# USING GIS TO EVALUATE LAND USE CONFLICT AND MODEL POTENTIAL ENVIRONMENTAL IMPACTS OF FUTURE DEVELOPMENT PATTERNS: A CASE STUDY OF CENTRAL FLORIDA

By

EMILY E. STALLINGS

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To Mom and Dad

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| | |
|---|---|
| AG | Agricultural |
| COM | Commercial |
| CONS | Conservation |
| ECFRPC | East Central Florida Regional Planning Council |
| FDEP | Florida Department of Environmental Protection |
| FED | Military / Federal |
| FLMA | Florida Managed Areas |
| FLU | Future Land Use |
| FLUM | Future Land Use Map |
| FNAI | Florida Natural Areas Inventory |
| GIS | Geographic Information System |
| IND | Industrial |
| INST | Institutional |
| LOD | Hotel / Motel / Timeshare |
| LUCIS | Land Use Conflict Identification Strategy |
| MF | Multi-Family |
| MU | Mixed Use |
| OFF | Office |
| PD | Planned Development |
| REC | Recreation / Open Space |
| RH | High Density Residential |
| RL | Low Density Residential |
| RM | Medium Density Residential |
| RR | Rural Residential - Residential development not to exceed one unit for every two acres * |

| | |
|---|---|
| RVL | Very Low Density Residential |
| SF | Single Family |
| UNK | Unknown |
| WAT | Water Body |

Abstract of Thesis Presented to the Graduate School
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Emily E. Stallings

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Chair: Paul Zwick
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Urban development patterns in Central Florida have resulted in the loss of valuable ecological resources, a result of high rates of population growth supported by sprawling development into undeveloped natural land. Central Florida has seen some of the highest growth rates in the country in recent years; over the next 20 years these are expected to continue. Land use decision makers are thus challenged with the quandary of distributing new growth while maintaining the functioning of natural resources. How might the cumulative impacts of decisions regarding future growth be evaluated to identify potential negative environmental impacts?

This study suggests an approach to this question by applying the Land Use Conflict Identification Strategy (LUCIS), developed by Margaret Carr and Paul Zwick. Using GIS, LUCIS uses inputs of specified goals to evaluate suitability of land uses within a study area, with the outcome identifying areas of likely future land use conflict between agricultural, conservation, and urban land uses. This study applies the LUCIS methodology in two ways. First, results of the conflict analysis are compared to local spatial policy in the form of Future Land Use Maps (FLUMs) in the six county region of

Brevard, Lake, Orange, Osceola, Seminole, and Volusia Counties. Assuming the conflict analysis results reflect preferred placement of land uses, examining how land use designations correlate or differ from the analysis demonstrates how well policy reflects identified goals of land use distribution. The study then moves from the regional to the county level with a case study of Lake County using LUCIS results in the creation of two future growth scenarios for the year 2035, comparing the results to the FLUM. The first scenario models continuation of existing development patterns and densities (sprawl), and the second scenario revolves around increasing densities and a creation of a green infrastructure network.

Study results showed that FLUMs will need revisions to truly reflect identified goals and that Lake County faces a future or continued urban sprawl with its current FLUM. Regionally, urban FLUM designations were often in areas of land use conflict (showing a policy preference for urban land uses over agriculture or conservation) and in areas found better suited for other uses such as agriculture. Results from the County study show the FLUM more closely reflected the first scenario, showing similar spatial patterns of low density development and supporting urban sprawl over ecosystem values. The second scenario proved far more efficient at conserving ecologically valuable lands and suggests county goals must be revised to reflect higher density and environmental preservation to best protect a green infrastructure network.

# CHAPTER 1
# INTRODUCTION

## Overview

Land use changes, driven by land use decisions, are the primary cause of natural resources loss and degradation in the United States (Beatley, 2000; Wilson, 1999). These impacts to environmental resources are the cumulative result of land use changes over time. Incremental accumulation of singular land use changes and decisions, which on their own may be minor in nature and impacts, can result in unanticipated major environmental impacts on the region (Carr & Zwick, 2007; Theobald, Miller, & Hobbs, 1997). Land use decision making and protection of natural resources must be considered together to sustainably plan for both urban and natural environments.

To understand the relationship between land use and ecological health, a growing consensus advocates the need for environmental planning in the form of ecosystem management. Ecosystem management represents the approach of environmental protection on a holistic scale, addressing the overall ecosystem and all of its parts rather than individual species or specific resources (Randolph, 2004). Ecosystem management may be achieved in part through the protection of a regional network of protected natural areas and green spaces that prevent habitat fragmentation and promote ecological interconnectedness. This approach is embraced by the concept of green infrastructure, which may be defined as “an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations” (Benedict & McMahon, 2001, p. 5). Ecosystem management is inherent in the concept of green infrastructure, and can be implemented through land use planning (Benedict & McMahon, 2001).

The power and decision-making authority behind land use changes comes primarily from local governmental legislation in the form of comprehensive plans, policies, and other regulations guiding development patterns (Norton, 2007; Ben-Zadock, 2003; Pierce et al., 2005). Ecosystem management must therefore be incorporated into the legislative framework to prevent ecological degradation. Land use decisions, regional ecosystem protection, and legislation are thus inextricably connected and their relationships to one another must be considered to protect ecological resources. The impacts of cumulative land use decisions must be addressed to promote this approach and prevent undesired regional impacts.

A common approach to regional future land use planning is comprehensive or master planning, long-term approaches meant to reflect identified community goals and future growth patterns. Land use decisions are then made in the context of these plans (Theobald, et al., 1997). In Florida, future land use maps (FLUMs) provide spatial regulation for future development patterns. They are a component of the comprehensive plan and are required by the State to be prepared by each local government as a vision of desired future development. Requiring consistency with the comprehensive plan, the stated purpose is to promote development in specific areas to avoid adverse outcomes of unmanaged development such as urban sprawl and environmental impacts (Brody, Highfield, & Thornton, 2006).

Despite the existence of legislation and comprehensive approaches such as FLUMs to guide development, sprawling development and environmental impacts continue to occur in Florida. Individual decisions made in development review processes are still creating undesired regional impacts and affecting our ability to achieve ecosystem management or an integrated system of green infrastructure (Theobald, Miller & Hobbs, 1997; Carr & Zwick, 2007).

Spatial quantitative analysis of policy is one method available to assess the impacts of individual decision making relative to local adopted plans. In Florida, a form of measurement is to spatially analyze the degree of land use conformity to the original FLUM; that is, how well land use development reflects original policy statements (Brody, Highfield, and Thornton, 2006, p. 75). In Florida, studies have identified spatial deviations from FLUM policy, with results leading to ecological impacts. These results paint a picture of continued nonconformance, urban sprawl, and widespread ecological impacts in a state whose policy is dedicated to reducing sprawl and environmental harm (Brody, et al., 2006).

Evaluating FLUM quality may help demonstrate why these deviations are occurring. This understanding may help answer the question of whether impacts and urban sprawl are a result of inadequate spatial policy, or if they are instead deviations from “good” spatial policy (suggesting weakness in implementation). Modeling probable and desired future development patterns can demonstrate where deviations from policy might occur based on model projections (or where policy might prevent desired outcomes). Visualizing potential growth patterns can lead to a better understanding of the power of independent decisions and their regional impacts as well as show whether policy supports or deviates from identified goals.

One tool to analyze potential growth patterns is the Land Use Conflict Identification Strategy (LUCIS), created by Margaret Carr and Paul Zwick (2007). LUCIS acts as a tool to predict spatial distribution of land use. When used to model future growth it provides a way to “reveal the spatial reality of incremental land-use change” (Carr & Zwick, 2007, p. 5). LUCIS uses GIS to spatially compare suitability for categories of land use – grouped as agriculture, conservation, and urban uses – and determines where spatial conflicts between the suitabilities exist. The concept builds on the idea that suitability reflects appropriateness of the location for that particular land use. Further, the tool assumes areas with low land use conflict but high land use suitability represent optimal location and likely spatial distribution. The LUCIS methodology can be utilized in the modeling of potential growth patterns based on goals identified in the suitability process (Carr & Zwick, 2007). LUCIS provides a framework to both evaluate local policy and model future growth patterns to prevent ecological impacts.

## Study Objectives

The purpose of this study is to create a discussion of how to prevent negative cumulative, incremental impacts of land use decisions, which studies show are taking the form of urban sprawl and environmental degradation. The study consists of two parts, both applying the LUCIS process in GIS. The first part of the study evaluates local land use policy (in the form of FLUMs) as it relates to land use conflict identified in the LUCIS analysis. The second part creates two land use scenario models of growth through 2035 using population and employment projections: one to demonstrate the continuation of existing land use patterns, and thus urban sprawl (trend scenario), and the other to demonstrate a conservation-based development (conservation scenario).

One aspect of this study is to test quality of FLUM policy by spatially comparing FLUM designations to stated goals for land use placement (as identified in the LUCIS analysis). The regional part of this study compares FLUM designations of undeveloped land available for development to the LUCIS conflict analysis in order to quantify the extent to which FLUM designations support goals as expressed in LUCIS land use preferences. This may identify potential future policy deviations, because individual land use decisions may reflect land use suitability rather than policy. Similarly, it may identify where policy is preventing implementation of these goals.

The second part of this study focuses on Lake County and creates two models of potential future growth. It serves to create a discussion of the role of land use modeling to test policy and predict environmental impacts (in this case, in the form of spatial extent of habitat loss). Two models of future growth scenarios through the year 2035 are created for Lake County. Visualizing future growth impacts may help decisions makers envision the overall impacts of land use decisions, leading to more in-depth consideration of individual decisions and preventing the negative impacts of incremental decision making. Specific assumptions of population growth and densities are used to represent hypothetical supporting policies, and development is distributed based on the conflict analysis and policy assumptions for each. The first is a trend scenario, modeling continuation of existing development patterns and densities. Because existing patterns reflect urban sprawl, the trend scenario is a scenario of low density development. The second scenario is designed with the purpose of protecting and enhancing ecological features, creating a green infrastructure network to guide development. The spatial outputs of each model are compared to identify the difference in land area impacts.

Environmental impacts are of particular importance and are measured in the form of total area preserved. The scenarios are compared to the existing FLUM to spatially quantify how well proposed land use policy supports goals of each scenario, that is, whether the FLUM better supports urban sprawl or ecological preservation.

Results of the study will paint a picture of existing spatial policy and growth trends in the region, as well as provide insight to potential development futures and their impacts on Central Florida’s remaining ecological resources.

# CHAPTER 2
# LITERATURE REVIEW

This review of the literature seeks to evaluate the role of land use decisions, policy, and land use modeling as they relate to environmental impacts. First, the chapter evaluates the relationship between urban development and environmental impacts, including discussion on how to integrate environmental protection into land use planning in the form of ecosystem management and green infrastructure. Both the roles of policy and individual land use decisions are addressed in their impacts to regional land use patterns and the necessity to understand the power of each to contribute to or detract from regional goals. Suitability modeling is discussed as a viable component of land use planning, leading into the use of future land use modeling based on suitability and policy decisions to predict long-term regional spatial outcomes of land use policy and decision making.

## Conflicts between Environmental Protection and Urban Development

As population increases, so does the need for new homes, infrastructure, and commercial development, resulting in pressure to convert undeveloped or rural lands into higher intensity, urban uses. Environmental resources are threatened as the level of conflict between conservation and urban development intensifies (Salveson & Porter, 1995). Certain forms of urban development, such as urban sprawl, are associated with increased negative environmental impacts (Beatley, 2000).

### Ecological Impacts of Urban Development

Impacts to ecological resources occur because urban development changes the patterns and processes of ecosystems through habitat loss and fragmentation (Peck, 1998). These effects of urban development are the primary cause of environmental degradation and contribute significantly to species extinction and biodiversity (Beatley, 2000; Wilson, 1999). Conversion of natural land results in habitat loss and reduces overall amount of land available for species use in migratory patterns, foraging, and food supply. Species extinction and the threats to species' survival are directly correlated to reduction in habitat size. Fragmentation of natural land by dividing it into pieces also adversely affects ecosystems. Fragmentation increases the amount of edge habitat, which is more vulnerable to outside forces such as pollution and natural processes such as storms and wind (Dramsted, Olson, & Forman, 1996; Peck, 1998; Wilson, 1999). Fragmentation also upsets the balance of interior to edge species, as the process increases the amount of edge habitat and decreases the amount of interior habitat. With more edge habitat, there will be more edge species and fewer interior species (Dramsted, Olson, & Forman, 1996). Natural functions are lost due to land conversion. Wetlands, for example, provide the function of flood control through water storage. Wetland conversion can therefore increase threats of floods. Increased impervious surface pollutes and increases the amount of stormwater runoff and reduces the ability of water infiltration, reducing groundwater recharge potential. Impervious surfaces also change the local climate by contributing to the heat island effect and increasing the temperature of urbanized areas (Benedict & McMahon, 2006; Environmental Protection Agency, 2001).

Examples of development impacts on biodiversity are widespread. According to the U.S. Fish and Wildlife Service (2009a), as of late 2009, 1,312 species of plants and animals were considered endangered or threatened in the United States. The five states with the most endangered or threatened species were Hawaii (330), California (309), Alabama (117), Florida (115), and Texas (95) (U.S. Fish and Wildlife Service, 2009a). The red-cockaded woodpecker, for example, is one of the most threatened species in North America, due primarily to loss of habitat. To nest, the bird requires old growth longleaf pine trees at least eighty years old. These pine trees, however, have been significantly logged (Wilson, 1999). The Puget Sound Chinook in Washington has become federally listed due to loss of habitat directly related to urbanization. Roadways have caused deaths as animals such as grizzly bears or Florida's key deer try to cross traffic (Beatley, 2000).

Not just individual species are threatened, however. Entire ecosystems are disturbed by human influence. Further, protection of species requires protection of all aspects of the habitat upon which they depend; impacts to one variable of an ecosystem affect all others. Examples of threatened valuable ecosystems include San Bruno Mountain in California, the Mediterranean vegetated habitat of Central Chile, the California floristic province, the Atlantic coast of Brazil, and Madagascar. These are some of the most biologically rich areas of the world, yet are also some of the most threatened by human development. Worldwide, tropical rainforests have been reduced to about half of their original coverage, and as of 1989 were being lost at a rate of 142,000 square kilometers per year (1.8% of their total), a rate that doubled destruction in 1979 (Wilson, 1999). A study conducted in 2005 by the U.S. Fish and Wildlife Service (USFWS) found that nationwide from 1998-2004, 61 % of freshwater wetland losses in the U.S. were a result of rural and urban development (Dahl, 2006). A study by Noss, LaRoe, and Scott (1995) evaluated ecosystem level biodiversity throughout the U.S.

They identified 30 ecosystems as critically endangered, 58 as endangered, and over 30 as threatened.

**Urban Sprawl**

Development trends in the U.S., especially those prevalent in the second half of the 20th century, have tended towards low density development outside of urban areas, either just outside existing developed areas or "leapfrogging" across agricultural or natural lands to outlying natural areas (Hasse & Lathrop, 2003). This type of development is known as urban sprawl and is associated with increased impacts to the environment compared to more compact, centralized development patterns (Beatley, 2000).

Urban sprawl has been widely studied, but no one explicit definition exists to describe the phenomenon. Literature on the subject generally agrees on characteristics of low density, automobile dependent, widely dispersed, and segregated use development resulting in conversion of undeveloped natural or agricultural lands (Burchell et al., 1998; Downs, 1992; Ewing, Pendall, & Chen, 2002; Hasse & Lathrop, 2003; President's Council on Sustainable Development, 1999; Randolph, 2004). Non-residential uses include office parks, strip malls, and other uses including industrial or institutional buildings that have characteristics of single, segregated use in a suburban setting. Residential sprawl is generally in the form of single family, low density developments (Burchell et al., 1998).

Sprawling development begins with the building of single family residential communities outside the existing metropolitan area, followed by supporting commercial, entertainment, and industrial uses. These patterns have not always prevailed; in the early 1900s land uses were close together, with residential areas clustered around central hubs of retail, commercial, and public uses (Environmental Protection Agency, 2001). In 1940, 15% of the population resided in suburbs, outside the central urban areas (Burchell et al., 1998). Development patterns in the second half of the century have become more spread out and developed at lower densities (Environmental Protection Agency, 2001), with the single family subdivision pattern dominating much of this growth. By 1998 60% of the population lived in suburban areas (Burchell et al., 1998).

Reasons for the shift include increased ownership and efficiency of the automobile, making adjacency to existing urban areas, high density, and mixing of uses unnecessary. Additionally, low cost mortgages in the 1950s meant people could afford single family homes, and federally subsidized transportation expansion projects, including the creation of the interstate highway system, greatly increased efficiency and access to roadways (Burchell et al., 1998; Environmental Protection Agency, 2001). Instead, land is chosen for development based on factors such as land prices, residential preferences, ability to purchase larger lots, increasing dependence on the automobile, and government supported legislation aiding the development of transportation and other services to these new development patterns (Environmental Protection Agency, 2001).

Natural and agricultural land conversion is a major impact of sprawl. The Natural Resource Conservation Service’s (2003) National Resources Inventory has studied land use in the United States since 1982. The 2001 study demonstrated that land conversion to developed use from 1982 to 2001 across the United States totaled 33.5 million acres, with an estimated total of 106.3 million acres of developed land by 2001. Close to nine million acres were developed from 1997 to 2001. Of this, 46% was converted from forest uses, 20% from cropland uses, and 16% from pasture land uses. Throughout this time period, the amount of forest conversion increased. Rates of conversion have increased over time: from 1982 to 1992, conversion occurred at a rate of 1.4 million acres per year, while from 1992 to 2001, the rate was 2.2 million acres per year.

In addition to higher rates of conversion, studies demonstrate that land use conversion has actually exceeded population growth, further demonstrating trends of low density, spread out development. From 1982 to 1997, United States population growth was 17%, but urbanized land areas increased by 47%. These numbers are exacerbated in metropolitan areas. For example, the Cleveland metropolitan area actually decreased in population from 1975 to 1995, but increased in urban area by 33% (Benedict & McMahon, 2006).

Rural areas, due to their amount of available land, are especially threatened by sprawl. Rural counties in the U.S. containing lands considered wilderness areas grew six times faster than those without from 1994 to 1997. The American Housing Survey of 1997 showed communities with less than 40,000 people saw  60% of new homes starts from 1994 to 1997 (as cited in Benedict & McMahon, 2006, p. 6).

In addition to loss of natural habitat, sprawling development is associated with exacerbating impacts of urban development on natural processes due to the large land area required for low density development. Adding to the land requirement, sprawl is associated with increased land and resources dedicated to transportation, resulting in additional land lost and increased vehicle miles traveled, contributing to air pollution. Impervious surface is increased from transportation related infrastructure such as widened roads, additional road length, and parking lots (Environmental Protection Agency, 2001).

## Tyranny of Small Decisions and Cumulative Impacts

Land use changes often occur on a site-by-site, project level basis under the power of each local jurisdiction. It is these relatively small, localized, and independent land use decisions that ultimately drive development patterns (Ben-Zadock, 2003; Norton, 2008). The effect is many smaller changes that are considered innocuous individually but collectively and incrementally create a large-scale impact that may not represent planned outcomes (Brody, et al., 2006; Carr & Zwick, 2007; Odum, 1982; Theobald, Miller & Hobbs, 1997).

The economist Alfred Kahn's (1966) market-based concept of a "tyranny of small decisions" has been aptly applied to this phenomenon (see Odum, 1982). Small decisions that seem appropriate independently can cumulatively represent de facto large scale decisions (Ben-Zadock, 2003; Norton, 2008). Outcomes do not necessarily represent a conscious choice but in hindsight are seen to collectively create ecological impacts, sprawling development, or other impacts that are associated with urban development patterns. Many examples of these "choices" due to urbanization can be seen in regional impacts and environmental degradation over time, including the loss of over half of the nation's historic wetlands, destruction of endangered species habitat, loss of water resources, urban sprawl, and decline in air quality (Carr & Zwick, 2007; Bedford & Preston, 1988; Odum, 1982). Cumulative impacts are often not recognized until the undesired consequences occur (Brody, 2003; Brody, Davis, Highfield, &

Bernhardt, 2008; Carr & Zwick, 2007; Thompson, 2004; Holland, Honea, Gwin, & Kentula, 1995; Olson & Lyson, 1999).

To avoid the "tyranny" and prevent negative cumulative impact, the role of individual small scale decisions and development trends must be recognized in relation to one another and to the broader context of the landscape (Dramsted, Olson, & Forman, 1996). A study by Theobald, Miller, and Hobbs (1997) in Summit County, Colorado attempted to accomplish this task. They realized that even when decisions were made in keeping with the goals of comprehensive plans (which stated avoidance of ecological impacts), major impacts to wildlife were still occurring. The study created an approach to model cumulative effects, measuring the spatial correlation of development densities and patterns created over time to measures of wildlife disturbance. They found that cluster development (clustering homes in higher densities to preserve open space) positively benefited wildlife, when compared to low density development over the same spatial extent. Spatial pattern of development, particularly distance of wildlife from roads and buildings, was found to be more important than density when considering disturbance of wildlife habitat. Cumulative results of development patterns were only discovered through spatial analysis of policy implementation. In the future, proposed development patterns could be evaluated regionally based on measuring potential wildlife impacts (Theobald, et al., 1997).

