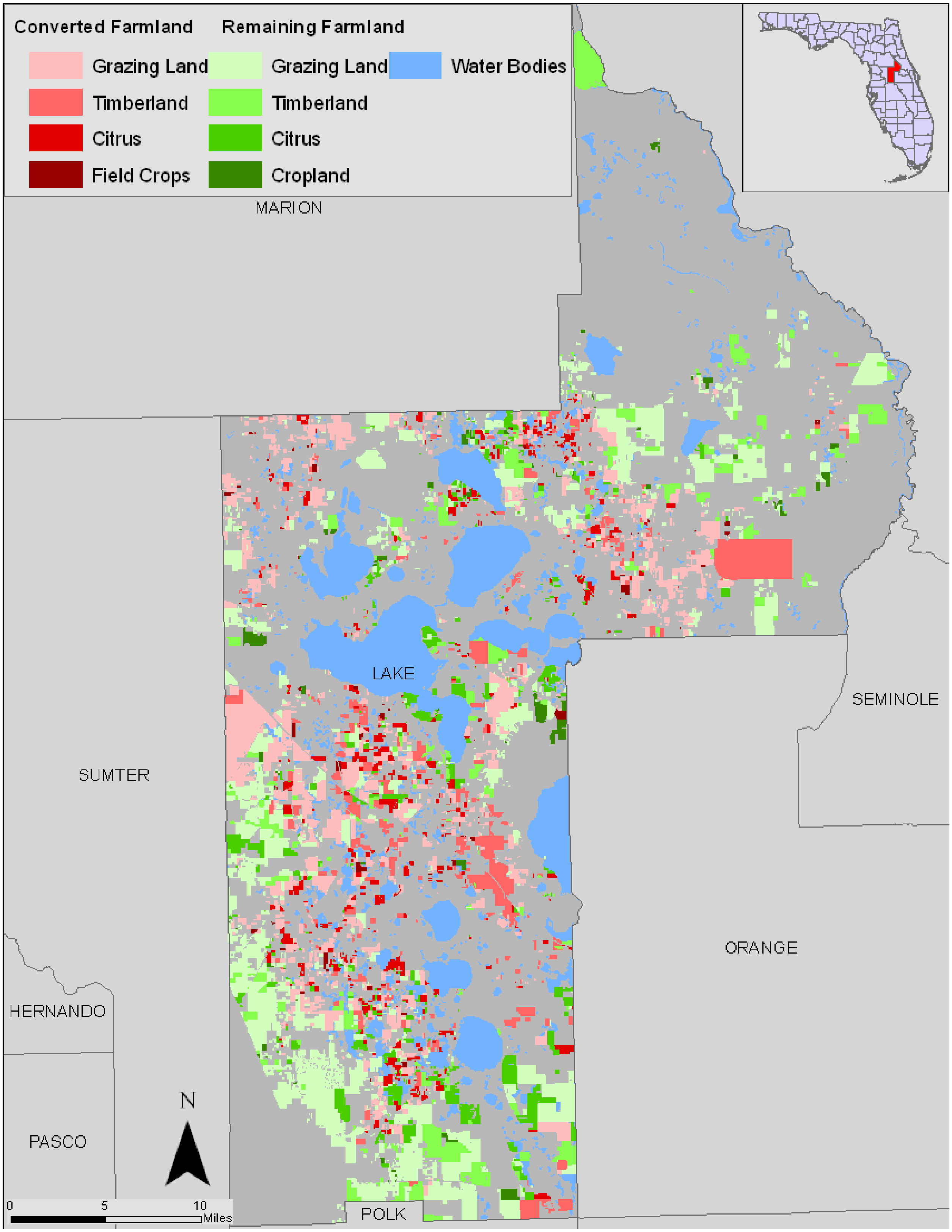

Figure 5-15. Converted and remaining farmland in the Lake County 2040 second infill scenario (using infill results and a GUD of 2.81 for new growth areas)