## Policy Implementation: Spatial Conformity

Undesired incremental, cumulative impacts of land use decisions, such as urban sprawl and loss of natural resources, suggest a divide between policy (created in regulations such as master plans and zoning codes) and implementation, and thus a lack of conformity to the original goals found in the master plan or other regulatory device (assuming the plans seek to avoid these impacts, such as is required by Florida law). Local master plans are assumed to be a vision of what each jurisdiction desires for future development, with associated policies providing guidance to reach that vision (Norton, 2008). Plans are, however, often changed and altered without measure of deviance from the original plan (Calkins, 1979). Calkins (1979) described this as the "new plan syndrome," referring to the repeated updating and changing of plans without attempting to measure adherence to the originally stated goals and objectives or monitor success of implementation (as cited in Brody & Highfield, 2005, p. 160).

Successful implementation of original goals and policies is difficult to measure because of the number of factors influencing outcome (Bengston, et al., 2004; Brody, et al., 2006). Growth management policy, economics, housing preference, and effect of other policies all have the potential to affect land use patterns. Additionally, impacts of policy often take a long time to be recognized and results may be spread out over time. Because of these reasons, studies of the impacts of policy implementation are limited (Bengston, et al., 2004). The difficulty in accounting for these outside factors means quantitative measurement of policy implementation is even more elusive and has been evaluated in only a few studies (Brody, et al., 2006).

The definition of successful plan implementation has been debated, with arguments ranging from Wildavsky's (1973) view of linear progression where success means exact conformance with original goals, to the notion that given the adaptive nature and unpredictable parameters of urban planning, success lies in the achievement of beneficial outcomes (Brody, et al., 2006). In the latter, results may arise either from flexible plan objectives or allowing for flexibility and change to the process as needed (Alexander and Faludi, 1989). However defined, success and degree of policy implementation within the field of planning has been infrequently quantified, with most planning analyses focusing on the process or the proposed outcomes rather than the actual comparative results (Brody & Highfield, 2005; Brody, et al., 2006; Talen, 1996a). While it may be considered unrealistic to assume plans will not be altered over time to accommodate changing outside conditions, conformity may serve as a measure of plan implementation and plan effectiveness (Brody, et al., 2006).

A few examples of studies quantifying spatial conformity exist. Alterman and Hill (1978) provide an early example of a quantitative study of plan implementation in which they used an overlay technique to evaluate the spatial distribution of building permits in relation to the study region's master land use plan in the Krayot area of Israel. Results demonstrated a 66% conformance with the plan. Calkins' (1979) study incorporated an evaluation model that utilized mathematical assessments to determine the degree of conformance, and included a comparison of spatial patterns of the plan and outcome to determine where aberrations occurred. Talen (1996b) utilized GIS to spatially compare distribution of public facilities in Pueblo, Colorado to the locations specified in the initial plan. Results demonstrated that actual placement of facilities deviated from the original spatial plan. Burby (1993) conducted a spatial study of sixty jurisdictions throughout Washington and Florida involving stakeholder participation in natural hazard mitigation policy. His study demonstrated a positive spatial correlation between original plan implementation and increased stakeholder involvement. Holland, et al. (1995), while not expressly linking spatial policy to outcome, demonstrated comparable patterns of wetland habitat loss in the Portland, Oregon area due to urbanization and land conversion, deviating from stated goals.

A similar study used wetland impact permits to represent developmental impacts and location. Brody, Highfield, and Thornton (2006) studied spatial deviance of development in South Florida from the original future land use map (FLUM) of the associated jurisdiction. The study built on a previous study (Brody & Highfield, 2005) that examined spatial distribution and concentration of state and federal dredge and fill permits to alter wetlands issued between 1993 and 2003 under Part IV of Chapter 373 of Florida Statutes and Section 404 of the Clean Water Act. In that study, clusters of these permits were assumed to represent development. It was found that much development was occurring outside urban areas and represented sprawl, and that factors such as conservation land barriers proved efficient at keeping development from sprawling outwards (Brody & Highfield, 2005). In the subsequent study, these wetland clusters of nonconforming development were compared to land use policy in the form of adopted FLUMs to determine the degree of conformity to the original plan. Stated purposes of FLUMs include prevention of urban sprawl. Results demonstrated that the majority of permit clusters were consistent with the “spatial design” (Brody, et al., 2006, p. 92) of local plans. The authors note this as a divergence from literature on the subject, which tends to cite lack of plan implementation. Rather, it was the development at the edges of urban areas (sprawl) that were found to be nonconforming and where the authors suggest more stringent planning regulations may be required. They also isolated specific circumstances that correlated with presence of nonconforming development, such as lower property values and distance from urban cores and infrastructure (Brody, et al., 2006).

Theobald, Miller, and Hobbs' (1997) study of development patterns and wildlife impacts in Colorado, discussed earlier, also demonstrates incremental impacts of development decisions on the environment. The study did not spatially link development to policy, but noted that even long-term policy does not necessarily ensure that “good” decisions will not result in undesired impacts. They suggest the benefits of modeling impacts of development patterns, a process that could be incorporated into policy to prevent long-term undesired consequences.

These studies demonstrate how incremental effects of land use decisions can lead to non-conforming development and a lack of implementation of the original policy found in the plan. Further, areas of nonconforming development were spatially consistent with areas of urban sprawl and natural land conversion. Identifying spatial deviation may help determine reasons why implementation failed and help prevent it in the future (Brody, et al., 2006). Similarly, studies such as Theobald, Miller, and Hobbs' (1997) demonstrate that even when decisions are made within the confines of plan conformity, the long-term impacts may in fact be nonconforming with goals such as wildlife protection. Larger-scale planning and modeling of potential development pattern impacts may help to mitigate these effects and identify gaps in policy (Theobald, et al., 1997).

## Environmental Planning

Urban development is the leading cause of loss of habitat and ecosystem services. Urban sprawl holds particular blame as it exacerbates environmental impacts associated with development (Benedict & McMahon, 2006; Environmental Protection

Agency, 2001). Urban-oriented initiatives to mitigate and prevent impacts have become popularized and address timing, placement, and design of urban development. Growth management is one such effort undertaken by governments and refers to regulations, plans, and other steps to guide the placement and timing of new growth. Smart growth is a form of growth management that generally works to locate development in existing urbanized areas rather than in outlying areas. New urbanism is a primarily design-oriented movement that also combats urban sprawl by directing new growth away from low density land use patterns and instead focuses on designs that promote such concepts as rural preservation, multi-modal transportation, walkable communities, and dense, mixed use neighborhoods (Randolph, 2004).

Another approach known as green infrastructure, however, prioritizes environmental planning. Rather than separate conservation from urban form, it proposes to consider resource preservation within the urban planning realm, using ecological resources as the framework for urban growth. Proponents such as McHarg (1992), Beatley (2000), and Peck (1998) believe that because development patterns are resulting in loss of habitat and habitat fragmentation, prevention of these impacts may be achieved by addressing competing and conflicting land use interests. All land cannot be preserved; an approach must be adopted to identify lands best suited for conservation purposes, understanding the relationship between preservation uses, urban development, and agricultural uses (Peck, 1998). Peck (1998) states, "plans are inevitably balancing acts among competing interests. Planners cannot protect every aspect of biological diversity, and so must use their judgment to sustain the most significant aspects of the ecosystem" (p. 5). Ian McHarg (1992) has noted,

> We wish to find discrete aspects of natural processes that carry their own values and prohibitions: it is from these that open space should be selected, it is these that should provide the pattern, not only of metropolitan open space, but also the positive pattern of development (p. 57).

To choose areas appropriate for green infrastructure, the process depends on the concept of ecosystem management. A discussion of ecosystem management and an expanded discussion of green infrastructure are provided below.

**Ecosystem Management**

Literature accepts that environmental protection is best achieved through an approach known as ecosystem management (Beatley, 2000; Benedict & McMahon, 2006; Dramsted, Olson, & Forman, 1996; Environmental Protection Agency, 2001; Grumbine, 1994; Hoctor, Oetting, & Beyeler, 2008). Ecosystem management focuses on ecological protection at the ecosystem level (Dramsted, Olson, & Forman, 1996; Grumbine, 1994). It addresses not only the components of the ecosystem, but also the processes and patterns between living and nonliving elements. To protect the individual elements of the system, all interrelated parts must be protected as well, as they are dependent on one another for survival (Peck, 1998). One cannot protect a species without protecting the entire ecosystem upon which it depends (Wilson, 1999). The approach is closely related to, and for the purposes of this discussion is synonymous to, studies of landscape ecology, regional ecology, biodiversity planning, or various other terms that recognize the limitations of focusing on protection of specific species or individual environmental components (Dramsted, Olson, & Forman, 1996; Grumbine, 1994; Peck, 1998). Limiting protection to one species or a single objective such as flood control could lead to destruction of other species or ecological functions if the entire ecosystem is not considered. Instead, the approach is taken at an ecosystem scale, taking into account larger system boundaries, interactions between living and non-living elements, and the role of humans (Grumbine, 1994; Noss & Scott, 1997; King County, Washington, 2008).

There is no strict definition of ecosystem management, but a literature review conducted by Grumbine (1994) of the subject highlights ten qualities generally agreed upon by literature, policy and science on the concept:

1. A systems approach involving more than just one level of the ecosystem
2. Moving beyond jurisdictional boundaries and focusing instead on ecological boundaries for management purposes
3. Maintenance of biodiversity through protection of all the natural processes that support it
4. Increased research and data collection
5. Monitoring of success and results of management practices
6. Ability to adapt management practices based on success of results and new research
7. Effective interagency cooperation to handle management of ecosystem boundaries extending across jurisdictional lines
8. Change in organizational structure of entities with power over land management to appropriately manage at an ecosystem scale, including policy and power structure shifts
9. Acknowledgement of the interrelationship between humans and ecosystem processes and the impact of humans on natural patterns
10. Change in our value system to place importance on the need for ecosystem management (pp. 29-31).

The ecosystem approach has only become more widely accepted since the 1980s, driven by factors such as research highlighting the need for larger, holistic ecosystems for biodiversity preservation and public outcry for ecosystem preservation (Grumbine, 1994). This approach is becoming increasingly adopted as a more effective way to manage natural resources (Lackey, 1998; Yaffee et al., 1996). A 1996 study identified 600 “cooperative ecosystem management” initiatives within U.S. in which environmental challenges were being approached based on ecological, rather than political, boundaries, addressing the goals of ecosystem management and long-term impacts (Yaffee et al., 1996). These concepts are working their way into regulatory documents, such as the King County, Washington comprehensive plan. The plan recognizes the need to change the focus of environmental protection from individual species to multi-species biodiversity, not only for the sake of species protection but also to protect the long-term interests of agricultural uses and resource-based activities. Also in Washington State, the Washington State Biodiversity Council, created in 2004, and the Washington State Department of Fish and Wildlife work to promote biodiversity and landscape-level protection in the state, deliberately moving away from the narrow concentration on single species or functions (King County, Washington, 2008).

Ecosystem approaches can therefore be utilized to mitigate ecological impacts that may disrupt the overall system at the ecosystem level. As pointed out in Grumbine’s (1994) analysis of ecosystem management, this move requires a change in political structure and interagency coordination. Lackey’s (1998) account of ecosystem management states these governing entities must define ecosystem management and direct policy by identifying desired goals and objectives and specifying locations for management efforts based on scientific analyses (Lackey, 1998).

Another example of an ecosystem level approach is the Cosumnes River Project in California. The 1,250 square mile watershed is one of the last remaining undammed rivers in the state and contains high levels of biodiversity. The Nature Conservancy worked to create a plan to protect the area, taking into account not only individual species, but the patterns and processes within the watershed as guiding points for the plan. The plan was created at the watershed level and selected those areas most important to sustain the overall integrity of the area. By 1998, 14,000 acres across the watershed were included in the plan (Peck, 1998).

Addressing land use patterns at this scale can help prevent cumulative impacts of individual land use decisions by placing small scale decisions within a broader context (Dramsted, Olson, & Forman, 1996). Environmental issues addressed by ecosystem management span jurisdictional boundaries and must be addressed beyond the local scale, focusing on the regional, or ecosystem, scale and associated environmental boundaries to protect ecological systems (Benedict & McMahon, 2006; Environmental Protection Agency, 2001). This broad scale approach can help prevent cumulative impacts because it takes land use decisions into account based on larger ecosystem properties rather than localized conditions of each project. If greenspace plans, mitigation areas, or restoration projects take into account their role in the overall ecosystem, larger, longer-term results may be realized (Beatley, 2000).

To advance both urban and environmental planning, then, the two must be approached together, avoiding development where ecological resources have high value, and placing development where it is best suited while preserving the environment (Beatley, 2000; Benedict & McMahon, 2006; McHarg, 1992). The concept of green infrastructure builds upon the concept of ecosystem management to provide a framework for urban development (Benedict & McMahon, 2006).

**Green Infrastructure**

Ecosystem management requires a network of green spaces to allow proper functioning of natural systems. Implementation involves carefully selecting land suitable to support ecosystem management objectives, preventing haphazard conservation by creating an integrated, long term plan for conservation (Benedict & McMahon, 2006). Grumbine's (1994) and Lackey's (1998) analyses of ecosystem management point out that implementation of ecosystem management requires a new approach to land conservation, reorganizing political structures and building consistent policies based on identified ecosystem management objectives. Green infrastructure represents an approach to organize and prioritize ecosystem management while considering urban development growth needs.

Green infrastructure integrates both concepts of urban-focused smart growth and ecology-based smart conservation, addressing both conservation and community growth at the same time. It assumes some areas are better suited for growth than others, and has preservation of natural systems and flows at its heart to guide development (Benedict & McMahon, 2006).

Ecosystem management recognizes the need to prevent habitat fragmentation and allow movement between natural habitats while conserving natural system flows. Green infrastructure upholds these concepts while recognizing the benefits to humans (Benedict & McMahon, 2001). By incorporating green infrastructure, ecosystem management may be addressed within the structure of land use planning, providing the basis of land development by prioritizing land important for ecosystem management and natural services. Ideally, this allows development and green infrastructure planning to work with one another to achieve mutually beneficial long term goals (Benedict &

McMahon, 2006), a process that may address Grumbine's (1994) and Lackey's (1998) concerns regarding ecosystem management implementation. By recognizing the those areas most important to ecosystem protection and assigning priorities, regions most important to ecological integrity may be preserved, while allowing development elsewhere in places with less conflict and more suitable for urban uses.

Green infrastructure has been defined in the literature, though its role in defining placement of development is not always explicitly recognized, as it is in the definition by Benedict and McMahon (2001; 2006) (which is also the definition used in this thesis). A report commissioned by the Sprawl Watch Clearinghouse described green infrastructure as “an interconnected network of green space that conserves natural ecosystem values and provides associated benefits to human populations” (as cited in Benedict & McMahon, 2001, p. 5). The President's Council on Sustainable Development (1999) defined it as "the network of open space, airsheds, watersheds, woodlands, wildlife habitat, parks, and other natural areas that provide many vital services that sustain life and enrich the quality of life" (p. 64). Benedict & McMahon (2006) state green infrastructure is “an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife” (p. 1).  Benefits are not only for the preservation of ecological integrity, but for the use of humans as well, tying together the concepts of greenways planning and ecosystem management. Identification of green infrastructure needs and priorities “provides a way to link land use planning to the preservation of biodiversity” (Benedict & McMahon, 2001).

A green infrastructure network may include a variety of green spaces, including ecological preserves, farmland, local parks, and linkages such as greenways that tie the network together (Benedict & McMahon, 2001). The network, as defined by Benedict and McMahon (2001), includes "hubs" and "links" (p. 7). Hubs are larger natural areas that provide habitat for wildlife, including large preserves such as national and state parks, farmlands that provide habitat, and community parks. Links are the features of the system that connect hubs, and include conservation corridors, greenways, and other natural areas that provide connectivity between larger habitats (Benedict & McMahon, 2001).

The concept of creating a linked system of green spaces to benefit people and preserve wildlife is attributed to ideas initially utilized 150 years ago by proponents for green space such as landscape architect Frederick Law Olmsted, who touted the benefits of a connected system of parks to better serve people. Preservation of green space for the benefit of people has "evolved into the modern greenways movement" (Benedict & McMahon, 2001, p. 8). Similarly, the recognition of the need to preserve a system of natural areas is found in the modern science of ecosystem management. Each approach is often addressed separately, but green infrastructure seeks to integrate both concepts, understanding that protection of a green space network benefits both people and biodiversity in a number of ways (Benedict & McMahon, 2001).

In this way, green infrastructure may be differentiated from "traditional" conservation tactics for several reasons (Benedict & McMahon, 2001; President's Council on Sustainable Development, 1999). Green space has been considered an amenity, self-sustaining, and created and maintained in isolation. Green infrastructure, in contrast, is seen as more than an added benefit, is based on the concept on interconnectivity rather than isolation, and relies on continued maintenance to ensure sustainability of the system. It differs from the popular greenways movement as well. Greenways are generally comprised of recreational trails, and consist of smaller linear areas of conservation. Green infrastructure recognizes the value that trails may provide, but is larger in scale and has at its heart the ecological benefits of open space and linkages (Benedict & McMahon, 2001). Finally, green infrastructure is integrated with urban development and is seen as a "framework for growth" rather than an amenity or afterthought (Benedict & McMahon, p. 9). Natural resources are given value based on ecosystem management concepts; development is then planned for in a sustainable manner to maintain the integrity of the natural system (President's Council on Sustainable Development, 1999).

Green infrastructure is becoming more widely recognized and has been integrated into initiatives in a few states such as Florida and Maryland, both of which created statewide green infrastructure programs in the 1990s, understanding it as a "way to link land use planning to the preservation of biodiversity" (Benedict & McMahon, 2001, p.8). In 1999 the President's Council on Sustainable Development (1999) recognized green infrastructure as one of five themes to achieve sustainable communities in their report, "Towards a Sustainable America: Advancing Prosperity, Opportunity, and a Healthy Environment for the 21st Century."

Green infrastructure is thus closely related to urban planning, and its proponents state it should be an integral part of the comprehensive planning process, much like transportation or other public infrastructure. The concept suggests using a green infrastructure plan to guide urban growth in a way that avoids ecologically sensitive areas and prevents sprawl (Benedict & McMahon, 2001). Beatley (2000) calls for the integration of biodiversity planning, or ecosystem planning, into the urban planning process, because the conflict between the two is the primary cause of ecosystem degradation and species loss. The President's Council on Sustainable Development (1999) suggests utilizing green infrastructure in conjunction with land use strategies to reduce sprawl and protect open spaces identified in the green infrastructure plan. Thus, even when its definition does not explicitly include application in urban planning, literature notes the appropriateness of this step.

Proponents cite examples of the loss of valuable resources due to a failure to incorporate green infrastructure, such as in the case of St. Petersburg, Florida. In 1923, John Nolen designed a plan for the region that included an interconnected system of parks and preserves, including preservation of the waterfront. The plan was never implemented, and development related impacts have resulted in poor air quality, congested roads, polluted waters in Boca Ciega Bay, loss of a fishing industry, and the need for a desalinization plant in an area that receives over fifty inches of rain per year. It wasn't until the 1970s that the city adopted a new comprehensive plan, one that strongly resembled Nolen's original, as a way to combat these ecological impacts (Stephenson, 1997). Austin, Texas, also had a plan in the 1970s that used ecological studies to send development to a growth corridor and protect sensitive areas. The plan was never implemented, and the region lost valuable habitat to development. To counteract these impacts, a costly conservation planning effort has been implemented, but may not have been needed to such an extent had initial green infrastructure planning taken place. In Oregon, urban development has resulted in salmon and other fish species becoming threatened or endangered, requiring extensive restoration plans to attempt to bring the populations back and restore the habitat (Beatley, 2000).

Planning for green infrastructure thus must identify the suitability for both development and green spaces (Benedict & McMahon, 2001). Further, to accommodate growth levels, urban form must be addressed. Sprawl development results in high levels of ecosystem impacts and habitat loss; concentrating development into appropriate, higher density areas is considered vital to proponents of green infrastructure planning (Beatley, 2000).

## Suitability Modeling

Planning for green infrastructure involves determining optimal locations for both development and the green infrastructure network. Assessing land use suitability for various land uses thus provides a way to determine where to guide development and green infrastructure (Benedict & McMahon, 2001). Land use suitability refers to the optimal use for a property based on its existing condition and context within surrounding lands (Carr & Zwick, 2005). With this assessment, a map depicting the suitability index is created, demonstrating the appropriateness, or suitability, of a particular use across the study area (Joerin, Theriault, & Musy, 2001). Attributes specific to each parcel of land are assessed for their appropriateness relative to a particular land use, using assumptions as to what is or is not appropriate. For example, one may assume that wetlands are unsuitable for commercial development or that a particular soil is well suited for agriculture. Final suitability is determined by combining the suitability values of individual attributes, either by manually layering data or using mathematics to compute combined suitability values (Lyle, 1985). Suitability maps are useful to assist in land use decisions while considering a variety of diverse variables (Joerin et al., 2001).

Suitability modeling has been utilized for some time and may take form in a number of various types of models, using different methods of analysis, input variables, and techniques to combine values. Examples include techniques utilized by the Soil Conservation Service, sieve mapping, landscape unit approaches, use of graytones (Lyle, 1985). Combining GIS raster data is now the most commonly utilized methodology (Steiner, 1991; Carr & Zwick, 2005).

Sieve mapping involves creating a series of maps for a particular land use that designate the areas which are desired or inappropriate for that use. Maps are layered such that inappropriate uses are stripped away, as though being sifted through a sieve, leaving only the suitable land uses. The sieves may work the opposite way as well by identifying factors that determine appropriate uses for the land the land, or land that is "desirable or attractive" (Lyle, 1985, p. 245). A combination of both methods of sieve mapping can produce maps demonstrating land that is suitable or capable of handling the land use, and desired based on selected criteria. This method was utilized in the mid-1900s in Europe (as cited in Carr & Zwick, 2005, p. 46), and as recent as 1980; Deitholm and Bressler (as cited in Lyle, 1985, pp. 244-245) utilized the method to determine locations for new ski runs in for Mount Bachelor, Oregon. Sieve mapping does not assign values or determine a scale of suitability (Lyle, 1985).

Suitability may also be considered in terms of landscape units. Here, the landscape is broken down into units, with unit size depending on desired precision. Each unit is evaluated based on its natural physical attributes, such as soils, slope, and vegetation. Classifications are created based on groupings of attributes, and each unit is assigned to a classification based on its features. Suitability may then be determined based on the appropriateness of each classification for particular uses. Complex analyses are generally considered inappropriate for this type of model (Lyle, 1985).

Ian McHarg depicted the use of graytones to assign suitability in his book, *Design with Nature* (1969). Here, each characteristic of the land is assigned a shade of gray, generally with lighter shades representing higher suitability and darker shades the least suitable for the particular use being studied. Each characteristic's graytone suitability is placed on a map. A composite map is assembled, layering the maps from each characteristic. The more overlapping graytones there are, the darker the shade is. Darkening shades representing reducing suitabilities of that area for the use. The lightest areas are considered the most suitable. The technique allows for more subtle shading than the previously discussed model types, allowing a range of suitability values from least suitable to most suitable rather than simply a classification of suitable or not suitable.

Graytone modeling, however, has several limitations. When many attributes are being studied, the result is a great number of maps that may be difficult to combine (Lyle, 1985). Mathematical concerns were pointed out by Lewis Hopkins (as cited in Lyle, 1985, p. 246), who contended that the graytones actually represented ordinal values. Thus, overlaying the graytones equated adding ordinal values to achieve an outcome, which was, according to him, unacceptable in mathematical terms. He also asserted that the equal overlaying of graytones suggests they are independent of one another, though many attributes are in fact interdependent. Hopkins instead suggested assigning weights to each attribute, then multiplying the assigned value by the weight, as a way to demonstrate relative significance (Lyle, 1985).

The use of computer-aided aggregation, using programs such as Geographic Information System (GIS), has greatly aided the task of combining attributes into a final suitability map. Utilizing raster data analysis, values are assigned to each cell, or land unit, within the study area. Maps are digitally overlaid and calculations on the aggregation of these values are completed within the program, thus removing the task of time-consuming and complex mathematical determination of final suitability values (Lyle, 1985).

## Modeling Future Land Use

Creating future land use scenarios provides a way to determine the benefits or consequences of land use or policy decisions. It also works as an effective public communication tool because it quantitatively and visually shows spatial outcomes of policy (Jantz, Goetz, & Shelley, 2003). The modeling process may be a build-out scenario to demonstrate the effects of current policy and development trends, or a series of alternative scenarios showing the effects of various policy or land use decisions. For each alternative scenario, land use is allocated based on parameters affecting land use distribution such as density, development patterns, environmental protection areas, or political decisions. Alternative future scenarios can provide a way to analyze the effects of land use decisions and compare scenarios, analyzing trade-offs of the outcomes of each scenario. For example, scenarios may be created to demonstrate potential spatial outcomes of trend land development patterns compared to the creation of high density nodes of development. The outcomes can be assessed relative to one another and compared to previously identified community goals. Creating alternatives for analysis allows for better-informed land use decisions (Benedict & McMahon, 2006).

**Examples of Future Land Use Modeling**

Future land use modeling has been used by many jurisdictions and organizations to study potential outcomes of growth patterns. A few examples are discussed below:

The Upper San Pedro River Basin in Arizona and northern Sonora, Mexico implemented a program to analyze regional growth and land use in relation to identified ecological goals. Various land use scenarios were analyzed for their effects on water resources and wildlife; results may be used to guide land development decisions in a manner that best supports protection of vital resources (Steinitz, et al., 2003).

The State of Massachusetts (2000) completed a build-out analysis for the entire state, using existing land use policy such as density and land use designations to demonstrate what the region would look like under current legislation. The state calls this analysis "a crucial first tool in the development of a Community Development Plan" (p. A-1). The analyses were provided to each community to provide support for a Community Development Plan and to allow them to analyze existing policy to see if it matched their long term goals, such as environmental protection or sprawl.

The Willamette Valley Livability Forum, an organization in the Willamette Valley region of Oregon, created a study entitled "Alternative Transportation Futures." The project created multiple scenarios of land development patterns, and modeled their effects on transportation (Willamette Livability Forum, 2001).

Maryland has modeled predicted growth for the state using a process known as the Growth Simulation Model. This model was used to determine potential impacts to the established green infrastructure network through the year 2020 (Weber & Aviram, 2002).

### Land Use Modeling Methods

Various software options and models have been created to support the need to create future land use alternatives.

**CommunityViz.** CommunityViz is a GIS software package designed to help communities create these alternative future scenarios and has been used across the United States. The software allows for analysis of development's impacts on various aspects of the community such as economic impacts, effects on wildlife habitat, transportation, etc. The software can be used at varying scales and includes a 3D modeling package to visually display outcomes (Orton Family Foundation, 2009).

**California Urban Futures Model.** The California Urban Futures Model, Second Generation (CUF-2) is another model that projects future development scenarios based on land use policy. Building on the first generation model (CUF-1), the model was designed for the Northern California Bay region. It takes into account past development trends, land characteristics, user-input policies affecting development patterns, user-defined land use categories, and allocates population (residential and employment) accordingly into defined units (PlaceMatters, n.d.).

**SLEUTH.** The SLEUTH model uses five different “growth coefficients”: “dispersion, breed, speed, road gravity, and slope” (Jantz, et al., 2003, p. 254) to model four growth scenarios: “spontaneous growth, new urban center growth, edge growth, and road-influenced growth” (p. 254). Each coefficient is assigned a value based on potential of development. The study area is divided into a cellular grid; the combination of coefficients for each cell provides an outcome of its potential development (Jantz, et al., 2003).

**UrbanSIM.** UrbanSIM has been used in Honolulu, Hawaii, the Eugene-Springfield metropolitan area in Oregon, and Salt Lake City, Utah, among others (Waddel, 2002). The model incorporates concepts of market driven land use decisions for various land uses, using a number of inputs such as land value, density, and square footage. Scenarios are created much in the same way as other model processes, allowing for input of policy decisions to determine spatial impact. The results are based on market changes as a result of impacts such as supply of land; the choice to protect ecologically sensitive land, for example, could be evaluated relative to its impact on the market value of remaining undeveloped land (UrbanSim, 2009).

**CITYGreen.** CITYGreen is another software application that uses GIS and can be used to support future development studies. It assesses a community's ecosystem, placing value on urban forests. The impacts of loss of urban green space can be calculated based on these values; preservation or creation of green space can also be quantified (Benedict & McMahon, 2006)

**LUCIS.** The Land Use Conflict Identification Strategy (LUCIS) model, developed by Margaret Carr and Paul Zwick (2007), does not itself model future land use, but provides a method for analyzing land use suitability and conflict. LUCIS provides a spatial representation of likely land use patterns by identifying areas of conflict between land use suitabilities. It allows for analysis of land use based on suitability, then compares suitabilities of various land uses to identify where conflict lies; that is, areas where land uses are equally suitable and therefore in competition with one another. The idea is that land use should be placed in areas of corresponding high suitability but with the least conflict (Carr & Zwick, 2007). The results of the analysis may be utilized as a decision support tool in future land use planning, environmental planning, or allocation of future land use (Carr & Zwick, 2005).

Six steps are involved in the LUCIS process and are defined by Carr & Zwick (2005) as:

1. **Goals and Objectives:** Define the criteria for determining suitability by creating a set of goals and objectives.
2. **Inventory:** Create an inventory of data related to the goals and objectives.
3. **Suitability:** Analyze the collected data to determine the suitability of the goals and objectives.
4. **Preference:** Combine the suitabilities of each goal to determine preference.
5. **Collapse Preference:** Collapse the preferences for each land use into three ranges of high, medium, and low.
6. **Conflict:** Compare the preferences ranges to determine areas of conflict (p. 60).

## Summary

This review of the literature has sought to paint the picture of the environmental impacts of urban development and the need to monitor present and future development patterns to prevent impacts created through cumulative decision making. Purposes of this chapter included tying the process of environmental planning into the urban planning realm through discussion of green infrastructure, exploring the function of suitability modeling and its role in green infrastructure, and examining the importance of modeling growth patterns to evaluate impacts of land use decisions.

Green infrastructure incorporates concepts of ecosystem management and urban planning. Land use suitability analyses have been discussed in the literature as an effective method to determine appropriate locations for both conservation and development, with flexible inputs based on identified objectives. Understanding potential impacts and outcomes of incremental decision making may assist decision makers in avoiding undesired outcomes, such as loss of natural resources. Modeling potential outcomes of land use decisions can therefore be helpful in land use planning and has been implemented across the country. Combining these concepts represents an opportunity to integrate green infrastructure into suitability analyses and land use modeling within the urban planning realm to observe their impacts on one another.

# CHAPTER 3
# STUDY AREA

The study area for the first half of this thesis study includes the Central Florida region of Brevard, Lake, Orange, Osceola, Seminole, and Volusia Counties. The second half of the study takes place in Lake County. This chapter describes the history of growth and specific development policies affecting development patterns (and hence associated environmental impacts) in both the state and the Central Florida region, discusses aspects of the history and success of environmental planning, and provides specific information on resources affected by growth development patterns in Lake County.

## Florida's Urban Growth

### State Growth

Since the 1960s, population growth in Florida has grown considerably. From 1960 to 2000, approximately three million people have moved to Florida every decade (Nicholas & Chapin, 2007). Nationwide, population between these years increased by 38%, while growth in Florida was 135%, with five counties (Flagler, Hernando, Osceola, Collier, and Citrus) demonstrating over a 500% increase (Sanchez & Handle, 2007). In 1950, annual population growth was 3.86%, with just 87,389 people entering the state each year. By 1960, growth was 5.98%, with 218,026 new residents every year. From the 1980s on, annual population growth for the state has been roughly 300,000 residents per year, with growth not expected to slow (Nicholas & Chapin, 2007). Assuming growth trends continue, Florida will pass New York to become the third largest state at some point between 2015 and 2020 (Nicholas & Chapin, 2007).

Growth is expected to continue at high rates. Census projections demonstrate that Florida is projected to be the third-highest in net increase in population from the years 1995-2025 (Campbell, 1997).

**Central Florida Growth**

Growth patterns show that Central Florida, along with the southwest and southeast coastal regions of the state, has seen the highest rates of urban growth in the country in recent years (Sanchez & Handle, 2007).

Central Florida's population (including the six-county region of Brevard, Lake, Orange, Osceola, Seminole, and Volusia) is expected to grow from approximately three million in 2005 to a population of five million people by 2035, a 60% increase of two million people. Lake County alone is expected to see an increase of 240,858 people, nearly doubling from a population of 263,642 in 2005 to 504,500 in 2035[1] (see Table 3-1).

**Florida Future Land Use Policy**

Urban growth puts pressures on natural resources, and Florida has not been an exception. Ecosystems were being destroyed and water resources threatened by growth in the 1960s, spurring a number of laws in the early 1970s to regulate development's impact on the environment. The Coastal Control Act of 1971, the Environmental Land and Water Management Act of 1972, the Water Resources Act of 1972, and the State Comprehensive Planning Act of 1972 the first steps to manage urban growth and its impacts. The Local Government Comprehensive Planning Act of

[1] All county 2015 to 2035 population forecasts are based on BEBR totals recorded in the document - "Florida Population Studies, Volume 41, Bulletin 150, March 2008" except for Orange, Osceola, and Seminole which were provided by the counties through the METROPLAN ORLANDO 2030 SE data forecasting efforts.

1975, effectively updated by the Growth Management Act of 1985, established a set of rules for local governments to produce comprehensive plans to manage new growth (Nicholas & Chapin, 2007).

In Florida, local policy dictates what lands will be developed (Ben-Zadock, 2003). With the inception of the Local Growth Management and Comprehensive Planning Act of 1975 (Ch. 75-257, 380.06, F.S.), each local government was required to create a comprehensive plan. The plan is a document meant to reflect the vision for future development, providing guidance and a legal basis for land use decisions. However, the 1975 Act called for no state oversight, and lacked state funding, timeframe requirements for preparation, definition of plan composition, and non-compliance sanctions. To rectify these issues, the Local Government Comprehensive Planning and Development Regulation Act of 1985 (Ch. 163, Part II, Florida Statutes), known as the Growth Management Act (GMA), was instated, setting forth additional time and composition requirements for the comprehensive plans to assist in mandating implementation (Ali, 2007).

The GMA inverted the power structure, changing growth management to a top-down system in which regulation and approval of the comprehensive plans falls under the responsibility of the state's Department of Community Affairs (DCA) and plans must be consistent at state, regional, and local levels (Chapin, Connerly, & Higgins, 2007; Ben-Zadok, 2007). An objective of the GMA is to protect agricultural and natural resources by regulating growth patterns, intending to prevent development associated with fast population growth from sprawling into these areas (Ben-Zadok, 2007).

Growth management in Florida is implemented through several regulatory measures. Florida was the first state to require that development demonstrate that adequate public facilities are available concurrently with new development, known as concurrency. Adequate water, sewer, and transportation, for example, must be available for new growth to be allowed by the local government. Local jurisdictions are charged with determining these levels of concurrency (Bengston, et al., 2004). Growth management is also addressed in part through future land use maps (FLUMs). FLUMs are created by each local government and are required as part of the comprehensive plan. This map specifies location of permitted land uses within jurisdictional boundaries. Following the GMA objectives, the FLUM is to be created with the purpose of preventing development with inadequate infrastructure, growth in environmentally sensitive areas, and sprawling development. Though requiring state approval, each local government is given the power to designate lands for specific uses and densities based on their vision of future growth and development (Brody & Highfield, 2005; Brody, et al., 2006).

FLUMs therefore represent a form of spatial policy, a planned set of land uses meant to be a prescriptive vision for the future (Brody, et al., 2006). Brody, Highfield, and Thornton's (2006) comparative study, discussed in the previous chapter, of nonconforming uses and FLUM designations suggests that despite FLUM creation, policy decisions discouraging urban sprawl may not be carried out within individual land use decisions. The combined impact of land use decisions may effectively be working against the original policy to continue trends of urban sprawl and environmental degradation.

**Florida Growth Patterns and Land Use Change**

Despite the existence of FLUMs and other growth management efforts within Florida, studies of land use change over time within the state demonstrate that impacts of urban growth on the landscape have still occurred, characterized by urban sprawl and high losses of agricultural and ecologically sensitive lands.

**Statewide growth patterns and land use change**

Carruthers, Boarnet, and McLaughlin (2007) studied growth patterns in Florida and the Southeast from 1982 to 1997. Their study found that urban sprawl characterizes much of growth in Florida, as areas experiencing high population growth over this timeframe did not reflect areas of high density.

A study conducted by the Florida Fish and Wildlife Conservation Commission (FWC) in 2007 reclassified the existing 1985-1989 Florida vegetation and land cover map to reflect updated 2003 conditions, using 2003 Landsat satellite imagery and other data sets from agencies such as the water management districts and the Florida Department of Environmental Protection. The date range of 1985-1989 reflects a collection of Landsat imagery data spanning those years. Results of the comparison between the two data sets showed that statewide land cover conversion of natural and semi-natural cover types to urban, developed, or agricultural use amounted to 3.2 million acres (13.3% of all natural and semi-natural lands: 6.2% converted to urban uses and 7.1% converted to agricultural uses). Agricultural and pasture uses also showed significant losses, with 878,417 acres (13.5% of all agricultural and pasture land) converted to urban and developed uses (Kautz, Stys, & Kawula, 2007). Of the land use conversions detected in the FWC (2007) study, the majority of conversions from natural and semi-natural land to urban and developed uses occurred adjacent to lands that were already in urban and developed use in 1985-89.

Other studies similarly show the effects of population growth and land use conversions over time. A study completed by Sanchez and Mandle (2007) examined urban sprawl in Florida by utilizing census tract data to calculate population densities for 1970, 1980, 1990, and 2000. The study then calculated square mileage for categories of urban development types based on census year for the state. The study showed growth from 1970 to 2000 in urban (119% or 834 square miles), suburban (165% or 2,213 square miles), and exurban (80% or 2,389 square miles) land uses, while exhibiting a reduction in total amount of rural land uses (15% loss, or 5,423 square miles). Population over this time period grew from 6,789,437 in 1970 to 15,982,824 in 2000 (135%), with most growth occurring in the south and central part of the state.

Xian and Crane (2005) demonstrated growth patterns in the Tampa Bay region of Florida using high resolution satellite images to examine land cover change from 1991 to 2002. The study monitored land cover change by determining the amount of impervious surface as a measure of urbanization. Impervious surface was chosen as a measurement because of its impact on ecological resources. Land development was categorized as low density, medium density, or high density development based on percent of impervious surface. The study then went on to model growth in the region through 2025 using the SLEUTH land use modeling methodology, defining potential growth by these three density categories. Results of the modeling found that 2500 square kilometers had a 90% chance of being developed into impervious surface. Combined with existing impervious area, 38% of all land area in the region was predicted to be converted to impervious land uses by 2025.

Brody, Highfield, and Thornton (2006) examined spatial distribution and concentration of state and federal dredge and fill permits to alter wetlands issued between 1993 and 2003 under part IV of chapter 373 of Florida Statutes and Section 404 of the Clean Water Act. Wetland impacts were assumed to be associated with development (Brody, et al., 2006). It was found that conversion of land from natural and rural land uses were most commonly occurring in areas just outside existing urban areas (Brody & Highfield, 2005). It was assumed land conversion to accommodate urban growth outside of urban areas represented sprawl development. Thus, the study demonstrated continuing trends of sprawl and associated environmental impacts in the state, despite statewide policy to prevent both (Brody, et al., 2006).

**Central Florida growth patterns and land use change**

Central Florida land use trends reflect these statewide patterns. Much of the region's development has been low density, sprawling development (myRegion.org, n.d.). The MyRegion.org initiative has conducted recent studies of the Central Florida seven county region of Brevard, Lake, Orange, Osceola, Polk, Seminole, and Volusia counties. Gross residential density has actually decreased, from 1.56 units per acre in 1995 to 1.44 units per acre in 2000 (PennDesign, 2005). Even the Orlando Metropolitan Statistical Area, one of the more developed areas in the region, showed a decline in the number of residents per square mile from 2,315 in 1994 to 1,820 people per square mile in 2005 (myRegion.org, 2005). The amount of urban land developed per household has increased by approximately one third of an acre between 2000 and 2006, and land development outside of cities is occurring at a faster rate than within city limits. Agricultural land uses have declined; from 2000 to 2007 the region lost 9% of its agricultural lands, and 25% of the land in citrus production. Transportation in the region is based almost solely on the automobile and vehicle miles traveled has increased by 40% between 2000 and 2007. Per capita, residents drive approximately 300 miles a year more than the statewide average, and the region lacks mass transit opportunities compared to other similarly sized metropolitan areas (myRegion.org, 2009). In terms of environmental conservation, 35% of the region is under conservation management of some sort (myRegion.org, 2009). However, many valuable resources remain threatened directly and indirectly by urban development. The Green Swamp area, for example, is important to maintain the aquifer's water quality and supply (Schue, 2005), and coastal areas are increasingly affected by erosion (myRegion.org, 2009).

## Florida's Environmental Planning Initiatives

Florida represents a prime location for analysis of effective ecological management. Florida is recognized for its highly valuable ecological resources, and benefits from regional and statewide ecosystem management guidelines and inventory that may be followed by local jurisdictions. For example, in 1993 the Florida Department of Environmental Protection (DEP) recognized the need to incorporate ecosystem management based on natural, rather than political, boundaries, addressing air, water, and land environmental concerns as integrated rather than individual issues (Brody, 2003). Further, each jurisdiction's comprehensive plan must address environmental concerns by including a conservation element, as well as identification of conservation lands within the future land use plan (Ch. 163.3177 5(a), 6(d), Florida Administrative Code). The comprehensive plan is also required to include an intergovernmental coordination element, providing another opportunity to address cross-jurisdictional environmental issues (Brody, 2003).

The greatest impacts on ecosystem services occur as a result of urban development, particularly urban sprawl. Urban sprawl is generally characterized by traits such as disconnected leapfrog development, commercial strip centers, and low-density development. Florida’s growth management regulations identify these within its definition of urban sprawl and further identify it by a series of indicators including poor accessibility and lack of functional public open space (Ewing, 1997). Negative impacts on the environment include habitat fragmentation, loss of habitat, air pollution due to increased vehicular use, and loss of natural functions such as flood control (Radeloff, Hammer, & Stewart, 2005; Ewing, 1997; Terris, 1999; Allen, 2006).

Brody, Highfield, and Thornton (2006) completed a study (also discussed earlier in this chapter) of policy implementation through analysis of FLUMs to demonstrate the relationship between implementation of policy and urban sprawl. The study demonstrated the degree of non-conforming uses (uses not conforming to FLUM policy) occurring throughout south Florida. While the majority of development demonstrated consistency with the FLUM spatial land use plan, results directly related sprawl to deviation from the FLUMs and associated policy. Continuation of sprawl brings with it negative environmental effects associated with sprawling development. A primary objective charged to each local government when drafting the future land use element of comprehensive plans is to “ensure the protection of natural resources” and “discourage the proliferation of urban sprawl” (Chp. 9J-5.006 (3)b, Florida Administrative Code). Despite this policy, Brody, Highfield, and Thornton’s (2006) study demonstrates that deviations from policy are still occurring and resulting in loss of natural lands and potential green infrastructure.