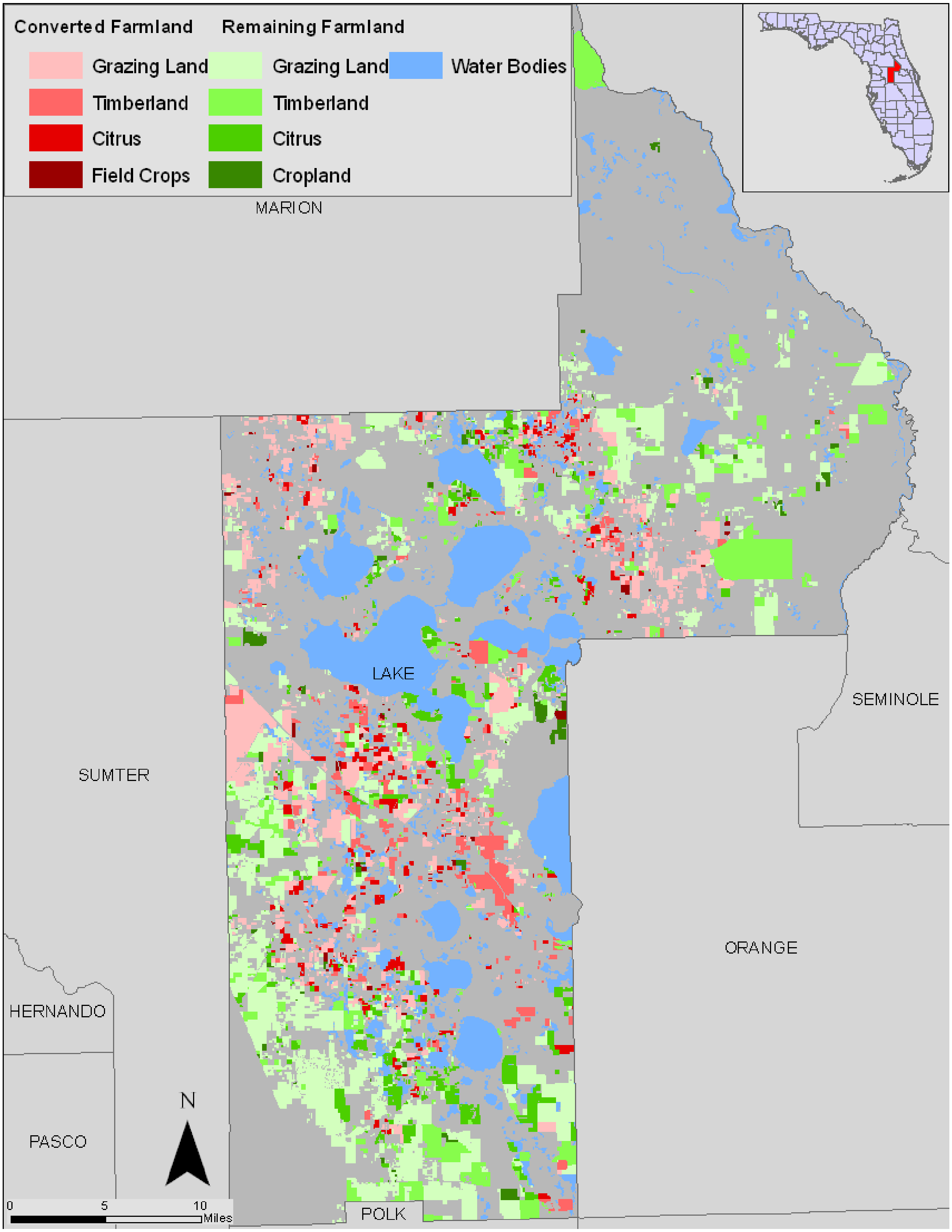

Figure 5-16. Converted and remaining farmland in the Lake County 2040 third infill scenario (using infill results and a GUD of 3.75 for new growth areas)

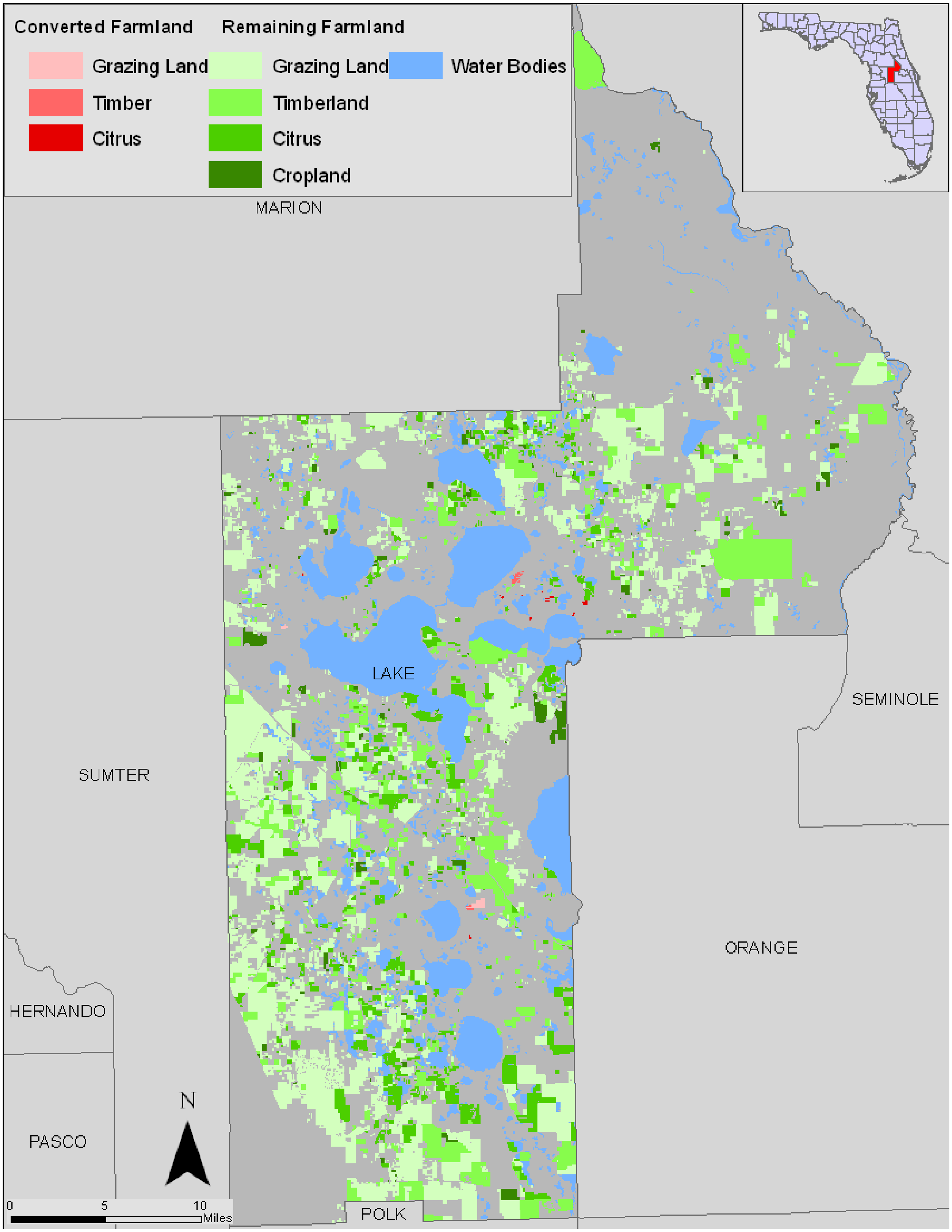

Figure 5-17. Converted and remaining farmland in the Lake County 2040 “infill only” scenario (all new development restricted to infill areas)

CHAPTER 6
DISCUSSION

Discussion of Results

The purpose of this study was to quantify the impact on agriculture that future urban growth will have in Lake County, and to investigate if intensive urban infill would mitigate this impact. Indeed, it was shown that with infill to ease the burden on the need for new growth, some of the agricultural land that would otherwise be converted will instead be preserved. However, this amount is only a fraction of the farmland that would still be converted. The comparison scenarios that use a higher density for new growth show additional agricultural preservation, and the implications of this are discussed.

Infill Results

In the infill analysis, the infill areas were calculated to accommodate 35,173 incoming persons. This is 33,575 more than the increase of population within infill areas under the trend scenario (1,598). While it is significant that urban infill allows an increase of 35,173 persons in an area that would "normally" (following a trend scenario) accommodate only 1,598, this infill increase is only 15.7% of BEBR's (2011) projected population increase of 223,648 for the county by 2040. This entails that in all three of the scenarios that use this infill simulation, 84.3% of the 2040 incoming population would need to be accommodated in new growth areas, suggesting that the effectiveness of infill to mitigate agricultural losses, at least in this scenario, may be limited.

In addition to the incoming population, 23,455 jobs were created by commercial development in the infill simulation. Though this is less than the simulated incoming population, with this many jobs, infill areas would likely act as a job attractor, rather than to be insufficient at employing the new population. This is especially due to Lake County's particular demographic chacteristics: according to the 2005-2009 American Community Survey, only 51% of the Lake County workforce over 16 is employed – at a time when the unemployment rate in the county was only 3.9% (US Census, 2009). This is likely due to the high number of retired persons in the county; the median age is 45.6, and 24.2% of the population is over the age of 65 (US Census, 2010). Part of The Villages, a vast retirement community mostly located in adjacent Sumter County, is also in Lake County. With this low ratio of workforce to general population, the 23,455 new jobs would likely be a surplus.

Results of Urban Growth Scenarios

The LUCIS urban growth scenarios showed the effectiveness of intensive infill at curbing excess urban growth, and how denser new growth may strengthen this effectiveness. The trend scenario increased the gross urban area of Lake County by 75% over the next thirty years, while the first infill scenario, using the base GUD for new growth, reduces this to a 64% increase. The 11% decrease in urban area growth, which consists of 18,772 acres, is a substantial drop, and represents the effects of infill alone, without any need to change the urban density of new growth. However, when infill is combined with new growth that is 1.5 times denser than the 2010 gross urban density, the 2040 increase in gross urban area is only 42%. This 22% drop in new urban area from the first infill scenario, compared to the 11% drop from infill alone, suggests that increasing density of new growth areas, at least in this modeling scenario, is highly effective at reducing the area of new urban growth, and potentially more so than infill. However, by increasing the new urban density to double the 2010 GUD, diminishing returns are experienced, with only a further 10% drop to a 32% increase in new urban area. Unsurprisingly, by restraining all new urban growth to the TOD and Secondary Area infill areas, in the “infill only” scenario, urban growth only increases by 2%. As a result, the density of new urban growth in the infill areas is pushed to 67 persons per acre. This is an incredibly high density that ranks with some of the world’s most densely populated cities, such as Monaco and Macau (Central Intelligence Agency, 2011). It is impossible that such a future could occur in Lake County by 2040, as there would be no economic motive to so densely develop the county’s urban areas while land surrounding these areas remained massively underdeveloped relative to the cities. As a result, this scenario cannot be considered valid, or compared to the other four scenarios as a possible future for Lake County that can be planned for or deliberately avoided.