Studies of Florida’s land use conversion over time and comprehensive plan effectiveness in addressing regional ecosystem management suggest that effective regional ecological considerations are often absent in local land use planning. Samuel Brody (2003) studied of the integration of ecosystem management into comprehensive planning in Florida, demonstrating that while initiatives exist at state and regional levels, local level planning often fails to directly incorporate these principles into their comprehensive plans. The study demonstrated a lack of incorporation of “factual basis” (p. 524), meaning a failure by many to incorporate specific scientifically based ecological inventories or ecosystem management plans. General goals to protect the existing environment are included in most plans, but very few actually list specific objectives and policies for management or restoration that would be effective in guiding land development regulations and resulting land use decisions. Brody’s findings indicate that when conservation policies are included, they tend to be “traditional environmental policies” (p. 529) of restricting development around critical habitats, restricting removal of native vegetation, and implementation of conservation zoning. It has been demonstrated that growth management tools such as specification of high growth, high density areas and site-specific land use regulations are effective ecosystem management tools (as cited in Brody, 2003, p. 530). Brody’s study, however, suggests these techniques are rarely utilized in local comprehensive planning in Florida.

## Lake County’s Ecological Resources

Lake County has a number of valuable ecological resources at risk of direct and indirect impacts by development. Past and projected population growth rates and associated threat of urban development places them especially at risk of impact.

Resources include the Green Swamp, the Wekiva-Ocala Greenway, and multiple water resources (see Figure 3-1).

The Green Swamp is located in the southern portion of the County and has been called the "liquid heart of Florida" (Ryan, 2005, p. 24). It is largely a wetland system, second in size in the state only to the Everglades at 870 square miles. It contains the highest point of the Florida Aquifer, which sits 132 feet above sea level, thus creating the pressure to support springs, rivers, lakes, and other water bodies throughout the state. The Florida aquifer supplies most of the water to the state's population and the Green Swamp is an important source of aquifer recharge. The Green Swamp houses endangered species such as the Florida black bear and panther, and the National Audubon Society has given the Green Swamp the designation of an "Important Bird Area." Due primarily to threats of development, the Green Swamp was officially designated an Area of Critical State Concern in 1974 by the Florida Legislature, including 106,000 acres within Lake County and 189,000 acres in Polk County to the south (Ryan, 2005). The area is particularly vulnerable due to the closeness of the aquifer to the surface, placing the water supply at high risk of development impacts. To better protect this resource, uses within the designated area have been limited to low intensity, low density development, along with agricultural and passive park uses (Lake County, Florida, 2009). The area has been the focus of land acquisition efforts; a total of 194,000 acres of land is owned by the Southwest Water Management District and other public entities. Another 40,000 acres are protected by land protection agreements or conservation easements, which leave the land in private ownership while legally protecting its natural resources. Development pressures continue, however, within the unprotected areas of the Green Swamp Area of Critical State Concern; groups such as MyRegion.org that work to prevent negative impacts of development call for continued regulation and enforcement by local governments to provide protection of the ecosystem, water supplies, and other natural resources provided by the region (Ryan, 2005).

Lake County contains four watersheds: the Ocklawaha River Watershed, the Withlacoochee River Watershed, the Wekiva River Watershed (part of the Middle St. Johns Watershed), and the Kissimmee River Watershed (Lake County Water Atlas, 2009a; Florida Department of Environmental Protection, 2009). The Ocklawaha River Watershed has the most land coverage of the four within the county, covering 568.4 square miles. It encompasses the central portion of the county and contains 345 named lakes and ponds, as well as 43 named rivers, streams, and canals (Lake County Water Atlas, 2009a). The Palatlakaha River system extends 44 miles through central Lake County and is a part of the Oklawaha River Watershed and River system (Lake County Water Atlas, 2009b). The Ocklawaha River's headwaters are in Lake Louisa, within the Green Swamp. It travels north through the County through the Clermont Chain of Lakes and empties out in Lake Harris (Florida Department of Environmental Protection, 2009). Development within the watershed has impacted the water quality within the watershed, resulting in nonpoint source pollution that adds nutrients such as nitrogen and phosphorus as stormwater runoff flows over impervious surfaces directly into waterways (Upper Ocklawaha Basin Working Group, 2007).

A portion of the Wekiva-Ocala Greenway is located in northeastern Lake County, connecting the Wekiwa Springs State Park in Orange County to the Ocala National

Forest, and includes both areas. The forest is approximately half a million acres in size and maintains the largest black bear population in the state. The Greenway is home to a number of springs, rare habitats, and has been designated as a federal Wild and Scenic River. Despite protections, the area is at risk as development pressures continue in areas adjacent to and near the waterways. The protection zone established in 1988 has proven to be inadequate; studies show the springshed of the Wekiva system is much larger. Development within the region is threatening habitat, altering the patterns of water flow and aquifer recharge, and polluting the water that enters the Wekiva system (Schue, 2005).

Providing another indicator of development impacts, portions of the Ocklawaha River Watershed are considered "impaired" by the Florida Department of Environmental Protection (FDEP) (Florida Department of Environmental Protection, 2002). This designation is the result of the Federal Clean Water Act (CWA), section 303(d), which states that each state must create a list of waters that are not meeting established water quality standards (Meeter & Niu, 2000). A plan to restore water health in the watershed has been adopted by the FDEP that relies in part on reduction of nonpoint sources of pollution, specifically nitrogen (Upper Ocklawaha Basin Working Group, 2007). Nonpoint source pollution from impervious surface such as asphalt and concrete, and from agricultural lands, is a major source of pollutant loading to waterbodies (National Oceanic and Atmospheric Administration, 2008).

Table 3-1. Existing population by county for year 2005 and projected population totals by year 2035.

| County | Year 2005 | Year 2035 | Change |
|---|---|---|---|
| Brevard County | 533,646 | 762,500 | 228,854 |
| Lake County | 263,642 | 504,500 | 240,858 |
| Orange County | 1,052,479 | 1,887,638 | 835,159 |
| Osceola County | 243,501 | 713,212 | 469,711 |
| Seminole County | 422,630 | 496,458 | 75,200 |
| Volusia County | 494,631 | 691,900 | 197,269 |
| TOTAL | 3,010,529 | 5,056,208 | 2,047,051 |

Note: All county 2015 to 2035 population forecasts are based on BEBR totals recorded in the document - "Florida Population Studies, Volume 41, Bulletin 150, March 2008" except for Orange, Osceola, and Seminole which were provided by the counties through the METROPLAN ORLANDO 2030 SE data forecasting efforts.

Lake County
Ecologically Sensitive Areas

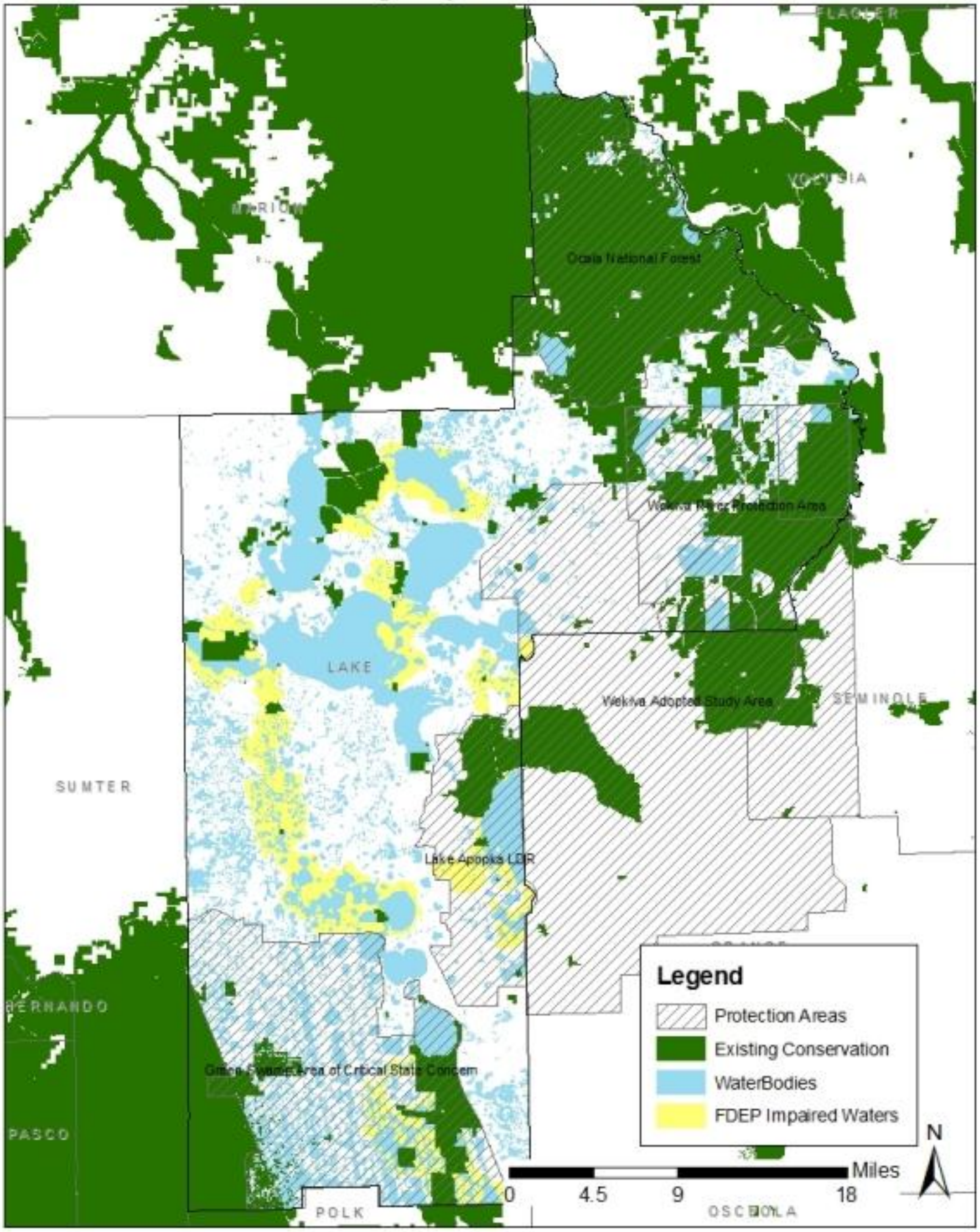


Figure 3-1. Lake County ecologically sensitive areas

# CHAPTER 4
# METHODOLOGY

## Overview

This study uses the land use conflict identification strategy (LUCIS) methodology to quantify land use conflict in the Central Florida Region and demonstrate applications in land use assessment. The first part of the study provides a comparison of assessed conflict to existing Future Land Use Map (FLUM) designations in the 6-county Central Florida region to conceptualize and quantify potential conflict inherent in future regional development as it relates to current legislation. The second part of the study focuses the analysis through utilization of projections of population and employment growth through the year 2035 in a case study of Lake County, Florida to spatially allocate new growth based on land use conflict and preferences identified using the LUCIS methodology. This analysis is completed through creation of two alternative growth scenarios, one based on current growth patterns and the other modeling implementation of a green infrastructure system and prioritization of land conservation.

This chapter describes the methodology employed to research the above topics. It begins by describing the process of study area selection, followed by the source of GIS data used, and then explains the parcel and FLUM analyses used to assess existing conditions and patterns of the region. The LUCIS process is then described, followed by the steps used to compare LUCIS conflict analyses results to parcel and FLUM data. Finally, methodology of creation of the growth scenarios is described, along with the processes used to analyze results of the scenarios.

## Selection of Study Area

The six county Central Florida region of Brevard, Lake, Orange, Osceola, Seminole, and Volusia was chosen for the regional analysis of FLUM and LUCIS results (see Figure 4-1). The Central Florida region has seen extensive urban growth in recent decades, with much of this growth occurring in low density sprawling development patterns with land consumption actually exceeding population growth (PennDesign, 2005). The region was chosen as the site for analysis because of these high rates of population growth, current problems of urban sprawl, and projected future growth patterns. There have been extensive urban growth studies in these counties based on these factors, such as the MyRegion.org “How Shall We Grow” efforts (MyRegion.org, 2009). Studies suggest that without a concerted planning effort to prevent urban sprawl and change existing land use trends in this region, sprawling development will continue and many valuable resources will be lost (PennDesign, 2005). The amount of existing data provided an opportunity to expand upon previous studies and work to provide supplemental research with the intent of quantifying the spatial relationship between regulatory devices and the regional goals identified through the LUCIS conflict analysis.

Lake County (Figure 4-2) was chosen for the growth allocation scenario case study for several reasons. First, it has seen and is projected to experience very high levels of population growth, due in part to its proximity to the growing Orlando metropolitan region (East Central Florida Regional Planning Council, 2001). Secondly, the county has many valuable ecological and rural resources that are currently unprotected (Ryan, 2005; Schue, 2005), demonstrating potential for green infrastructure. A great deal of growth that has occurred in the county has been low density, sprawling development. As with the rest of the region, continuation of current development patterns will result in the continuation of sprawl and the loss of ecological resources. With expanses of undeveloped land and potential for growth, the county could see great changes in land use in the next decades. It therefore provides an excellent location to both apply the LUCIS methodology and demonstrate the impacts of the growth scenarios on land use distribution.

## GIS Data

Information regarding assumptions used and sources of GIS data used in the study analyses is described below.

### General Assumptions

All raster analyses were completed using a cell size of 31. This creates a cell approximately one quarter of an acre in area. To convert to acreage, the cell count was multiplied by 0.237473.

Acres = Cell Count * 0.237473

### Data Sources

**Parcel data:** Department of Revenue standard tax appraisal data, as provided by the GeoPlan Center at the University of Florida. 2007 data.

**Future Land Use Data:** Retrieved from the Central Florida Geographic Information Systems website (www.cfgis.org). Data reflects second quarter 2008 data, updated July 2008.

**Population projections:** Bureau of Economic and Business Development (BEBR) 2005 data.

**Land Use Suitability Rasters:** With the exception of the Conservation suitability model that was modified in this study for use in this analysis, suitability rasters for land use were provided by Paul Zwick at the University of Florida.

**All other datasets:** Unless otherwise indicated, all other datasets were retrieved from the Florida Geographic Data Library (www.fgdl.org).

## Parcel Data and FLUM Analyses

### Future Land Use Analysis

The first part of the study examined future land use map (FLUM) designations in the six county Central Florida region including Brevard, Lake, Orange, Osceola, Seminole, and Volusia counties. The process is described below.

To analyze existing FLUM designations, generalized future land use designations for each county (including all municipalities) were utilized. This data is created by the East Central Florida Regional Planning Council (ECFRPC) and found within the Central Florida GIS library (CFGIS) (http://cfgis.org/). The ECFRPC updates the data based on information received from each jurisdiction. Though each jurisdiction maintains its own set of future land use categories, this generalized map creates a unified FLUM by applying a specified set of defined land use designations such as commercial, mixed use, and high density residential. For this study, data reflecting information through the second quarter of 2008 data was used. This dataset includes both small and large comprehensive plan changes and updates FLUM designations based on information received from jurisdictions between the dates of April 1$^{st}$ through July 1$^{st}$, 2008.

Because each jurisdiction maintains their own methodology and FLUM descriptions, the ECFRPC generalizes the data into a common group of FLUM categories. Residential FLUM categories are especially difficult to generalize because each jurisdiction defines high, medium, or low residential densities in a different way. For this reason, assignment of residential densities is completed relative to the overall density of the county, and they are assigned general future land uses (FLUs) of

Residential-High, Medium, Low, Very Low, and Rural, based on their portion of the overall densities of the county. For example, if one county's highest density were 5 units per acre, and another county's highest density were 20 units per acre, these highest categories would both be considered Residential High Density, because they are a relatively high density for their region.

Generalized FLUM categories as defined by the ECPRPC within the shapefile metadata are as follows:

RH - High Density Residential - Residential development where the maximum allowable density exceeds approximately 12 units per acre *

RM - Medium Density Residential - Residential development up to approximately 12 units per acre, but generally greater than that allowed in the Low Density Residential category *

RL - Low Density Residential - Residential development up to approximately 5 units per acre, but greater than that allowed in the Very Low Density Residential category *

RVL - Very Low Density Residential - Residential development of less than two units per acre, but greater than that allowed in the Rural Residential category *

RR - Rural Residential - Residential development not to exceed one unit for every two acres *

AG - Agricultural - Land specifically designated as Agricultural in the comprehensive plan. May include silvicultural uses in some cases.

REC - Recreation / Open Space

CONS - Conservation - Includes any Wetlands categories.

INST - Institutional

IND - Industrial

OFF - Office

COM - Commercial

LOD - Hotel / Motel / Timeshare - Most Future Land Use Maps do not include these uses. Includes RV parks if in separate category.

PD - Planned Development

FED - Military / Federal - Federal lands in unincorporated Brevard County encompassing Kennedy Space Center, Cape Canaveral Air Force Station, and the Merritt Island National Wildlife Refuge

MU - Mixed Use

WAT - Water Body - Not all Future Land Use Maps include water as a category. In these cases, water bodies include a land use for an adjacent use.

UNK - Unknown - Information not available

* Residential classifications should be determined individually for each local government to ensure the best fit with the generalized categories. For example, if City X has categories for 1 - 3 units per acre, 3+ - 9 units per acre, and 9+ - 15 units per acre, these would be classified as Low Density Residential, Medium Density Residential, and High Density Residential. If City Y has categories for 1 - 2.5 units per acre, 2.5+ - 6 units per acre, and 6+ - 14 units per acre, these would be classified as Low Density Residential, Low Density Residential, and Medium Density Residential - there would be no High Density Residential for this city. (East Central Florida Regional Planning Council, 2008).

Analysis of FLUM categories was completed by first removing conservation lands and waterbodies classified as lakes and ponds. Only waterbodies over five acres were removed for the purpose of this evaluation. Then, the acreage and percentages of each use were calculated regionally and for each county. This demonstrates FLUM patterns on a regional scale and allows county comparison of FLUM distribution.

**Parcel Analysis**

2007 parcel data was utilized for the parcel data analysis. Existing conservation lands and water bodies classified as lakes and ponds were removed from the analysis. Each parcel in the dataset is assigned a land use and associated code, in the field "LUCODE," ranging from '000' to '100' (see Appendix B). Acreages were determined based on the land use code provided within the "LUCODE" field of the parcel data attribute table. Lakes and ponds were removed from the dataset, followed by removal of conservation lands. The output shapefile was then dissolved based on land use code, and acreage calculated for each land use. Percentages of each use to the overall total of vacant and greenfield lands available for development were then calculated by dividing the acreage of each use by the total acreage. The output shapefile displays the dissolved parcel land uses.

A second spatial analysis of parcel data was completed to evaluate the acreage of vacant and greenfield lands: undeveloped lands not under conservation protection with potential for development. The process to determine vacant and greenfield lands is described below:

Vacant land uses are legally platted but not yet built and therefore represent opportunity for new development. Vacant platted lands were considered to be vacant platted residential, vacant platted commercial, and vacant platted industrial uses. Vacant land use codes were ‘000,’ ‘010,’ and ‘040’ (see Table 4-1). The following statement was utilized to select vacant platted lands:

"LUCODE" = '000' OR "LUCODE" = '010' OR "LUCODE" = '040'

Greenfield uses were considered to be all agricultural land, with the exception of agricultural land considered as industrial use such as greenhouses, nurseries and beekeeping facilities, and also included land in the category of “acreage not zoned for agricultural.” Agricultural land is considered available for future development, and “acreage not zoned for agricultural” refers to land not under agricultural zoning, but currently utilized for agricultural purposes. Greenfield land use codes included codes ‘050’ through ‘066,’ ‘070,’ and ‘099’ (see Table 4-1).

The following statement was used to select Greenfield land:

("LUCODE" >= '050' AND "LUCODE" <= '066') OR “LUCODE” = ‘070’ OR "LUCODE" = '099'

Analysis was completed for each county in GIS by first selecting the appropriate land uses based on land use code. Lakes and ponds were then removed from the dataset, followed by removal of conservation lands. The output shapefile was then dissolved based on land use code, and acreage calculated for each land use. Percentages of each use of the overall total of vacant and greenfield lands available for development were then calculated by dividing the acreage of each use by the total acreage. The output was a shapefile of the dissolved parcel land uses available for development.

**FLUM Vacant/Greenfield Analysis**

Because this study is based on future land development, comparison of parcel and FLUM data for each county was conducted by utilizing parcel data to select vacant and greenfield land using the methodology described above, then analyzing the area of each FLUM category within this spatial boundary.

The shapefile created of vacant platted and greenfield land extracted from parcel data, with surface water and conservation lands removed was used as a mask on the FLUM data. This identifies undeveloped land and excludes land that will not change. The mask was used both on the regional FLUM and on each individual county for separate analyses. The resulting shapefile was then simplified by using the Dissolve tool based on the generalized FLU field. Acreages for each FLU category were calculated using the Calculate Geometry tool.