This study included no direct comparison between the effectiveness of denser new growth areas and urban infill at curbing sprawl, and was not meant to. However, the greater drop in new urban area when the density of new growth is raised, as opposed to infill alone, may have occurred for the following reasons: first, the infill areas (24,342.7 acres) in proportion to the land area of the entire county (610,016 acres) are quite small – under 5%. It was necessary to designate such a small area as an “infill area” because the existing “urban cores” of Lake County, where infill is possible, are fairly small. A great amount of scattered additional urban development extends from these cores, but given its heterogenous nature (often adjacent to agricultural land), it is not suitable for infill, especially if the purpose of the infill project is to control sprawl, rather than continue it. Secondly, Lake’s population over the next thirty years (as per the medium projection by BEBR) is projected to increase by 75%. With such a huge demand for new development, it is difficult to contain this amount of growth within existing urban areas without an enormous increase in density for those areas – as demonstrated by the "infill only" scenario and its 67 persons per acre gross density for new infill development.

Agricultural Analysis Results

Losses of farmland over the next thirty years are generally extensive, especially in the trend scenario, in which 69% of farmland is converted. However, this varies by farm type. In the trend scenario, the percentage of farmland acres converted ranges from 52.8% for field cropland to 82.2% for citrus cropland. Similarly, the amount of farmland saved between the trend scenario and the first infill scenario (with base GUD for new growth) varies between farm types. 70.9% of timberland is converted in the trend scenario, yet this only drops to 65.2% for this first infill scenario; by contrast, the 82.2% of citrus cropland converted in trend drops to 69.5% in the first infill scenario. However, all farm types make a more significant drop in conversion when new growth density is made a factor. Between the first and second infill scenarios (where new growth density is 1.5 times GUD), the percentage of land converted drops in a range of 14% to 17% for timberland, field crops, and grazing land, and 27% for citrus cropland. This ties in with the conclusion drawn earlier that higher new growth density may be more effective than infill for controlling sprawl. As with the growth scenarios, there are diminishing returns for the third scenario (with double GUD for new growth) and very minimal losses for the "infill only" scenario, including zero loss of field cropland. However, that there was any loss at all of farmland by growing within an infill area designed to avoid such a thing shows that even within Lake County's urban areas, different land uses are scattered and mixed enough to include farmland.

The loss of crop yields generally follows a similar pattern between the different scenarios as farmland loss does, with a few exceptions. Yield losses are generally heavy in the trend scenario, ranging from an 89.2% loss for cucumber yield to 37.6% for sweet corn, with an average of 69%. Yield losses are notably heavy for the citrus crops, oranges (84.3%) and grapefruit (84.2%). Because these crops are grown much more abundantly than field crops, the potential financial impact of these yield losses is much greater - $77.4M for oranges and $95.3M for grapefruit. The greatest potential loss for a field crop is for watermelon, which sees a potential $5.4M loss.

As with losses of farm acreage, there was generally a smaller drop off of yield loss between the trend scenario and the first infill scenario, than between the first and second infill scenarios. For some crops, as for peanuts and watermelon, the difference of loss between the trend and first infill scenario is less than 2%. By contrast, the loss of yield for cucumbers drops almost 15% between these scenarios, but only 7% between the first infill scenario and the second. This variance could be due to the smaller number of field crop farms in general – when one or only a few are eliminated (or spared), it can make a noticeable impact in yield. The three more abundant farm types (citrus, timberland, and grazing land) didn't have such anomalies in either direction. Most crop types had diminishing returns in terms of drop of yield loss between the second infill scenario (1.5 times GUD for new growth) and the third (double GUD), with the exception of cucumbers, with a 21.4% drop, and wood, with a 15.5% drop.

Finally, in the agricultural scenario, the cost for the loss of agricultural products in the trend scenario totaled to $189.7M using 2011 prices. This financial loss represents 76.3% of the 2011 value of this yield (from existing farms). This figure dropped to $165.5M in the first infill scenario, a savings of about $24M. Between the first and second infill scenarios, this drops more – about $46M. Diminishing returns are experienced for the third infill scenario, with a savings of about $29.5M. These values show, once again, the biggest impact coming from the second infill scenario – combining infill with a new growth density that is 1.5 times higher than the 2010 GUD.

Conclusion

Once again, it is not the aim of this study to determine if higher densities in new growth areas are more significant than intensive infill for decreasing agricultural conversion. Instead, the aim was to determine to what extent infill can mitigate agricultural conversion in Lake County. The bottom line to this question is that infill alone will save thousands of acres of farmland and millions of dollars in agricultural products. However, the results also show that in almost every case, infill alone will not save the majority of the farmland present today, and that in all cases, it will not save the majority of the current potential crop yield. The scenarios that include new growth density as a variable were created to show what is in fact more likely to occur than a region with dense infill areas perpetually surrounded by low density sprawl. Infill is only one part of Calthorpe's urban model, which is inclusive of new growth areas, and maintains the same transit oriented development principles for them as well. It is easy to extend an existing transit network between the dense infill areas to new areas of growth, and in fact, once the utility of the transit lines was realized, the inhabitants of new growth areas might demand it. Development would cluster around new transit hubs, and increase new urban density in the process. Additionally, the same strategies that work to preserve agriculture and pursue urban infill can also work to make new growth dense. By putting land at a premium, urban growth boundaries make use of both the vacant land within cities and on the fringes to produce compact growth. Transfer of development rights strategies can be used to prioritize land development that is contiguous with existing urban areas, so that a scattered, low-density pattern isn't propagated.

Limitations of Infill Development

Lake County presented several challenges to modeling urban infill. On a large scale, it can easily be seen from its land cover map (Figure 6-1) that defining the "urban edge" of Lake County's cities is a difficult and subjective task. There are clusters of dense urban area in the center of the county's municipalities, but beyond these clusters and without any defining line are a scattered smattering of developed, often large, parcels surrounded by rural greenfield. Incorporating Calthorpe's (1993) principles into the methodology, through the use of TODs and Secondary Areas, was a way of making this distinction, in order to avoid modeling "infill" in places that would actually constitute edge development, as well as to avoid modeling unrealistic high densities in low-density suburban areas.

The lack of an "urban frontier" in Lake County is well illustrated in Figure 6-2, which shows an aerial image of Mt. Dora where urban growth has almost encircled several agricultural parcels. Should these parcels be candidates for infill? If they are developed, it would provide a more continuous urban landscape, and possibly eliminate the need for "edge" development elsewhere. However, it would be ironic to do so if the stated purpose of pursuing infill is to avoid agricultural conversion.

The sprawling urban form prevalent across Lake County provided other difficulties for modeling infill. The classic "loops and lollipops" suburban design is prevalent throughout the county, making connectivity difficult. Residential suburbs in which this urban form occurs are characterized by a curving street pattern with many cul-de-sacs, rather than a grid. They are connected to larger highways by usually only one or a few exits. An excellent example of this is in Tavares, as seen in Figure 6-3, where residents of the circle-shaped housing development southeast of a major retail center in North Tavares would be required to follow a circuitous route exiting their suburb in order to reach it, as they are blocked from doing so in a straight line, despite being nearly adjacent to it. This phenomenon compromises the effectiveness of TODs by limiting their walkability. To make them function correctly, infill would need to be combined with structural changes to the streetscape.

Even some of the county's vacant parcels are placed to support a sprawling cityscape, making effective allocation of infill difficult. In Chapter 4, it was noted that in the Minneola Secondary Area (Figure 6-4), there are a group of large vacant commercial parcels situated along US Highway 27. It is clear that these parcels are meant to be developed into large retail box stores along the highway. They are within the infill area, but allocating retail development to these areas is antithetical to transit oriented design. A large retail development along a major artery would only serve to encourage auto use within the infill area, and attract economic activity away from the Core Commercial Area. Along with Calthorpe's (1993) guidelines for transit oriented development, it was this sort of urban geography that necessitated a two acre limit for retail development for Secondary Areas in the infill model.

Finally, it must be mentioned that there are limitations in applying this study to Lake County. There would be many challenges in actually implementing intensive infill in the County's urban areas, especially as a means to mitigate agricultural conversion. Though there is some acknowledgement and support for infill development in the county's comprehensive plan and "Economic Action Plan", creating a denser urban form for the county's cities is not a stated priority. Agricultural preservation, by any means, is rarely mentioned in the comprehensive plan, and not at all in the "Economic Action Plan". Instead, Lake County seeks to maintain a business-friendly climate first and foremost, and while this is not inconsistent with encouraging infill development, it doesn't push businesses away from the status quo of edge development and sprawl, unless there was a demand for this. Lake County also faces a challenge in curbing sprawl as result of its being a supporting county in Greater Orlando. With Orlando as the primary economic engine of the region, Lake County, being adjacent to Orange County/Orlando, naturally has adopted the role of a bedroom suburb, as its commuting rates and recent growth rate show. Urban development that follows bedroom suburbs is low density and auto oriented, and if its propagation is the result of the forces of urban geography, some type of regulation (such as urban growth boundaries) would be needed to divert urban growth from this sprawl to infill, but so far the county government seems to have little interest in this.