Percentages of each FLU category of all of the vacant and greenfield land were calculated by dividing the FLU acreage by the total vacant and greenfield acreage within the county or region. The percentage of vacant and greenfield land within each county was calculated by dividing the total acreage of vacant and greenfield land by the total acreages of all land uses within both the county and region. To further evaluate the percentage of land in vacant and greenfield use, the amounts of vacant and greenfield were also compared to total county acreages with conservation lands and water bodies classified as lakes and ponds  removed.

## LUCIS Methodology

The Land Use Conflict Identification Strategy (LUCIS) involves the following steps:

1. Creation of goals and objectives.
2. Data inventory.
3. Suitability analyses.
4. Preference creation.
5. Determine conflict (Carr & Zwick, 2007, p. 12).

The processes for each step are described below. For more information on the LUCIS methodology, please see the book, *Smart Land Use Analysis: The LUCIS Model* by Margaret H. Carr and Paul D. Zwick (2007).

### Goals and Objectives

This study utilized the goals and objectives identified by Margaret Carr and Paul Zwick as part of the LUCIS methodology. No goals or objectives were modified for this study (see Appendix A for Conservation goals and objectives).

### Data Inventory

Data to support the goals and objectives were primarily retrieved from the Florida Geographic Data Library (FGDL) and the Critical Lands and Waters Identification Project (CLIP). The most recent and best available data at the time of the study was utilized.

### Suitability

The land use suitability rasters used assign each cell in the study area a land use suitability value ranging from one to nine, one being the lowest suitability and nine the highest, representing the relative suitability of the cell. Suitability is determined based on the goals and objectives of the first step. Suitability of each land use for the region had been previously determined by Margaret Carr, Paul Zwick and their research team using the LUCIS methodology. This study chose to utilize the existing suitability maps for the Agriculture and Urban land uses. For the Conservation suitability study, this study re-created the suitability process with several alterations.

Conservation suitability was created using the goals, objectives, subobjectives, and associated datasets outlined in the LUCIS process (see Appendix A for the outline), with various changes to the datasets utilized. Research was conducted to find the most recent versions of the datasets. In some cases, the data was not found or available; in these cases the most relevant information available was utilized. Additional data was included if it was determined that it further clarified the goal or objective.

Changes were made to the original goals, objectives, and subobjectives of the conservation suitability model as follows:

Goal 1 Objective 1.3:

- Objective: “Identify areas important for protecting or restoring intact landscapes.”
- Added the Critical Lands Inventory Project (CLIP) landscape integrity file. This file was included to supplement conservation information provided by the FLMA file and further support the objective. The dataset considers information such as patch size, intensity of land use, and presence of roadways to determine and rank the ecological integrity of habitat.

Goal 2, Objective 2.2, Subobjective 2.2.1

- Subobjective: “Identify recharge zones for groundwater.”
- Rather than select swamps and wetlands from the aquifer datasets, this study utilized the index scale provided in the attribute table. Higher index numbers reflect higher recharge potential and increased vulnerability of impacts to water

quality. The file was converted to raster data based on the Index field, and reclassified into nine classes, with increasing suitability corresponding to increased index value.

Goal 2, Objective 2.2, Subobjective 2.2.2

- Subobjective: “Identify unconfined aquifers (springs) and sinkholes.”

- An additional springs database, the FDEP springs database, was included in this model because the original datasets failed to include all springs in the region, such as Wekiva Springs. This data was merged with the other data using the Merge tool.

Goal 3, Objective 3.1, Subobjective 3.1.3Cg3o31so313

- Subobjective: “Identify surface waters and associated buffers of a size sufficient to protect their flood storage function.”

- This model as provided contained no information. This study incorporated the nhd waterbody dataset. Euclidean distance was used on the dataset, with decreasing suitability as distance increased. Values were reclassified as follows (distance in meters):

Distance 0-100: Suitability 9
Distance 100-200: Suitability 7
Distance 200-300: Suitability 5
Distance 300-400: Suitability 3
Distance 400-1,000,000: Suitability 1
NoData: Suitability 1

Goal 4, Objective 4.2

- Objective: “Identify areas of continuous native vegetation most likely to facilitate functional connections between existing conservation lands”

- This study omitted the "landuse" dataset included in the original model, which was included to identify land types suitable for connecting existing habitats. The objective already contained the CLIP greenway dataset. The purpose of the CLIP greenway dataset is to identify areas necessary to connect existing natural habitats and maintain ecological functions (Hoctor, Oettig, & Beyeler, 2008), and so the landuse model was assumed not necessary.

Goal 5, Objective 5.1, Subobjective 5.1.1

- Subobjective: “Identify existing and potential trail systems.”

- This study utilized Cell Statistics rather than Weighted Sum to combine the data into the final outcome.

Goal 5, Objective 5.1, Objective 5.1.3

- Objective: “Identify areas that provide access to resource based recreation.”

- This subobjective was removed completely from this study.

Goal 5, Objective 5.2

- Objective: “Identify surface water features with the potential use for outdoor recreation.”

- As with subobjective 2.2.2, the FDEP Springs dataset was included here to provide additional springs data.

- Included the St. Johns River Water Management District Springs dataset (springs_sjrwmd_2007)

Goal 5, Objective 5.3

- Objective: “Identify areas more suitable for wilderness based and hunting opportunities.”

- In this objective’s original form, high suitability was based on proximity to roads, with decreasing suitability as distance from roads increased. This lowered overall conservation suitability/preference and effectively counteracted other Goals, which generally increase conservation suitability the further from urban development a cell is. The objective was adjusted to counteract this impact, as follows:

    - Removal of roads (“tggrds”) variable

    - Final objective 5.3 was then found by reclassifying FWC managed areas dataset (“fwcmas_aug07”) so that:

        - management areas (values ) = "9"
        - NoData = 1
    - Revised Goal 5 was included in Final Conservation Goal in the same manner as in original model.

Subobjectives were combined to create objectives using Cell Statistics (maximum) or Weighted Sum as appropriate. Objectives were similarly combined using the Weighted Sum to create the final suitability raster.

**Preference**

Preference rasters were created from the final suitability rasters for each land use. The preference raster contains preference values of low, medium, and high and allows for easier comparison of spatial relationships of the preference raster of each land use. The suitability values (ranging from one to nine) were collapsed into three values where:

1 = low preference
2 = medium preference
3 = high preference

This was completed by reclassifying the nine values into three values based on geometric interval. The result is a preference raster in which each cell is assigned high, medium, or low preference values.

**Conflict**

Once preference rasters are created for each category of agriculture, conservation, and urban land uses, the LUCIS process involves a comparison of the preference rasters to analyze the level of conflict between preferences. Preference rasters of each are combined using the Single Output Map Algebra tool, using the expression:

AgriculturePreference * 100 + ConservationPreference * 10 + UrbanPreference

The result is a conflict raster where each cell is assigned a three-digit number representing the preference and conflict between land uses. The first number represents agriculture preference, the second conservation preference, and the third urban preference. Where one number is higher than the others, it represents higher preference for that land use than the others. For example, “311” represents high agricultural land use preference, but low conservation and urban land use preferences. Agricultural use is preferred over the other uses. Where two or all three numbers are equal, land use conflict is demonstrated. For example, “233” represents high conflict between conservation land use preference and urban land use preference (see Table 4-2).

## Comparing LUCIS to Existing Land Use Designations

### Conflict in Vacant and Greenfield Lands

To determine the conflict present in lands with potential for development, the conflict raster was analyzed within the limits of the vacant and greenfield lands identified with county parcel data by using the vacant and greenfield land shapefile as a mask on the conflict raster. Acreage of each conflict category present in vacant and greenfield land was calculated.

### FLUM/LUCIS Conflict Analysis

FLUM designations were compared to LUCIS conflict to demonstrate how local policy may be evaluated in relation to LUCIS-identified preference and conflict. FLUM designations and LUCIS conflict were spatially compared to one another by first using the Tabulate Area tool was used to cross-compare both datasets based on zones of FLUM and conflict categories. A raster created from the vacant and greenfield shapefile (created from the parcel data analysis described earlier) was used as the mask within the Tabulate Area operation to restrict the study to areas of potential future development.

Analysis was completed to quantify the area of each FLU within each conflict category and vice versa by converting the area calculated within the table from square meters to acres. Further analysis was completed to determine the area of generalized conflict within generalized FLU categories, assigning FLUs as either urban, non-urban, or agricultural. Areas designated as urban FLU uses were evaluated for their conflict. FLU urban uses were considered uses of commercial, industrial, institutional, mixed use, office, planned development, and residential uses. Similarly, agricultural uses were evaluated for their conflict.

## Creating Alternative Scenarios of Future Development in Lake County

Future growth projections estimate the amount of population growth and employment growth that a specified area may expect to see within a set amount of years. To analyze how this growth might take form spatially, this study created development scenarios to demonstrate potential growth patterns based on inputs of such as density, land use conflict and suitability determined through LUCIS, and preservation of certain ecological features.

This study created two scenarios: a trend scenario and an alternative development scenario based on conservation of ecologically sensitive lands. The trend scenario models growth based on the continuation of current growth patterns, while the conservation scenario models growth based on concepts to promote ecosystem management and green infrastructure. Creation of two scenarios allows for comparison of the conservation scenario to the growth scenario, demonstrating differences in land area usage as well as type of land affected by urbanization patterns.

### Identifying Lands Available for Development

Lands available for development were identified as vacant and greenfield lands within the parcel analysis described earlier.

### Reclassifying Suitability

Suitability rasters are used for more than creation of preference rasters. The suitability rasters are used in the population allocation process when spatially allocating land use using suitability as a criteria. Having only nine classes of suitability limits subtlety in the analysis when used as selection criteria because of the large number of records being analyzed. Therefore, the Slice tool was utilized to slice each of the suitability rasters into 1000 equal area classes for use in the population allocation process.

### Determining Population and Employment Needs

Total population and employment growth through the year 2035 for Lake County was determined from information provided by the Bureau of Economic and Business Research (BEBR) at the University of Florida. For both scenarios, it was assumed that 10% of the residential population growth would be allocated to redevelopment areas.

### Assigning Land Use Categories

Because employee type is categorized differently for each dataset, employee types as defined by parcel data were reclassified as necessary to correspond to the TAZ data, which groups all employment types into Commercial, Service, or Industrial uses. Information provided within the Florida Department of Transportation (FDOT) Long Range Transportation Plan (Data Transfer Solutions, 2008) was used to classify and collapse parcel land use employment codes into these three categories. Discrepancies between the TAZ data and parcel data definitions of “commercial” and “service” lands were discovered in the analysis. In respect to the commercial and service land use classifications, TAZ and parcel data definitions are almost opposite of one another. TAZ considers service uses to include office, while parcel data considers office as “commercial/office.” For example, vacant commercial land use as identified in parcel data would be considered service land use by TAZ standards. To resolve, parcel data classifications were amended to reflect TAZ definitions. Vacant commercial, identified as land use code “010” in parcel data, was used to accommodate needs for service employment. For the purposes of this study, this land will heretofore be described as “service” (see Appendix B).

### Calculating Existing Gross Densities in the Study Area

To gain an understanding of existing conditions within the study area, existing gross densities for residential, commercial, service, and industrial uses were calculated. Traffic Analysis Zone (TAZ) and 2007 parcel data were utilized to calculate the existing densities of each land use based on TAZ zone.

Gross densities represent the density of the population respective to the area of land in that particular land use category. Gross densities were utilized to provide a more accurate depiction of density, as opposed to finding the densities respective to all land in the study area, which does not account for the ratio of land uses or undevelopable land area. To further focus on land actually utilized for each land use, open water bodies and conservation lands were removed from the parcel data before analysis. Gross densities for residential population were calculated by dividing the population within the TAZ by the calculated area of the corresponding land use within the same TAZ. Gross employment density was found by dividing the number of employees within each TAZ by the area of the corresponding land use within the same TAZ. To perform the calculations, the table created with the Tabulate Area tool was joined with the TAZ data based on the TAZ code. A new field was created to hold gross density calculations for each category. Field calculator was used to divide employment or population by the calculated acreage for each of the categories. Data was manually checked to identify incorrect outliers; these were replaced by the mean gross density value.

### Allocation Methodology

Allocation of projected population and employment through 2035 was completed for each alternative development scenario using the following basic steps within GIS:

1. Creation of a Combine raster with all variables used to select land for allocation such as sliced suitability rasters, conflict rasters, and TAZ raster. This creates a separate record, with spatial reference, for every possible combination of data included in the Combine.

2. Calculate gross density using methodology described earlier in “Calculating Existing Gross Densities”

3. Join the Combine grid to the created table based on TAZ zone. This assigns variable gross densities based on TAZ to each record created in the Combine raster.

4. Use a selection query to select records in the Combine attribute table as desired (i.e. placing commercial uses into urban preferred areas with high commercial suitability).

5. Multiply the acreage of the selected records by the gross density for the land use associated with each record to determine total population able to be allocated by the current selection.

6. Continue making selections until desired population allocation (or acreage) is reached.

7. Assign the land use to a new field within the Combine.

Details of each allocation scenario are described below.

**Trend Scenario Analysis – Lake County 2035**

The purpose of creating a trend scenario was to provide a vision what growth patterns will look like through 2035 if current conditions and trends continue to guide new development. The trend analysis utilizes current population and employment densities and land use ratios within Lake County and uses conflict analyses created with LUCIS as a tool to create a model of future growth.

This section describes the methodology utilized to create a trend scenario for Lake County.

**Allocating to Vacant Platted Land**

Allocation was distributed first to vacant platted land (as identified in the parcel analysis described earlier) based on the assumption that these lands would be the first to be developed because they have already gone through the processes of zoning and platting. Allocation was completed using the general allocation methodology steps, described earlier, with additional details described below.

One Combine raster was created for all allocation into vacant platted land. Rasters were created for inclusion in the Combine as needed from vector data. The Combine was created using input rasters of:

- Vacant platted land
- TAZ data
- Single family sliced suitability
- Multi-family sliced suitability
- Service sliced suitability
- Commercial sliced suitability
- Agriculture/Conservation/Urban Conflict

New fields were created to calculate Acreage, Population, and Allocated Land Use.

The Combine was joined to the TAZ table containing the gross density data, based on TAZ zone. The result shows the gross densities for each record in the Combine based on which TAZ they are located in.

Population and employees were allocated based on the growth projections created by BEBR. Because these calculations did not distinguish between multi-family and single family population growth, existing percentages of each were utilized to determine projected residents for each category.

Additional details for allocation into each of vacant platted residential, commercial, and industrial uses are described below.

**Vacant platted residential.** To gain an idea of existing trends of residential development, the acreage ratios of existing single family and multi-family residential land uses were calculated for each TAZ, using parcel data from the table created using the Tabulate Area tool. Multi-family acreages were divided by single family acreages to determine the amount of multi-family land use per acre of single family land use. This acreage was calculated in order to provide assumed acreages of trend development based on variable single family to multi-family ratios across the county. The amount of vacant platted residential land per TAZ was then calculated by selecting LUCODE ‘000’ from the table and calculating its acreage. Existing acreage ratios were applied to the vacant platted residential acreage to determine potential acreage of each single family and multi-family uses.

Multi-family land use was allocated first. A selection query was created for the combine raster using the Select by Attributes tool. The query selected lands within the Vacant Platted Residential land use, and then chose records based on multi-family suitability. Suitability was altered manually until the desired acreage was selected. These records were assigned to multi-family land use. To determine how many residents were placed in these areas, the created Population field was used to multiply the Acreage field by the multi-family GRD field. Results were recorded.

Single family land use was allocated into the remaining records. A selection query was created to select vacant platted residential lands that were not yet assigned a land use. These records were assigned to single family land use. Allocated population was determined within the Population field by using Field Calculator to multiply the Acreage field by the single family GRD field. Results were recorded.

**Vacant platted service.** Service uses were the first land use allocated into the vacant platted service lands. A selection query was created using the Select by

Attributes tool. The query selected lands within the vacant platted service land use, and then chose records based on service suitability. Suitability was altered manually until the projected employment needs were met. These records were assigned to service land use. To determine how many employees were placed in these areas, the created Population field was used to multiply the Acreage field by the gross service density (GSD) field. Results were recorded.

The amount of land available within the vacant platted service category for service employment was in excess of that required. Remaining land was assumed suitable for commercial employment. The land not appropriated to service employment was selected using the Select By Attribute tool with a query selecting vacant platted service land not assigned a land use. The employment population was calculated by multiplying acreage by the gross commercial density (GCD). Because the number of employees allocated did not exceed the total projected need for employment, all selected records were assigned to commercial land use.

**Vacant platted industrial.** To allocate to vacant platted industrial land use, the Select by Attributes tool was used to select records within the vacant platted industrial land use category. The amount of acreage within the land use was multiplied by the gross industrial density (GID) for each TAZ to determine the number of industrial employees able to be placed in vacant industrial lands. Because the number of employees did not exceed the total projected employment needs, all selected records were assigned to industrial land use.

## Allocating to Greenfield

To accommodate population and employment needs remaining after allocation into vacant platted lands, greenfield lands were utilized. Allocation was completed using the general allocation methodology steps, described earlier. Additional details are described below.

One Combine raster was created for the allocation procedure. The Combine was created using input rasters of:

- TAZ data
- Single family sliced suitability
- Multi-family sliced suitability
- Service sliced suitability
- Commercial sliced suitability
- Agriculture/Conservation/Urban Conflict

A mask of greenfield lands was used on the Combine to limit the area of analysis.

New fields were created to calculate Acreage, Population, and Allocated Land Use.

The Combine was joined to the TAZ table containing the gross density data, based on TAZ zone. The result shows the gross densities for each record in the Combine based on which TAZ they are located in.

To determine the employment and population needs remaining after allocation into vacant platted lands, the amount previously allocated was subtracted from the total projection numbers. The result represented the amount to be allocated into greenfield land.

Land use allocation was completed in this order: commercial, service, industrial, multi-family, single family.

Urban land use allocation was based on conflict in this order: urban preferred, agriculture-urban medium conflict, medium conflict, low conflict, agriculture-urban high conflict, conservation-urban medium conflict, conservation-urban high conflict, and high conflict.

Descriptions of allocation methodology for each land use are described below.

**Allocating commercial, service, and industrial land uses into greenfield.** Allocation was completed using the greenfield Combine raster. Commercial employment land uses were the first allocated. Allocation was completed by using the Select by Attributes tool to create a query based on commercial suitability. Total number of employees able to be allocated based on the query was determined within the Population field by using Field Calculator to multiply the acreage by the GCD. The query was manually altered until the total remaining need for commercial employees was met. The selected records were assigned “commercial” land use.

All service employment needs were already allocated into vacant platted lands, so industrial employment was allocated next. The Select By Attributes tool was used to create a query selecting records not yet assigned a land use and based on industrial suitability. Total number of employees able to be allocated based on the query was determined within the Population field by using Field Calculator to multiply the acreage by the GID. The query was manually altered until the total remaining need for industrial employees was met. The selected records were assigned “industrial” land use.

**Allocating residential land uses into greenfield.** Allocation was completed using the greenfield Combine raster. Multi-family employment land uses were the first allocated. Allocation was completed by using the Select by Attributes tool to create a query based on multi-family suitability. Total number of residents able to be allocated based on the query was determined within the Population field by using Field Calculator to multiply the acreage by the multi-family GRD of the TAZ. The query was manually altered until the total remaining need for multi-family population was met. The selected records were assigned “multi-family” land use.

Allocation of single family population was completed by using the Select by Attributes tool to create a query based on single family suitability. Total number of residents able to be allocated based on the query was determined within the Population field by using Field Calculator to multiply the acreage by the single family GRD of the TAZ. The query was manually altered until the total remaining need for single family population was met. The selected records were assigned “single family” land use.

**Allocating vacant land uses into greenfield.** For each category of existing land use, there is a certain percentage of land that is vacant platted to accommodate future land development. To account for these needs, existing ratios of occupied to vacant acreages were calculated for each land use by dividing the amount of existing occupied land by the amount of existing vacant platted land. These same ratios were applied to the sum of existing and allocated land uses to determine the total amount of vacant platted land needed per land use based on existing trends. These land uses were allocated in the same order and methodology as the occupied land uses, based on conflict and suitability. Land uses were assigned as “vacant residential,” “vacant commercial,” “vacant service,” and “vacant industrial.” No vacant commercial lands currently exist. To determine what percentage of occupied commercial lands to use to create new vacant commercial land, the approximate percentages of the vacant platted service land that was allocated to each of commercial and service uses was applied.

**Remaining greenfield.** The remaining greenfield that was not allocated into was determined to be appropriate for either agriculture, conservation, or agricultural preservation based on conflict. Areas of agricultural preference or agricultural-urban conflict were assigned as “agriculture.” Areas of conservation preference or conservation-urban conflict were assigned as “conservation.” Areas in medium or high conflict, or in agriculture-conservation conflict, were assigned to “agricultural preservation.”

## Alternative Scenario Land Use Analysis - Lake County 2035

The objective of the alternative scenario aims to protect ecological resources through creation of a green infrastructure strategy that identifies land with high environmental value. This scenario has the purpose of using greenspace as a framework for urban growth and development, and of preventing some of the impacts of trend development in the state. New development will be allocated after selection and designation of land as green infrastructure, at densities higher than existing, with the purpose of preventing sprawl and preserving identified green infrastructure. Specifically, the process utilizes the LUCIS process and other strategies to identify lands appropriate for green infrastructure land uses and assigns land uses and densities for new growth based on evaluation of preference and conflict.