Limitations of LUCIS Urban Growth Scenarios

Creating future urban growth scenarios with LUCIS did not feel limiting, though modifications to the model could certainly be made to take additional factors into account which may affect it. New growth is allocated via land use preferences (and conflicts), technically irrespective of location. Transportation networks could be incorporated into the model, and new growth could be allocated first around these networks, and then outward, just as actual sprawl behaves as it grows. However, in some ways this is already taken into account. Cells that are proximate to current transportation networks will already have a higher urban preference, since adding suitability data based on transportation was likely part of the LUCIS process in creating urban preference.

In general, LUCIS appears to be an excellent methodology for designing future scenarios. However, because of the many assumptions that must be made to create a LUCIS scenario, it is not a crystal ball – any LUCIS results can't be taken as what "will" happen, but what could, if certain choices are made. It is necessary to create several scenarios, so as not to be limited by these assumptions.

Limitations to Agricultural Analysis

Several difficulties were also experienced with agricultural analysis, generally concerning the availability of agricultural data. Three main data sources were used: the 2007 USDA Agricultural Census, FDOR property parcel data, and STATSGO soil yield data. Finding compatibility between these sources took effort. Agricultural property parcels were divided by the broad category of their product types – i.e. timberland, field cropland, etc. Timberland and grazing land could contain only one product each, wood and grass, so it was easy to match up the yield data for these products with their corresponding farm parcels. However, six potential crops could be grown on the field cropland in the county, but there was no data to indicate which crops were being grown where. Once again, this is why an "agricultural scenario" was necessary, where all the potential yields for these crops were calculated, then proportionately divided, because not all of them can be grown at once. Quantitatively, field crops make up only a small part of Lake County's agricultural output, so this kind of estimation doesn't make a major impact on the overall estimate of losses in the agricultural scenario.

Recommendations for Further Research

Though two of the scenarios used in this study included increases in new growth density, the purpose of this study was not to compare the effectiveness of this and urban infill at mitigating agricultural conversion. However, the results suggest the possibility that higher new growth density may be more effective than infill at this. Directly investigating this possibility would be a good extension of this study. This could be done by producing separate urban growth scenarios for high new growth density and infill, and then comparing their effectiveness at mitigating conversion. Perhaps a test of statistical significance could be used on the results of these scenarios to definitively make a judgment on the effectiveness of one method over the other.

As discussed earlier in Chapter 6, variables tied to the study area may have had some effect on the effectiveness of infill at mitigating agricultural conversion. These include the rate of growth for the study area, which in this case was high, and the area available for infill development, which here was low. By continuing this study with new scenarios comparing new growth density and infill, for multiple study areas, trends might emerge that show which of these factors influences agricultural conversion more for different circumstances. For example, if a similar study to this was performed on a place with a low projected growth rate but a large supply of vacant urban land for infill, such as a “rust belt” city, very different results may emerge. In this hypothetical study area, an intensive infill scenario might preserve more agricultural capacity than a scenario where new growth density is increased by 50%, or even doubled. By using urban growth scenarios as a control variable across study areas, a model could be formulated that shows how different conditions of the study area will affect agricultural conversion.

Finally, agricultural conversion could be studied with new urban growth models that use policy as variables rather than future conditions of urban form. This could include a Transfer of Development Rights model (TDR) in which potential receiving areas are identified for future urban growth that would otherwise be placed on farmland. A trend scenario could be created, and agricultural losses calculated, as in this study. The model could then be evaluated by the number of agricultural acres (the sending areas) that can be preserved by redirecting some portion of urban growth to these receiving areas. Similarly, an urban growth boundary policy could be incorporated into a scenario, which would show the agricultural losses incurred within the boundary, and compare this to the losses in a trend scenario, in order to evaluate the agricultural preservation that an urban growth boundary policy can afford.

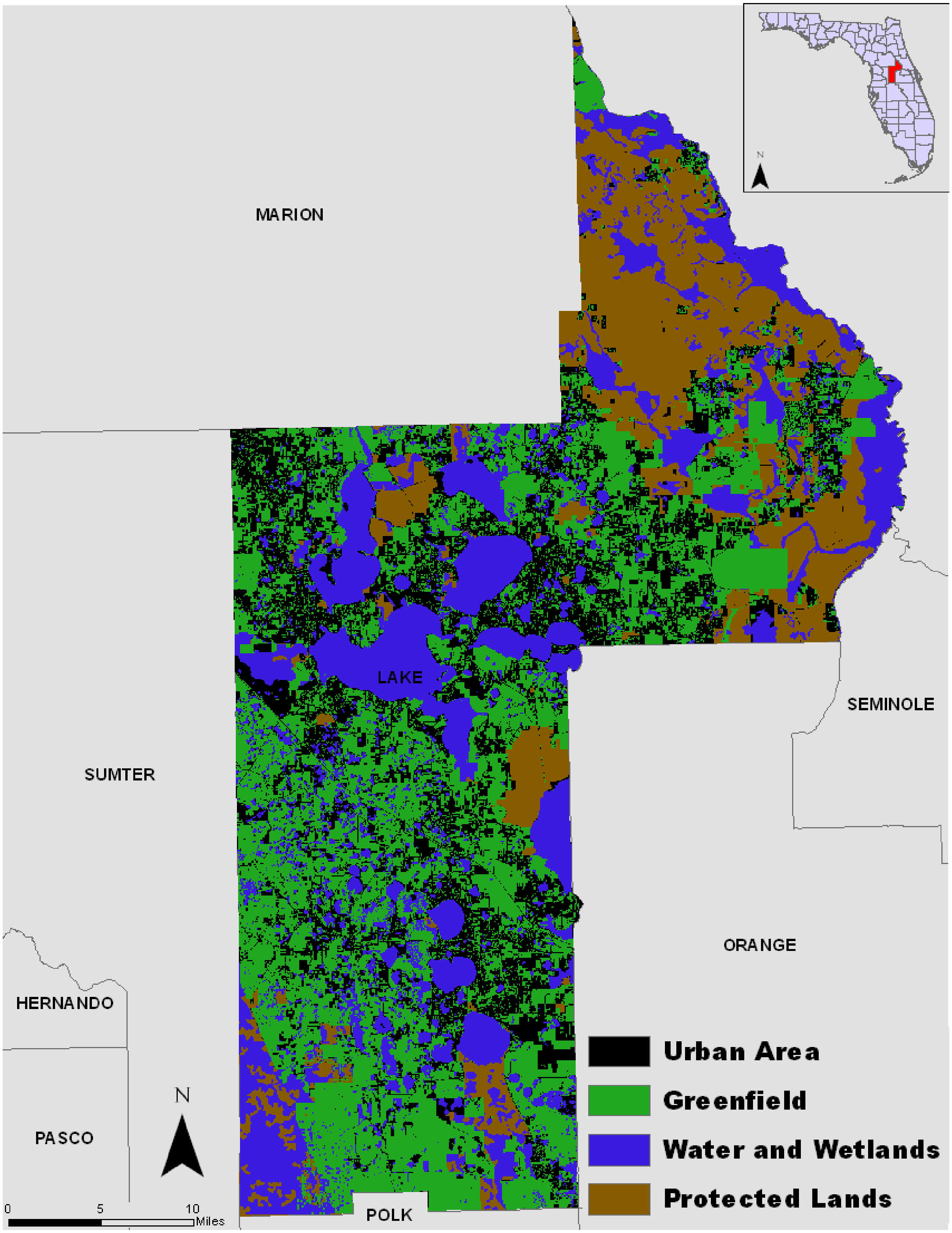

Figure 6-1. Lake County land cover map

Figure 6-2. Encroaching urban developed surrounds agricultural land near Mt. Dora

Figure 6-3. Circuitous route from a neighborhood to an adjacent retail center, in Tavares