The methodology used to achieve these objectives included following steps:

### Determining Vacant and Greenfield Land

Vacant and greenfield land was determined as described earlier, with the exception that lands identified as brownfields were included with the greenfield area. Brownfields are lands previously developed in some way, but currently unused and requiring special consideration due to hazardous contamination of the site. Brownfields were identified through use of a shapefile entitled “brownfields” retrieved from the Lake County GIS website (ftp://ftp.co.lake.fl.us/GIS/GisDownloads/).

### Modeling Policy: Green Infrastructure

To model a policy supporting creation of a green infrastructure network, ecologically sensitive lands were chosen for preservation and additional protection requirements. The following variables were identified for inclusion within the green infrastructure network and to protect existing natural resources. These protections were established before development was allocated.

- Waterbodies, including wetlands (Development prohibited.)
- Areas identified as impaired waters by the Florida Department of Environmental Protection (FDEP) outside city limits (Development prohibited. Assigned as “Conservation.”)
- Areas identified by the Conflict analysis as Conservation Preferred (development prohibited, assigned to “Conservation”)
- Areas identified by the Conflict analysis as Conservation-Urban High Conflict (development prohibited, assigned to “Conservation.”)
- Areas of Agriculture-Conservation Conflict (assigned as “Agricultural Preservation.” Agricultural uses allowed with specific regulations to protect natural habitat and prevent adverse environmental impacts of agricultural activities)
- Areas of High Conflict (Assigned as “Agricultural Preservation.” Agricultural uses allowed with specific regulations to protect natural habitat and prevent adverse environmental impacts of agricultural activities)
- Areas currently identified as protection zones (Development allowed at lower densities than non-protected zones, assumptions of specific development requirements to protect ecological value.)
- Existing conservation areas. These areas were not considered at risk of development, but were identified as part of the existing green infrastructure network.
- Areas identified by the FLUM as Recreation areas.

First, all waterbodies, including wetlands, were removed from the vacant and greenfield lands. The waterbodies dataset was retrieved from the Lake County GIS website (ftp://ftp.co.lake.fl.us/GIS/GisDownloads). This dataset was utilized as analysis showed it to be a more comprehensive dataset for the purposes of this analysis, including more waterbody types than other available datasets.

To further identify vulnerable hydrologic areas, areas identified as "impaired waters" by the FDEP, located outside of city limits, were assigned as "conservation" because these areas do not meet water quality standards, and the quality is further threatened by development. Impaired waters were identified by using two datasets for Group 1 verified impaired waters, the first from the initial study in 2002 and the second from the second cycle of analyses in 2008-09, retrieved from the FDEP website (http://www.dep.state.fl.us/water/basin411/download.htm). This combination of data was confirmed with the FDEP as best representing impaired waters (J. Espy, personal communication, November 05, 2009).

Conflict analysis was utilized to identify areas of high conservation value. Areas within vacant and greenfield lands identified as conservation preference by the conflict analysis were allocated as "conservation" to become part of green infrastructure. Similarly, areas identified as having high conflict between conservation and urban preferences were allocated to "conservation" to eliminate high development threats.

Conflict was also used to identify areas demonstrating conflict between preference for both agriculture and conservation. These areas were assumed appropriate for agricultural preservation, meaning areas where agricultural activities are allowed but with special protections to protect ecological resources on the land. Areas of medium agriculture-conservation conflict, high agriculture-conservation conflict, or high conflict were assigned to “agricultural preservation.” High conflict was included to eliminate threat of development on highly suitable agriculture and conservation land.

Lands in protection zones were identified using data provided by the Lake County GIS website, entitled “protection areas” (ftp://ftp.co.lake.fl.us/GIS/GisDownloads/). These areas include: the Green Swamp Area of Critical Concern, the Wekiva Study Area, the Wekiva Protection Area, the Ocala National Forest, and the Lake Apopka protection area. These areas have been identified as holding ecological value and as requiring additional protections to protect natural resources (Lake County, 2009). Development was permitted in these areas but at lower densities than other allocations not located in protection zones, under and assumption of policy requiring additional protections.

As with the trend alternative analysis, lands in conservation were identified using the Florida Managed Areas dataset created by the Florida Natural Areas Inventory. These lands were not used for allocation and were considered part of the green infrastructure of the county. FLU designations of Recreation were also considered part of the existing green infrastructure.

**Modeling Policy: Promoting Compact Development**

One objective of the alternative scenario was to preserve natural lands by reducing the amount of vacant and greenfield land used for new development. To reduce sprawl and promote compact development, the following guidelines were utilized:

- Create areas of mixed use with 30% to 50% higher gross density than existing densities.
- Create minimum densities based on average county gross density. Use this density as a minimum in environmental protection zones. In areas outside

protection zones (other than mixed use) set minimum density to 20% higher than the density inside protection zones.

- Increase the proportion of multi-family land use to 25% of all new residential development.
- Change the proportion of vacant platted land so that total vacant land uses equal an amount equal to 20% of occupied development.
- Vacant land uses allocation methodology altered to give preference to location within city limits to promote urban infill.

Environmental protection zones were used to identify areas of increased environmental sensitivity and as less suitable for high density development. Areas included the Green Swamp Area of Critical Concern, the Wekiva Study Area, the Wekiva Protection Area, the Ocala National Forest, and the Lake Apopka protection area. Development placed within these areas was done so at the existing gross variable densities. Densities were left at existing numbers in protection zones under the assumption that the policy would require development practices such as low impact development and conservation development to mitigate impacts, or would institute a program such as transfer of development rights to reduce densities in protected areas, allowing higher densities in non-protected areas suitable for urban development (see Table 4-3).

Variable densities outside of protection zones were calculated by increasing the existing gross density by 20% (except in the case of mixed use). Minimum densities were thus set at a number 20% larger than the minimum of areas inside protection zones.

Within mixed use, densities were uniformly applied. Mixed use densities were calculated by increasing the average gross densities of commercial and service by 30% and the average gross density of multi-family by 50% (see Table 4-3).

Currently, multi-family population accounts for less than 10% of the population. The proportion of multi-family population was increased so 25% of all new residential population would be multi-family (see Table 4-4).

The ratio of occupied land uses acreages to vacant platted land uses was reduced so that vacant platted land use acreage accounted for 20% of the corresponding land use's occupied acreage (see Table 4-5).

**Allocating into Vacant Platted Land**

Allocation was distributed first to vacant platted land (as identified in the parcel analysis described earlier) based on the assumption that these lands would be the first to be developed because they have already gone through the processes of zoning and platting. Details of allocation into vacant platted lands are described below.

**Mixed use development**: The allocation of mixed use development was assigned within vacant platted residential and vacant platted service land. Mixed use was comprised of the land uses of commercial, multi-family, and service uses.

To determine appropriate mixes, a conflict raster was created using the preference rasters for all three uses. The conflict raster was created by using the Single Unit Output Map Algebra tool with the expression:

CommercialPreference * 100 + MultiFamilyPreference * 10 + ServicePreference

The result is a raster where each cell is assigned a three-digit number representing the preference and conflict between land uses. The first number represents commercial, the second multi-family, and the third service. Where two numbers are equal and of higher suitability than the third number, or all three numbers are equal, conflict is demonstrated and the cell was considered appropriate for mixed use.

To limit analysis to potential areas of mixed use, areas of conflict were selected and used to create a new raster file. Then, for each vacant platted service and vacant platted residential the Clip tool was used with inputs of vacant platted land and the created mixed use conflict areas as the clip feature. It was assumed that only areas of one acre or larger were large enough to support multiple uses. The Region Group tool was utilized to group cells from a raster created from each of the vacant platted residential and vacant platted service land. From the resulting rasters, Select By Attributes with an expression query of “count >= 4” was used to extract areas of appropriate size, as each cell is equal to approximately one quarter acre. This was completed for vacant platted service land and vacant platted residential lands.

Combine grids were created for both vacant platted service and vacant platted residential using the Combine tool, with the following input rasters and a mask of vacant lands over one acre:

- Mixed use conflict
- Protection zones
- Final agriculture-conservation-urban conflict
- TAZ zones
- Sliced suitability for commercial, service, and multi-family

Suitable areas for mixed use were further identified by creating a query selecting the following combination: areas not allocated to other land uses, areas not in a protected zone, and areas of urban high preference. Suitability of each land use was utilized only if the query resulted in potential employment exceeding projected needs.

Depending on mixed use conflict, mixed use categories created included commercial/multi-family, commercial/service, multi-family/service, and commercial/multi-family/service. Depending on whether the land was within vacant platted service or vacant platted residential, the land was proportioned to allow a certain percentage to each land use based on conflict category (see Table 4-6).

Vacant industrial was not allocated Mixed Use under the assumption that industrial uses are not appropriate for mixed use.

Densities for mixed use were assigned by increasing the average county-wide gross density for multi-family by 50% and the average county-wide gross density by 30%. Based on the type of mixed use assigned, the density was multiplied by the appropriate acreage proportion of each mixed use category to determine the number of employees or residents allocated. The following calculations were utilized to determine density:

Multi-Family Mixed Use Gross Density = County Average * 1.5
Service Mixed Use Gross Density = County Average * 1.3
Commercial Mixed Use Gross Density = County Average * 1.3

The amount of land allocated to each use was determined by the proportion described in Table 4-6. To determine population allocated, the calculated acreage per land use was multiplied by the corresponding mixed use density.

**Remaining vacant platted service and residential:** To allocate to the remaining portion of vacant platted service and residential lands, the mixed use areas were used to create masks of vacant platted service land and vacant residential land that had not yet been allocated. These masks were used on the vacant service parcel dataset and the vacant residential parcel dataset to create two new rasters of each remaining vacant service and vacant residential lands.

Combine rasters were created for each using the following raster datasets with a mask of remaining vacant platted land uses:

- Sliced suitability rasters for single family, multi-family, service, commercial, and industrial land uses
- TAZ zones
- Protected zones
- Final conflict of agriculture-conservation-urban uses

The combine grid was joined to the TAZ tabulate area table containing existing gross density data to display variable existing densities based on TAZ. New fields were added to calculate acreage, employees/population allocated, and land use was assigned as appropriate.

Density within the combine raster was adjusted to create a minimum density and remove areas of very low gross densities. This was done by finding the average existing gross density for each land use. Densities below the average were assigned the average density. Within protection zones, existing densities were left the same. Densities for areas outside of protection zones were calculated by increasing the variable existing densities by 20%.

To begin allocation, green infrastructure lands were selected by selecting lands in conservation preference and in high conservation-urban conflict and assigning them as "conservation," and selecting lands in agriculture-conservation conflict or high conflict and assigning them as "agricultural preservation."

Allocation was completed in remaining areas in this order: service, commercial, industrial, multi-family, single family. Areas within protected zones were allocated at the existing density within the TAZ. Areas outside protected zones were allocated at a 20% higher density than the existing density. Allocation was completed based on suitability of the land use.

**Vacant platted industrial:** To allocate within the vacant platted industrial area, a combine raster was created. The combine raster included the following rasters with a mask of vacant platted industrial parcels:

- TAZ zones
- Protected zones

The resulting combine raster was joined to the TAZ tabulate area table to display variable existing densities based on TAZ. New fields were created to hold values of acreage, employees, and allocated land use.

To begin, as with the other combine rasters, green infrastructure lands were selected by selecting lands in conservation preference and high conservation-urban conflict and assigning them as “conservation,” and lands in agriculture-conservation conflict or high conflict and assigning them as “agricultural preservation.”

Density within the combine raster was adjusted to create a minimum density and remove areas of very low gross densities. This was done by calculating the average existing gross density for each land use. Densities below the average were assigned the average density. Within protection zones, existing densities were left. Densities for areas outside of protection zones were calculated by increasing the existing variable densities by 20%. Land uses were assigned at these densities.

**Allocating into Greenfield**

Greenfield lands in the alternative scenario were the same as those considered greenfield within the trend allocation analysis, but with the addition of brownfields areas, as identified by FDEP.

A combine raster was created for the greenfield allocations, with the following raster inputs and a mask of greenfield land:

- Sliced suitability of commercial, service, industrial, residential, multi-family, and single family uses
- TAZ zones
- Protection zones
- City limits
- Final agriculture-conservation-urban conflict

New fields were created to hold values of acreage, population/employees allocated, and allocated land use.

To begin, as with the other combine rasters, green infrastructure lands were selected by using Select By Attribute to create a query expression to select lands in conservation preference and assigning them as “conservation,” and lands in agriculture-conservation conflict or high conflict and assigning them as “agricultural preservation.”

Density within the combine raster was adjusted to remove areas of very low gross densities. First, the average gross density for each land use was calculated and increased by 20%. Within areas outside designated as environmental protection zones, densities below this number were assigned the calculated increased average density. Areas inside environmental protection zones with densities below the average county density (not increased) were assigned the average county density.

Only industrial and employment and single family population projection allocation needs remained to be allocated into greenfield after allocation into vacant platted lands. Allocations were completed based on suitability and conflict. Conflict was allocated in this order: urban preferred, medium conflict, agriculture-urban medium conflict, agriculture-urban high conflict. Details of industrial and single family allocation are described below, followed by descriptions of vacant platted land allocation and classifications of remaining greenfield land.

**Allocating industrial land uses into greenfield.** Industrial land was allocated by using Select By Attributes to create an expression query selecting lands that have not yet been allocated, areas of urban preference, areas outside of protection zones, and higher industrial suitability. To determine industrial employment available within the selected records, the acreage was multiplied by the Gross Industrial Density (GID), increased by 20%.

Possible Industrial Employees = Selected land acreage * (GID*1.2)

Within this selection, industrial suitability was manually adjusted to change the selection until the remaining needs for industrial employees were fulfilled. No industrial land was allocated to protected zones.

**Allocating single family land uses into greenfield.** Single family land was allocated by using Select By Attributes to create an expression query selecting lands. The query selected lands not yet allocated and based on conflict (in the order described earlier). Lands not in protected zones were given preference over those within protection zones and were allocated into first. To determine population available within the selected records, the acreage was multiplied by the Single Family Gross Residential Density (SF GRD), increased by 20% for areas outside protection zones, and was left at existing SF GRD for areas within protection zones.

Outside Protection Zones: Possible Single Family Population = Selected land acreage * (SF GRD*1.2)

Inside Protection Zones: Possible Single Family Population = Selected land acreage * (SF GRD)

Within this selection, single family suitability was manually adjusted to change the selection until the remaining needs for single family population were fulfilled.

**Allocating vacant land uses.** For each category of existing land use, there is a certain percentage of land that is vacant platted to accommodate future land development. A ratio of 1:0.2 was utilized, such that an amount equal to 20% of total occupied land use for each category would be assigned to each vacant service, commercial, industrial, multi-family, and single family. To complete, existing and allocated land uses were summed to determine the total amount of vacant platted land needed per land use based on this ratio. These vacant land uses were generally allocated in the same way as the other corresponding land uses, based on conflict and suitability, but with priority of allocation to remaining greenfield lands within city limits. This was accomplished by including only records within city limits when creating the query expression, in addition to the sliced suitability and selection of unallocated land portions of the query. Once all greenfield within city limits was allocated, conflict and suitability were used to allocate the remaining vacant land use needs.

Vacant residential land was not distinguished by multi-family or single-family. Therefore, the general residential sliced suitability was used in the expression query to select lands appropriate for vacant residential uses.

**Remaining greenfield.** Remaining unallocated greenfield land was allocated based on its conflict. All conservation preferred, high conservation-urban conflict, agriculture-conservation conflict, and high conflict areas were already allocated earlier to create a green infrastructure network. The remaining conflict areas of conservation-urban conflict were assigned as “conservation.” Of the remaining area, areas within protection zones were assigned as “agricultural preservation” and areas outside protection zones were assigned as “agriculture.”

## Environmental Impacts of Growth Scenarios

Environmental impacts were calculated by analyzing land area use of allocated urban development on waterbodies, environmental protection zones, and areas identified as top priorities within the Critical Lands & Waters Identification Project (CLIP).

### Waterbodies

Waterbodies were analyzed based on the dataset retrieved from Lake County and used to limit development in the alternative analysis. The Intersect tool was used to find area of potential impact, with inputs of trend scenario allocated urban uses and waterbodies. The alternative scenario was not analyzed because all waterbodies were initially removed from the analysis.

### Environmental Protection Zones

Development within environmental protection zones was documented throughout the alternative scenario analysis. These areas were totaled to document total area impacted. The Intersect tool was used to find area of potential impact within the trend scenario, using inputs of allocated urban uses and environmental protection zones.

### CLIP Priorities

CLIP GIS data was retrieved from the Florida Century Commission projects website (http://www.collinscenter.org/?ReschProjectsOvrview). The final aggregated priority raster (clip_prio) was used to analyze and quantify area of development over areas identified as high priority by the CLIP analysis. This was completed by using the Intersect tool to analyze overlapping areas of combined priorities 1 and 2 of the CLIP dataset and allocated uses from the trend and alternative scenarios.

## Comparing Growth Scenarios to the FLUM

Each growth scenario was compared to existing FLUM designations. First, total urban uses allocated into vacant and greenfield lands were compared to total urban FLUM designations. Urban allocated uses included mixed use, commercial, service, residential, and vacant land uses. Urban FLUM designations included all designations except Conservation, Agriculture, Unknown, and Water.

To further analyze, residential uses were grouped and compared. Residential uses in the FLUM designations were considered all residential FLUs as well as mixed use and planned development. Residential uses in the alternative scenario included all occupied and vacant residential and mixed use allowing residential use. Residential uses in the trend scenario were considered all occupied and vacant residential allocations.

FLUM designations use different land use category names and definitions than those used in the allocation process. Therefore, the land uses grouped into the land use classifications are not comparable based on their current definitions. Because of this, land uses beyond residential/non-residential and urban/non-urban classifications were not compared.

Comparisons were completed quantitatively and spatially. Quantitative comparisons analyzed calculated totals for each designated land use category of total urban, residential, and non-residential urban uses. Methodology is described below.

To analyze urban versus non-urban land use designations, a final raster of allocated land uses for each growth scenario was created, as well as a raster of FLUM designations. Data was reclassified using the Reclassify tool for each raster. Each urban land use was reclassified to a value of “1” and each non-urban land use was reclassified to a value of “2”. NoData was not reclassified. After reclassification, the Minus tool was used to subtract the reclassified growth scenario raster from the reclassified FLUM raster. Where results equaled “0,” the FLUM and the growth scenario had the same value (both urban or both non-urban). Where results equaled “1” or “-1,” a discrepancy between location of urban and non-urban uses was found. Where the results were “1,” the FLUM designated the land as a non-urban use, while the growth scenario designated the land as an urban use. Where results equaled “-1,” the growth scenario allocated the land as a non-urban use, while the FLUM designated the land as an urban use. Waterbodies removed from the analysis of the alternative scenario were not included in the analysis (see Table 4-7).

To analyze residential versus non-residential land use designations, data was reclassified using the Reclassify tool for each raster. Each residential land use was reclassified to a value of “2” and each non-residential land use was reclassified to a value of “1.” NoData was not reclassified. After reclassification, the Minus tool was used to subtract the reclassified growth scenario raster from the reclassified FLUM raster. Where results equaled “0,” the FLUM and the growth scenario had the same value (both residential or both non-residential). Where results equaled “1” or “-1,” a discrepancy between location of residential and non-residential uses was found. Where the results were “1,” the FLUM designated the land as a residential use, while the growth scenario designated the land as a non-residential use. Where results equaled “-1,” the growth scenario allocated the land as a residential use, while the FLUM designated the land as a non-residential use. Waterbodies removed from the analysis of the alternative scenario were not included in the analysis (see Table 4-8).

## Comparison of Growth Scenarios

The two growth scenarios were compared to determine difference in allocated land use area, environmental impacts, and their relationship to the FLUM. Descriptions of each comparison analysis are described below.

### Urban, Conservation, Agriculture and Agricultural Preservation Land Use Area

Total land use allocations for each growth scenario were compared to calculate the difference in land use area allocations for total allocated urban land use, individual urban land uses, conservation, agricultural preservation, and agriculture.

### Environmental Impacts

Environmental impacts of each growth scenario on waterbodies, environmental protection zones, and areas of highest two priorities as identified by the CLIP data were calculated based on land area impacted, using each boundary as a mask on urban land use allocation in each growth scenario. The resulting areas of each scenario were then compared to determine the difference in impact acreage.

### Comparison of Growth Scenarios to FLUM

The calculated differences of each scenario's comparison to the FLUM were compared to calculate the difference between each set of results, specifically the amount of correlation between scenario land use and FLUM designations.

## Summary

This section has described the techniques and methodology used to analyze the Central Florida region and Lake County for existing land use patterns, existing spatial policy, relation of FLUMs to regional goals identified through conflict analysis, potential growth futures, and to what extent FLUMs in Lake County support urban sprawl or environmental preservation. The next chapter describes findings from these studies.