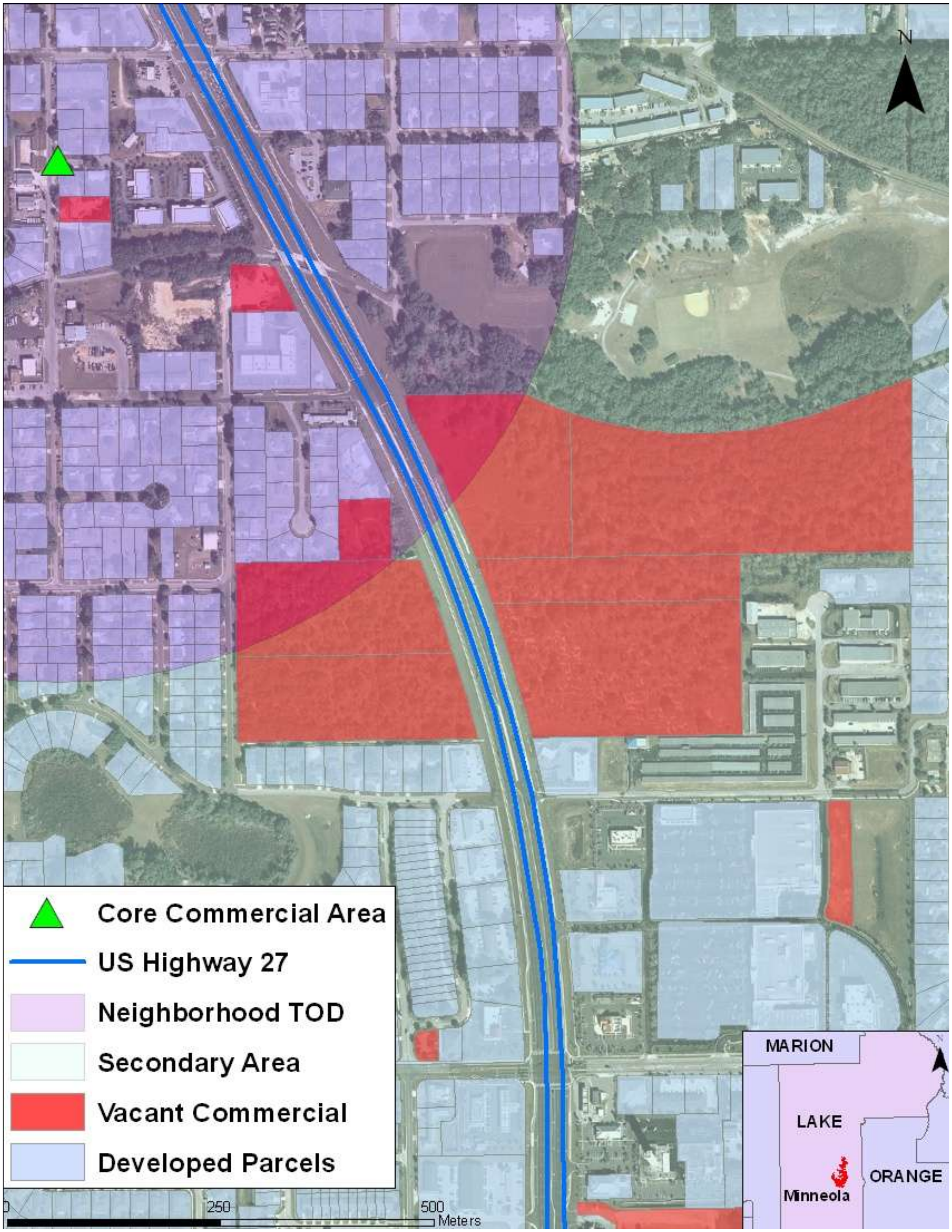

Figure 6-4. Large vacant commercial parcels on the edge of Minneola's TOD – likely meant to be developed into large retail centers

CHAPTER 7
CONCLUSION

Several lessons can be learned from this study, which provide a better understanding of the danger agriculture faces from urban growth, and where to look next for solutions to conversion.

First, low density urban growth is without question a huge threat to farmland that is proximate to a growing urban area. In this study, when the same low-density growth is projected into the future as the trend scenario, the agricultural losses are simply huge – once again, this includes 69% of both farmland acres and mean potential crop yield loss. These dire results are mirrored by the 33% loss of farm acres in only five years between 2002 and 2007, showing that rapid agricultural conversion has already begun (USDA, 2007). Of course, in many ways Lake County is a “perfect storm” of factors that lead to agricultural conversion – it is a formerly rural region in the sunbelt that is now growing rapidly as part of a major metropolitan area. However, it is not unique in this, as many similar suburban counties across the south and west face a similar situation, and as such their agriculture is similarly threatened.

Secondly, though urban infill does help mitigate this, the relief it provides against agricultural conversion isn’t enough to stop major losses. With intensive infill development and no other changes, about 9% of farmland that would otherwise be converted is saved, in addition to an average of 8% of potential crop yield, and $24M in the agricultural scenario. By themselves, these “savings” are significant, but in proportion to the whole of agriculture in Lake County, they don’t constitute a major change. This is, again, affected by the particular characteristics of Lake County, particularly its limited urban capacity for infill. Results may show infill as being more effective for other study areas, and as discussed in Chapter 6, this is worth further investigation.

Clearly, there is still a need to study both the phenomena which control agricultural conversion, and the means by which it can be controlled. Fortunately, there are many possible threads of investigation for this research to be continued, and LUCIS provides an excellent basis for new scenarios to be developed. These opportunities for additional study are well worth taking, in order to soon bring agricultural conversion under control. Once productive farmland is lost, it is lost forever.

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BIOGRAPHICAL SKETCH

Blake Harvey was born in Austin, Texas and grew up in Atlantic Beach, Florida. He has previously obtained a degree from the University of Florida in Geography. Through this degree and several internships, as well as a stint at the Alachua County Department of Environmental Health, he has developed experience and proficiency in GIS, remote sensing, and database management. He pursued a master's degree in Urban and Regional Planning in part to apply these skills in a planning context, and accomplished that through his work with Gainesville's Metropolitan Transportation Planning Organization, providing GIS support for their transportation planning activities. He now seeks to help solve the world's problems through spatial analysis and smart planning.