Table 4-1. Parcel land use codes considered vacant and greenfield

| Code | DESCRIPTION | Vacant or Greenfield |
|---|---|---|
| 0 | VACANT RESIDENTIAL | Vacant |
| 10 | VACANT COMMERCIAL | Vacant |
| 40 | VACANT INDUSTRIAL | Vacant |
| 50 | IMPROVED AGRICULTURE | Greenfield |
| 51 | CROPLAND SOIL CLASS 1 | Greenfield |
| 52 | CROPLAND SOIL CLASS 2 | Greenfield |
| 53 | CROPLAND SOIL CLASS 3 | Greenfield |
| 54 | TIMBERLAND | Greenfield |
| 55 | TIMBERLAND | Greenfield |
| 56 | TIMBERLAND | Greenfield |
| 57 | TIMBERLAND | Greenfield |
| 58 | TIMBERLAND | Greenfield |
| 59 | TIMBERLAND | Greenfield |
| 60 | GRAZING LAND SOIL CLASS 1 | Greenfield |
| 61 | GRAZING LAND SOIL CLASS 2 | Greenfield |
| 62 | GRAZING LAND SOIL CLASS 3 | Greenfield |
| 63 | GRAZING LAND SOIL CLASS 4 | Greenfield |
| 64 | GRAZING LAND SOIL CLASS 5 | Greenfield |
| 65 | GRAZING LAND SOIL CLASS 6 | Greenfield |
| 66 | ORCHARD, GROVES, CITRUS | Greenfield |
| 70 | VACANT INSTITUTIONAL | Greenfield |
| 99 | ACREAGE NOT ZONED FOR AGRICULTURAL | Greenfield |

Table 4-2. Description of conflict analysis categories

| Conflict Value | Conflict Category |
|---|---|
| 111 | Low conflict |
| 112 | Urban medium preference |
| 113 | Urban high preference |
| 121 | Conservation medium preference |
| 122 | Conservation-Urban medium conflict |
| 123 | Urban high preference |
| 131 | Conservation high preference |
| 132 | Conservation high preference |
| 133 | Conservation-Urban high conflict |
| 211 | Agriculture medium preference |
| 212 | Agriculture-Urban medium conflict |
| 213 | Urban high preference |
| 221 | Agriculture-Conservation medium conflict |
| 222 | Medium conflict |
| 223 | Urban high preference |

Table 4-2. Continued

| Conflict Value | Conflict |
|---|---|
| 231 | Conservation high preference |
| 232 | Conservation high preference |
| 233 | Conservation-Urban high conflict |
| 311 | Agriculture high preference |
| 312 | Agriculture high preference |
| 313 | Agriculture-Urban high conflict |
| 321 | Agriculture high preference |
| 322 | Agriculture high preference |
| 323 | Agriculture-Urban high conflict |
| 331 | Agriculture-Conservation high conflict |
| 332 | Agriculture-Conservation high conflict |
| 333 | High conflict |

Adapted from: Carr, M. & Zwick, P. (2007). *Smart land use analysis: The LUCIS model.* Redlands, CA: ESRI Press, p. 148.

Table 4-3. Densities used in alternative scenario (in relation to existing densities per TAZ)

| Land Use | Mixed Use Density | New Development Density Outside Protection Zones | New Development Density Within Protection Zones |
|---|---|---|---|
| Single Family | n/a | 20% increase | Existing Density |
| Multi-Family | 50% increase | 20% increase | Existing Density |
| Commercial | 30% increase | 20% increase | Existing Density |
| Service | 30% increase | 20% increase | Existing Density |
| Industrial | n/a | 20% increase | Existing Density |

Table 4-4. Occupied population proportions used in alternative scenario

| Resident Type | Existing % of population | Alternative Scenario % of population |
|---|---|---|
| Single Family | 90.61% | 75% |
| Multi-Family | 9.39% | 25% |

Table 4-5. Vacant land use area proportions used in alternative scenario (Occupied area: Vacant platted area)

| Land Use | Existing Ratio | Alternative Scenario Area Ratio (Occupied: Vacant) |
|---|---|---|
| Vacant Residential | 1:0.5291 | 1:0.2 |
| Vacant Service | 1: 0.9831 | 1:0.2 |
| Vacant Commercial | n/a | 1:0.2 |
| Vacant Industrial | 1:0.0715 | 1:0.2 |

Table 4-6. Mixed Use Definitions and Proportions

| Mixed Use Conflict | Mixed Use Designation | % Within Vacant Residential | % Within Vacant Service |
|---|---|---|---|
| 122; 133; 233 | Multi-Family/Service Mixed Use | 70%/30% | 30%/70% |
| 221; 331; 332 | Commercial/Multi-Family Mixed Use | 30%/70% | 70%/30% |
| 212; 313; 323 | Commercial/Service Mixed Use | 50%/50% | 50%/50% |
| 222; 333 | Commercial/Multi-Family/Service Mixed Use | 30%/40%/30% | 30%/30%/40% |

Table 4-7. Spatial analysis result interpretation of urban and non-urban uses: comparison of FLUM and growth scenario using the Minus tool (FLUM minus growth scenario)

| Resulting Value | Interpretation |
|---|---|
| -1 | Conflict: FLUM designated as urban, growth scenario allocation designated as non-urban |
| 0 | No Conflict: FLUM and growth scenario both urban or both non-urban |
| 1 | Conflict: FLUM designated as non-urban, growth scenario allocation designated as urban |

Table 4-8. Spatial analysis result interpretation of residential and non-residential uses: comparison of FLUM and growth scenario using the Minus tool (FLUM minus growth scenario)

| Resulting Value | Interpretation |
|---|---|
| -1 | Conflict: FLUM designated as non-residential, growth scenario allocation designated as residential |
| 0 | No Conflict: FLUM and growth scenario both residential or both non-residential |
| 1 | Conflict: FLUM designated as residential, growth scenario allocation designated as non-residential |

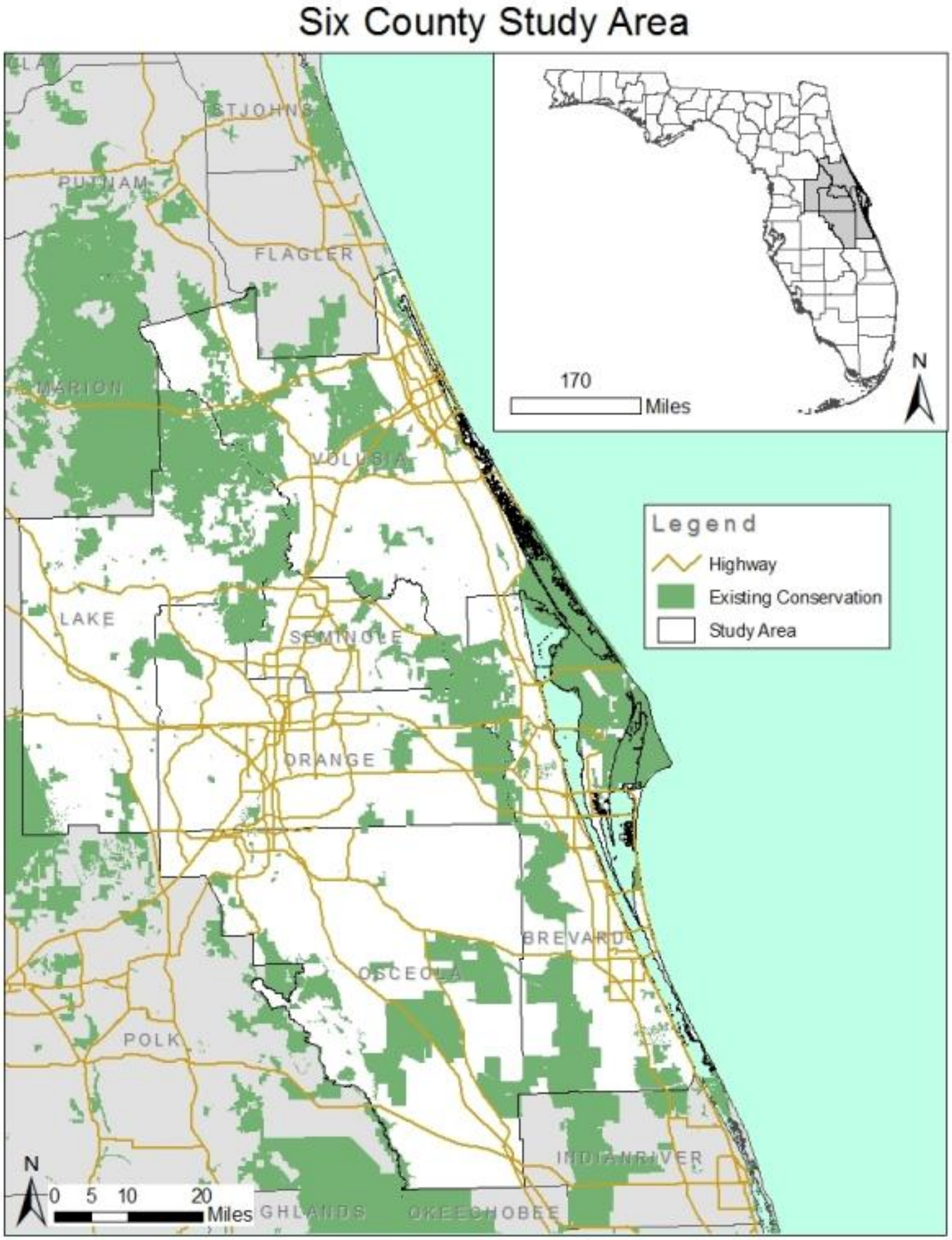


Figure 4-1. Six county study area

Lake County, FL


Figure 4-2. Lake County, FL

## CHAPTER 5
## FINDINGS AND RESULTS

### Overview

This study is divided into two parts to analyze land use conflict and future growth patterns. The first study analyzes the relationship between the conflict analysis and existing policy in the form of future land use map (FLUM) designations. The second uses conflict to allocate projected future growth in two alternative scenario models. This chapter describes the findings collected from these studies.

### Future Land Use Analysis

FLUM category acreages were calculated for each county and for the entire six-county region (see Figure 5-1).

The first calculation quantified the acreage of each FLUM category, with removal of surface waters over five acres and conservation lands. Conservation lands accounted for 24.1% of the entire region (971,405 acres), and surface waters over five acres accounted for 11.1% (447,699 acres) of the region. The analysis of remaining land was completed for each county and for the entire region. Regionally, agriculture accounted for the largest category of land use, at 35.3% (927,391 acres) of total land area. The second largest category was low density residential, at 21.7% (571,112 acres). Residential uses totaled 38.5% of total regional FLUM designations.

Of the counties, Osceola County had the highest percentage and acreage of agriculture, at 79.6% (518,987 acres). Seminole County had the lowest percentage of agriculture with the use accounting for 2.4% (3,916 acres) of the county. Lake County demonstrates the highest percentage of residential FLUM designations, with 72.9% (317,661 acres) of all land uses within the county being assigned residential use. The majority of this was low density residential (46.2%) and rural residential (21.2%). Seminole and Volusia Counties demonstrated 23.4% and 24.1% respectively of conservation FLU (see Tables 5-1to 5-4 for all county and regional data results).

To determine why results demonstrated FLUM areas in Conservation despite the removal of conservation lands, a simple analysis was completed, overlaying the conservation FLU lands overlaid with wetlands data. Visual analysis demonstrated that most of the remaining conservation lands were within wetlands areas. To further analyze, the original FLUMs of the counties were examined. Volusia County's original FLUM revealed that a majority of these lands were designated as Natural Resource Management Areas, meaning that while they may not be under conservation easements, they have been identified as areas of sensitive environmental resources requiring specific management procedures to maintain ecological integrity, including more rigid development standards (Volusia County, 2008). Seminole County's FLUM demonstrated that areas considered Conservation in the generalized FLUM were under an Environmentally Sensitive Lands Overlay. The Overlay creates stricter development regulations and identifies flood prone areas identified by the National Flood Insurance Program and major wetlands as identified by St. Johns River Water Management District (Seminole County, 2008).

**Parcel Analysis**

Parcel data was utilized to determine vacant and greenfield land, with conservation and surface waters over five acres removed from the analysis. Regionally, grazing lands accounted for the majority of vacant and greenfield land. Vacant residential was the next largest category, accounting for 15.2% of all vacant and greenfield land. Percentage of total county land considered vacant platted land uses ranged from 4.5% in Seminole County to 15.6% in Brevard County. The percent of county land considered vacant and greenfield ranged from 25.7% in Seminole County to 87.2% in Osceola County (see Tables 5-5 through 5-7 for individual county area of vacant and greenfield land, Table 5-8 for regional data, and Table 5-9 for combined results of county and regional data).

### Parcel/FLUM Analysis: Area of FLUM Within Vacant and Greenfield

Analysis of the area of FLUM designations within vacant and greenfield lands (with conservation land and surface waters over five acres removed) showed that regionally, agriculture FLU accounted for the largest area at 57.2% (798,612 acres). Low density residential was the next largest area, accounting for 13.6% (190,181 acres) of the region's vacant and greenfield lands. Residential uses combined accounted for 26% of the region. With the exception of Seminole and Lake Counties, agriculture represented the largest FLUM designation for each county. Lake County had the highest area dedicated to residential FLU at 77.8%. Brevard County had the next highest percentage dedicated to residential at 42.2%. Lake County also had the lowest percentage dedicated to agricultural FLU, with 10.2% (see Tables 5-10 through 5-13 for all county and region results).

Analysis of urban FLU categories revealed that Lake County had the largest area allocated to future urban land uses, accounting for 82.8% of all vacant and greenfield land within the county. This makes up 40.6% of all vacant and greenfield land designated as urban FLU in the region. Of Lake County's urban FLU's, 92.1% are residential, and 97.9% of the residential FLU's are low density, very low density, or rural residential. Brevard County had the next largest proportion designated as urban uses with 51.6% of all vacant and greenfield. Regionally, 34.3% of all vacant and greenfield land was designated as urban FLU (see Table 5-14 for all county and region results).

### Suitability

Existing suitability rasters for all land uses except conservation were utilized. Edits made to the conservation suitability analysis reflected up to date information and additional data (see Figure 5-2 for regional conservation suitability).

### Creating Preference

Creation of conservation preference resulted in 901,913 acres in low preference, 1,915,264 acres in medium preference, and 1,201,709 acres in high preference (see Figure 5-3).

### Creating Conflict

Creation of a conflict raster (of all land, including surface waters and conservation lands) showed the largest category by area was urban preferred lands at 25.5%, followed closely by agriculture preferred at 24.7%. Areas of low, medium, and high conflict accounted for relatively little of the total region, at 0%, 3.4%, and 2.5%, respectively (see Table 5-15 and Figure 5-4).

### Conflict in Vacant and Greenfield Lands

Conflict analysis within vacant and greenfield lands revealed that regionally, the majority of land was in the Agriculture Preferred category (58.2%). Within the counties, most land was in Agriculture Preferred, Urban Preferred, or Agriculture-Urban Conflict conflict categories (see Tables 5-16 through 5-19). Osceola County had the lowest percentage of land in urban preference (3.9%), while Seminole County had the highest percentage (21.2%). Osceola County also had the highest percentage of land in agriculture preference (81.6%) (see Figures 5-5 and 5-6).

## FLUM/LUCIS Conflict: Vacant and Greenfield Analysis

Comparison of FLUM and conflict within vacant and greenfield land demonstrated spatial correlations between FLU designations and conflict categories. Regionally, FLU categories of agriculture were primarily located within agriculture preferred land. Additionally, the majority of FLU urban use categories within the region (including commercial, industry, institutional, mixed use, office, planned development, and residential uses) were within urban preference and agriculture-urban high conflict. Between 39% and 40% of every county's urban FLUM designations were located in urban preferred areas, with the exception of Orange County, which had 45% of its urban uses in urban preferred areas, and Lake County, which had just 15.6% of its urban uses in urban preferred areas. All counties designated the majority of their urban FLU's into urban preferred, agriculture-urban high conflict, and conservation-urban high conflict areas. Orange County demonstrated the highest correlation between urban FLU's and these three conflict categories at 86.2% (see Table 5-20).

FLUM designations were not always consistent with conflict analysis. In Lake, Volusia, and Osceola Counties between 20% and 30% of conservation FLU were located in agriculture-urban conflict. In Brevard County, almost 50% of conservation FLU was located in urban preference. In Orange, Osceola, Seminole, and Volusia Counties, between 20% and 31% of conservation FLU was located in agriculture preference. 41.4% of mixed use FLU in Lake County was located in agriculture preference. Regionally, residential uses were primarily found in agriculture preference or agriculture-urban conflict areas, though this trend was more evident in lower density residential FLU's (see Tables 5-21 through 5-27).

## Creating Alternative Scenarios of Future Development in Lake County

## Identifying Lands Suitable for Development

Parcel analysis results showed Lake County had 48,411 acres of vacant platted residential, 5,131 acres of vacant platted service, 1,236 acres of vacant platted industrial, and 191,536 acres of greenfield (see Table 5-28). All results exclude conservation land and surface waters.

## Determining Population and Employment Needs

According to BEBR data, 240,858 new residents are projected for Lake County by the year 2035. Employment projections show a growth of 7,793 commercial employees, 64,620 service employees, and 12,010 industrial employees (see Table 5-29).

## Calculating Existing Gross Densities

**Residential Gross Densities**. 2005 population in Lake County was 263,642 residents. Of this, 238,897 (90.6%) are considered single-family, and 24,745 (9.4%) are considered multi-family. Total residential acreage in 2005 was 92,835 acres. Of this, 91,382 acres (98.4%) were considered single-family land use, and 1,453 acres (1.6%) were considered multi-family land use. Acreage totals do not include water bodies or conservation lands.

County-wide gross residential density for all residential land uses was 2.84 people per acre. The county-wide gross residential density for single family residential uses was 2.61 people per acre. The highest single family density per TAZ, once adjusted for outliers, was 18 people per acre; the lowest density was zero people per acre. The mean single family GRD among all TAZs was 4.39 people per acre.

The county-wide gross residential density for multi-family residential uses, calculated from TAZ data, was 17.03 people per acre. The highest multi-family density per TAZ, once adjusted for outliers, was 72 people per acre; the lowest density was zero people per acre. The mean multi-family GRD among TAZs was 9.18 people per acre (see Table 5-30).

**Commercial, Industrial, and Service Gross Densities**. Classification of parcel land use codes into commercial, industrial, and service uses revealed a total of 10,161 acres (30.7% of total employment acreage) of commercial land use, 17,285 acres (52.3%) of industrial land use, and 5,615 acres (16.7%) of service land use. Total employment land use area totaled 33,061 acres.

Employment counts identified by TAZ data for these three categories were 24,283 (23.9% of the three employment categories) commercial employees, 19,808 (19.5%) industrial employees, and 57,493 (56.6%) service employees.

Based on these results, gross commercial density was 2.39 employees per acre. Gross industrial density was 1.15 employees per acre. Gross service density was 10.24 employees per acre (See Table 5-30).

Analyzing the gross densities per TAZ revealed a wide range of gross densities. Commercial density ranged from zero to 232 employees per acre, with a mean of 10.39 (after adjusting for outliers in the data). Service density ranged from zero to 195 employees per acre, with a mean of 15.82 (after adjusting for outliers). Industrial density ranged from zero to 261 employees per acre, with a mean of 11.66. No outliers were apparent in the industrial calculations.

## Trend Scenario Land Use Model – Lake County 2035

### Multi-Family and Single Family Projected Growth

Ten percent of projected new residential growth was assumed to be allocated into redevelopment, leaving 216,772 residents to allocate. Existing percentages of single family to multi-family population were utilized to estimate residential growth for each category. Existing single family was found to account for 90.6% of the total population, and multi-family for 9.4%. Therefore, single family growth for the trend scenario was projected to be 196,426 residents, and multi-family growth was projected to be 20,346 residents.

### Trend Scenario Allocations

#### Allocating to vacant platted land

All of the 54,390.83 acres of available vacant platted land were utilized to allocate population and employment. Descriptions of specific allocations are described below (see Table 5-31 for complete results).

**Vacant platted residential**. A total of 126,008 residents were allocated to vacant platted residential lands. 844 acres (1.8% of vacant platted residential land) were allocated to multi-family use, accommodating 14,834 residents (11.8% of population allocated into vacant residential). The remaining 47,274 acres (98.3%) were allocated to single family use, accommodating 111,174 residents (88.2%).

**Vacant platted service**. Within vacant platted service land, 4,103 acres were selected to accommodate 64,627 service employees, fulfilling the service employment needs projections for the county. Remaining lands were able to accommodate 4,301 commercial employees based on variable gross commercial densities, using 1,024 acres. An additional 3,492 commercial employees will need to be allocated into remaining lands.

**Vacant platted industrial.** 1,236 acres of vacant platted industrial lands were available, accommodating a total of 2,432 employees. All vacant industrial lands were utilized for this allocation. A remaining 9,578 employees remained to be allocated into remaining greenfield lands.

**Allocating to greenfield**

187,575 acres of greenfield land were available for development after removal of existing conservation and lakes and ponds. A total of 155,186 acres, or 82.7%, of all greenfield land was allocated to urban uses of both occupied and vacant commercial, service, industrial, and residential land use (see Table 5-32). Specific descriptions are as described below.

**Occupied land uses.** 43,212 acres of greenfield were allocated to single family land use, accommodating 82,669 residents. 375 acres were allocated to multi-family land use, accommodating 5,438 residents. No service employment allocation needs remained after allocation into vacant platted lands. Of the remaining employment categories, 506 acres and 3,432 employees were allocated to commercial land uses, and 11,838 acres and 9,975 employees were allocated to industrial land uses. Almost 30% of all greenfield land was allocated to occupied land uses.

**Vacant land uses.** Analysis of existing ratios of vacant platted to occupied land uses found that the area of vacant platted land ranged from an amount equal to 91.4% (1:0.91) of occupied land for service uses to 7.2% (1:0.07) of industrial uses. Because not all vacant platted service land was used for service uses, it was assumed that an amount equal to 80% (1:0.80) of occupied service area would be required for vacant service. Vacant commercial was assumed to be an amount equal to 20% (1:0.20) of occupied commercial land area. Results of these calculations showed a need for 96,462 acres of vacant residential land, 2,338 acres of vacant commercial, 7,703 acres of vacant service, and 2,171 acres of vacant industrial. Approximately 53% of all greenfield land was allocated to vacant platted land use.

**Remaining greenfield.** Remaining greenfield land allocations included 7,892 acres allocated to agriculture, 23,647 acres allocated to agricultural preservation, and 848.7 acres allocated to conservation.

### Total vacant platted and greenfield allocated

A total of 218,824 acres (87% of total vacant platted and greenfield land) of urban land uses were allocated into vacant platted and greenfield land in the trend scenario (see Table 5-33 and Figures 5-9 through 5-14).

### Trend Scenario Total Allocated and Existing Land Uses for the Year 2035

Combined allocated urban uses (including new vacant land uses) and existing land uses totaled 335,473 acres (45.4% of the entire county) (see Table 5-34).

## Alternative Scenario Land Use Model – Lake County 2035

### Determining Vacant and Greenfield Land

The inclusion of brownfields in the analysis resulted in an additional 1,311 acres to greenfield for a total of 266,129 acres considered vacant and greenfield. This total does not include existing conservation land, but does include surface waters.

### Modeling Policy: Green Infrastructure

**Waterbodies.** Surface water area within vacant and greenfield land totaled 94,425 acres. Of this area, 71% were wetlands, and 35% were lakes and ponds. Approximately 2,900 of these acres were already in conservation, resulting in a total of 91,499 acres removed from potential development lands and added to green infrastructure.

**Impaired waters.** A total of 24,570 acres within Lake County were identified as “impaired waters” by FDEP. Of this total, 5,608 were within city limits. The remaining 18,968 acres outside of city limits were set as “conservation” and removed from the developable lands analysis.

**Conflict analysis**. Throughout the allocation process, a total of 10,896.92 acres were allocated to agricultural preservation based on conflict, and another 1,308 acres were allocated to conservation. These numbers are in addition to land previously allocated to conservation within waterbodies or impaired waters boundaries.

**Protection zones**. Total area of protection zones within vacant and greenfield land (with conservation, impaired waters, and waterbodies removed) was 89,297 acres (see Table 5-35).

**Existing conservation areas**. A total of 201,174 acres of existing conservation exist within the county. 1,495 acres of land within the county was designated by the FLUM as recreation (see Table 5-36).

**Promoting Compact Development**

**Density.** Densities used were dependent on location within mixed use and environmental protection zones. Minimum densities were set for new development based on location (see Table 5-37).

**Distinguishing multi-family and single family population growth.** 216,772 new residents are projected to enter Lake County by 2035. Of this the alternative scenario assumed 25% (54,193 people) to live in multi-family housing. The remaining 75% (162,579 people) were allocated to single family land use.

**Alternative Scenario Allocations**

**Allocating to vacant platted land**

**Mixed use development**: Within mixed use allocations, a total of 2,496 acres and 7,754 employees were allocated to mixed use commercial, 2,094 acres and 53,486 residents to mixed use multi-family, and 2,660 acres and 35,401 employees to mixed use service. All commercial employment needs based on growth projections were allocated to mixed use. 1,441 acres were allocated to conservation and 104 acres were allocated to agricultural preservation based on conflict analysis (see Tables 5-38 and 5-39).

**Vacant platted service.** 2,073.61 acres remained available in vacant platted service after mixed use allocation. The majority of the land was allocated to service land uses. All remaining service employee and multi-family population projections needs were allocated in this step (see Tables 5-38 and 5-39).

**Vacant platted residential**. 32,920 acres remained available in vacant platted residential after mixed use allocation. Conservation and agricultural preservation allocations totaled 897 acres and 9 acres, respectively. The remaining 32,014 acres was used to allocate 117,331 single family residents (see Tables 5-38 and 5-39).

**Vacant platted industrial.** All of the original 1,144 acres of vacant platted industrial were available for development analysis, as none of the land was used for mixed use allocations. Conservation and agricultural preservation allocations totaled approximately six acres; the remaining 1,138 acres was used to allocate 3,004 industrial employees (see Tables 5-38 and 5-39).

**Greenfield allocation**

278 acres of conservation and 10,453 acres of agricultural preservation were removed from greenfield through conflict analysis, leaving 117,357 acres available for allocation of urban uses. Of this land, a total of 46,538 acres (36.2% of original greenfield area, with existing conservation and waterbodies removed) were allocated to urban uses. Allocations totals are described below (see Table 5-40):

**Occupied land Use.** 42,971 single family residents were allocated into 10,145 acres to fulfill the remaining allocation needs for population growth. 8,994 industrial employees were allocated into 573 acres to satisfy the remaining needs for industrial employment growth.

**Vacant land uses.** A total of 35,820 acres were allocated to vacant land uses.

**Remaining Greenfield Lands.** 71,165 acres remained in the Based on conflict analysis, 70,819 acres were allocated to agricultural preservation, 280 to conservation, and 10,886 to agriculture.

### Total Vacant Platted and Greenfield Allocated Uses

A total of 88,886.84 acres (46% of total vacant platted and greenfield land) were allocated to urban land uses within both vacant platted and greenfield lands for the alternative scenario (see Table 5-41 and Figures 5-15 through 5-21).

### Alternative Scenario Total Allocated and Existing Uses for the Year 2035

Total land uses of combined existing and allocated urban uses (including allocated vacant land uses) totaled 214,783 acres, an amount equal to 29.1% of the entire county acreage (see Table 5-42).

## Environmental Impacts of Growth Scenarios

### Trend Scenario

**Water bodies and wetlands.** The trend scenario's removal of lakes and ponds protected 19,224 acres of surface water. Final total allocation of the trend scenario resulted in 37,361 acres of water bodies at risk of being lost to urban development (based on comparison of urban land use allocations to the more comprehensive water bodies dataset used to prevent development in the alternative scenario). 30,056 acres of this were classified as "swamp/marsh" (wetlands).

**Environmental protection zones.** 97,956 acres of allocated urban uses in the trend scenario were within environmental protection zones.

**CLIP Priority Areas**. 71,418 acres of allocated urban uses in the trend scenario were in areas identified as priorities one and two by the CLIP aggregated priority. Of this, 44,491 acres were within the highest priority category.

### Alternative Scenario

**Water bodies and wetlands.** Water bodies protected from development in the alternative scenario totaled 91,499 acres. The alternative scenario had no direct effects on wetlands.

**Environmental protection zones.** 32,750 acres of allocated urban uses in the alternative scenario were within designated environmental protection zones.

**CLIP priority areas**. The alternative scenario allocated urban development into 18,578 acres of priorities 1 and 2. Of this, 10,382 acres were in the highest priority category.

## Comparison of Growth Scenarios to the FLUM

### Urban versus Non-Urban Land Use Designations

**Trend scenario.** Results of the spatial analysis of urban and non-urban uses demonstrated that 184,470 acres of land (78%) were in agreement between the FLUM and trend scenario; that is, they were either both urban or both non-urban land use designations.

A total of 52,584 acres (22%) were in disagreement between the FLUM and alternative scenario. 20,888 acres (9%) were considered urban in the FLUM but non-urban in the trend scenario. 31,696 acres (13%) were non-urban in the FLUM but urban in the trend scenario (see Table 5-43).

**Alternative scenario.** Results of the spatial analysis of urban and non-urban uses demonstrated that 91,333 acres of land (53%) were in agreement between the FLUM and alternative scenario; that is, they were either both urban or both non-urban land use designations.

A total of 81,976 acres (48%) were in disagreement between the FLUM and alternative scenario. 72,029 acres (42%) were considered urban in the FLUM but non-urban in the alternative scenario. 9,947 acres (6%) were non-urban in the FLUM but urban in the alternative scenario (see Table 5-44).

Waterbodies removed from allocation analysis in the alternative scenario were not included in the comparison.

**Residential versus Non-Residential Land Use**

**Trend scenario.** Results of the spatial analysis of residential and non-residential uses demonstrated that 159,833 acres of land (67.4%) were in agreement between the FLUM and trend scenario; that is, they were either both residential or both non-residential land use designations.

A total of 77,220 acres (33%) were in disagreement between the FLUM and trend scenario. 32,687 acres (13.8%) were considered non-residential in the FLUM but residential in the trend scenario. 44,533 acres (18.8%) were residential in the FLUM but non-residential in the trend scenario (see Table 5-44).

**Alternative scenario.** Results of the spatial analysis of residential and non-residential uses demonstrated that 81,696 acres of land (47.1%) were in agreement between the FLUM and alternative scenario; that is, they were either both residential or both non-residential land use designations.

A total of 91,612 acres (52.9%) were in disagreement between the FLUM and alternative scenario. 11,758 acres (6.8%) were considered non-residential in the FLUM but residential in the alternative scenario. 79,854 acres (46.1%) were residential in the FLUM but non-residential in the alternative scenario (see Table 5-44).

Waterbodies removed from allocation analysis in the alternative scenario were not included in the comparison.

## Comparing Growth Scenarios

### Urban Land Use Area

The trend scenario allocated a total of 218,813 acres of urban land uses into vacant platted and greenfield land, while the alternative scenario allocated 88,887 acres of urban land uses. The alternative scenario resulted in 129,926 fewer acres (40.6% less land) of urban land use.

### Conservation Land Use Area

The alternative scenario allocated 20,867.65 more acres to conservation than the trend scenario: the alternative scenario conserved 21,716 acres while the trend scenario conserved 849 acres.

### Agriculture and Agricultural Preservation Land Use Area

Significantly more agricultural land use was preserved in the alternative scenario. The alternative scenario allocated a total of 81,820 acres of agriculture and agricultural preservation. Of this, 70,819 acres was agriculture and 11,000 acres agricultural preservation.

The trend scenario allocated a total of 31,540 acres of agricultural land use. Of this, 7,893 acres was agriculture, and 23,647 acres was agricultural preservation. 13,961 acres of this land use allocation fell within the waterbodies dataset used in the alternative scenario and therefore was preserved as conservation, not agricultural use, in the alternative scenario.

## Environmental Impacts of Urban Development

**Waterbodies and wetlands.** The trend scenario impacted 37,361 more acres of waterbodies and wetlands than the alternative development scenario, which had no direct impacts on these water bodies.

**Environmental protection zones.** The trend scenario allocated urban development to 65,206 more acres within environmental protection zones than the alternative development scenario.

**CLIP priority areas**. The alternative scenario preserved 52,840 more acres of priority one and two lands than the trend scenario. Of this, the alternative scenario protected 34,109 more acres of priority one land than the trend scenario.

## Comparison of Growth Scenarios to FLUM: Urban versus Non-Urban Land Use

The trend scenario showed a higher percent correlation to FLUM designations than the alternative scenario, with 77.8% correlation compared to a 52.7% correlation in the alternative scenario.

The trend scenario differed from the FLUM over 22.2% of total land area, and 47.3% of the land area of the alternative scenario. Specifically, where the FLUM designated land as urban, but the scenario allocated it as non-urban, the alternative scenario showed higher spatial disagreement. Where the FLUM designated land as non-urban, but was allocated as urban land in the scenario, the trend scenario showed higher spatial disagreement (see Table 5-31).

## Comparison of Growth Scenarios to FLUM: Residential versus Non-Residential Land Use

The trend scenario also showed higher percent correlation to FLUM designations than the alternative scenario in the residential comparisons, with 67.4% correlation compared to 47.1% correlation in the alternative scenario. The trend scenario differed from the FLUM over 32.6% of the land area, and 52.9% of the land area of the alternative scenario. Specifically, where the FLUM designated land as non-residential, but the scenario allocated it as residential, the trend scenario showed higher spatial disagreement. Where the FLUM designated land as residential, but was allocated as non-residential land in the scenario, the alternative scenario showed higher spatial disagreement (see Table 5-32).

Table 5-1. Generalized future land use (FLU) area by county, with surface water and conservation removed: Orange and Lake Counties

| | ORANGE | | LAKE | |
|---|---|---|---|---|
| FLU | Acres | % of county | Acres | % of county |
| AG | 128,278.10 | 27.12% | 37,475.22 | 8.60% |
| COM | 21,392.29 | 4.52% | 907.31 | 0.21% |
| CONS | 13,670.27 | 2.89% | 16,560.64 | 3.80% |
| FED | 0.00 | 0.00% | 0.00 | 0.00% |
| IND | 30,404.10 | 6.43% | 6,934.60 | 1.59% |
| INST | 27,820.81 | 5.88% | 8,734.05 | 2.01% |
| MDR | 0.00 | 0.00% | 0.00 | 0.00% |
| LOD | 2,586.60 | 0.55% | 1.11 | 0.00% |
| MU | 58,981.24 | 12.47% | 12,519.93 | 2.87% |
| OFF | 4,295.20 | 0.91% | 1,949.30 | 0.45% |
| PD | 16,346.95 | 3.46% | 968.25 | 0.22% |
| REC | 8,089.92 | 1.71% | 1,285.93 | 0.30% |
| RH | 15,404.47 | 3.26% | 1,255.60 | 0.29% |
| RL | 103,693.82 | 21.92% | 201,127.46 | 46.18% |
| RM | 19,314.02 | 4.08% | 11,890.86 | 2.73% |
| RR | 2,535.48 | 0.54% | 92,315.94 | 21.20% |
| RVL | 15,380.31 | 3.25% | 11,070.77 | 2.54% |
| UNK | 324.26 | 0.07% | 30,274.80 | 6.95% |
| WAT | 4,549.20 | 0.96% | 265.44 | 0.06% |
| TOTAL | 473,067.05 | 100.00% | 435,537.20 | 100.00% |

Table 5-2. Generalized future land use (FLU) area by county, with surface water and conservation removed: Osceola and Seminole Counties

| | OSCEOLA | | SEMINOLE | |
|---|---|---|---|---|
| FLU | Acres | % of Total | Acres | % of Total |
| AG | 518,987.27 | 79.61% | 3,916.08 | 2.42% |
| COM | 16,387.70 | 2.51% | 5,599.68 | 3.46% |
| CONS | 17,805.17 | 2.73% | 37,896.01 | 23.44% |
| FED | 0.00 | 0.00% | 0.00 | 0.00% |
| IND | 4,348.85 | 0.67% | 4,579.51 | 2.83% |
| INST | 4,215.43 | 0.65% | 7,914.97 | 4.90% |
| MDR | 0.00 | 0.00% | 0.00 | 0.00% |
| LOD | 0.00 | 0.00% | 0.00 | 0.00% |
| MU | 1,391.63 | 0.21% | 8,196.35 | 5.07% |
| OFF | 168.38 | 0.03% | 473.41 | 0.29% |
| PD | 4,019.88 | 0.62% | 12,375.88 | 7.66% |
| REC | 606.58 | 0.09% | 1,418.62 | 0.88% |
| RH | 2,383.87 | 0.37% | 1,109.21 | 0.69% |
| RL | 55,256.22 | 8.48% | 25,862.15 | 16.00% |
| RM | 8,476.89 | 1.30% | 5,920.68 | 3.66% |
| RR | 11,380.12 | 1.75% | 16,045.65 | 9.93% |
| RVL | 5,141.93 | 0.79% | 13,063.15 | 8.08% |
| UNK | 714.61 | 0.11% | 15,581.56 | 9.64% |
| WAT | 656.06 | 0.10% | 1,704.35 | 1.05% |
| TOTAL | 651,940.59 | 100.00% | 161,657.26 | 100.00% |

Table 5-3. Generalized future land use (FLU) area (acres and percent) by county, with surface water and conservation removed: Volusia and Brevard Counties

| | VOLUSIA | | BREVARD | |
|---|---|---|---|---|
| FLU | Acres | % of county | Acres | % of county |
| AG | 145,292.92 | 27.85% | 93,441.72 | 24.12% |
| COM | 11,985.22 | 2.30% | 20,074.18 | 5.18% |
| CONS | 125,776.52 | 24.11% | 8,147.15 | 2.10% |
| FED | 0.00 | 0.00% | 6,149.98 | 1.59% |
| IND | 11,299.77 | 2.17% | 13,469.71 | 3.48% |
| INST | 11,229.98 | 2.15% | 11,237.97 | 2.90% |
| MDR | 0.00 | 0.00% | 0.00 | 0.00% |
| LOD | 338.12 | 0.06% | 0.00 | 0.00% |
| MU | 14,888.94 | 2.85% | 7,557.72 | 1.95% |
| OFF | 1,898.14 | 0.36% | 249.61 | 0.06% |
| PD | 1,917.19 | 0.37% | 9,832.30 | 2.54% |
| REC | 4,357.01 | 0.84% | 7,084.16 | 1.83% |
| RH | 1,378.64 | 0.26% | 14,253.28 | 3.68% |
| RL | 75,447.53 | 14.46% | 109,724.48 | 28.32% |
| RM | 49,156.02 | 9.42% | 16,739.74 | 4.32% |
| RR | 1,688.43 | 0.32% | 18,508.02 | 4.78% |
| RVL | 57,819.55 | 11.08% | 50,365.14 | 13.00% |
| UNK | 154.38 | 0.03% | 416.96 | 0.11% |
| WAT | 7,000.68 | 1.34% | 184.40 | 0.05% |
| TOTAL | 521,629.04 | 100.00% | 387,436.53 | 100.00% |

Table 5-4. Regional generalized future land use (FLU) area, with surface water and conservation removed

| | REGION | |
|---|---|---|
| FLU | Acres | % of Total |
| AG | 927,391.31 | 35.25% |
| COM | 76,346.38 | 2.90% |
| CONS | 219,855.76 | 8.36% |
| FED | 6,149.98 | 0.23% |
| IND | 71,036.54 | 2.70% |
| INST | 71,153.21 | 2.70% |
| MDR | 0.00 | 0.00% |
| LOD | 2,925.82 | 0.11% |
| MU | 103,535.82 | 3.93% |
| OFF | 9,034.04 | 0.34% |
| PD | 45,460.45 | 1.73% |
| REC | 22,842.21 | 0.87% |
| RH | 35,785.06 | 1.36% |
| RL | 571,111.66 | 21.70% |
| RM | 111,498.22 | 4.24% |
| RR | 142,473.63 | 5.41% |
| RVL | 152,840.86 | 5.81% |
| UNK | 47,466.57 | 1.80% |
| WAT | 14,360.13 | 0.55% |
| TOTAL | 2,631,267.66 | 100.00% |

Table 5-5. Vacant and greenfield parcel area by county, with surface water and conservation removed: Orange and Lake Counties

| | | ORANGE | | LAKE | |
|---|---|---|---|---|---|
| Code | Description | Acres | % of county | Acres | % of county |
| 0 | Vacant Residential | 36,828.70 | 17.55% | 49,550.80 | 19.83% |
| 10 | Vacant Commercial | 9,913.18 | 4.72% | 5,197.31 | 2.08% |
| 40 | Vacant Industrial | 3,727.83 | 1.78% | 1,292.12 | 0.52% |
| | Greenfield | 159,396.18 | 75.95% | 193,833.61 | 77.57% |
| | Total | 209,865.89 | 100.00% | 249,873.85 | 100.00% |

Table 5-6. Vacant and greenfield parcel area by county, with surface water and conservation removed: Osceola and Seminole Counties

| | | OSCEOLA | | SEMINOLE | |
|---|---|---|---|---|---|
| Code | Description | Acres | % of county | Acres | % of county |
| 0 | Vacant Residential | 36,862.10 | 6.50% | 3,184.86 | 7.90% |
| 10 | Vacant Commercial | 6,325.04 | 1.12% | 2,927.58 | 7.26% |
| 40 | Vacant Industrial | 809.35 | 0.14% | 1,150.52 | 2.85% |
| | Greenfield | 523,226.68 | 92.24% | 33,050.53 | 81.98% |
| | Total | 567,223.17 | 100.00% | 40,313.49 | 100.00% |

Table 5-7. Vacant and greenfield parcel area by county, with surface water and conservation removed: Volusia and Brevard Counties

| | | VOLUSIA | | BREVARD | |
|---|---|---|---|---|---|
| Code | Description | Acres | % of county | Acres | % of county |
| 0 | Vacant Residential | 64,686.70 | 22.02% | 47,622.85 | 23.06% |
| 10 | Vacant Commercial | 7,009.62 | 2.39% | 7,171.45 | 3.47% |
| 40 | Vacant Industrial | 1,727.51 | 0.59% | 5,478.73 | 2.65% |
| | Greenfield | 220,362.49 | 75.01% | 146,288.51 | 70.82% |
| | Total | 293,786.32 | 100.00% | 206,561.54 | 100.00% |

Table 5-8. Regional vacant and greenfield parcel area, with surface water and conservation removed

| | | REGION | |
|---|---|---|---|
| Code | Description | Acres | % of total region |
| 0 | Vacant Residential | 238,736.01 | 15.23% |
| 10 | Vacant Commercial | 38,544.18 | 2.46% |
| 40 | Vacant Industrial | 14,186.06 | 0.90% |

Table 5-8. Continued

| Code | Description | REGION Acres | % of total |
|---|---|---|---|
| | Greenfield | 1,276,158.01 | 81.41% |
| | Total | 1,567,624.26 | 100.00% |

Table 5-9. Percent of total county and region land (all land uses, with conservation and surface water over five acres removed) considered vacant and greenfield

| County | Total Acres Vacant and Greenfield | Percent of total county land (with conservation and surface water over five acres removed) |
|---|---|---|
| Orange | 209,865.89 | 44.36% |
| Lake | 249,873.85 | 57.37% |
| Osceola | 567,223.17 | 87.01% |
| Seminole | 40,313.49 | 24.94% |
| Volusia | 293,786.32 | 56.32% |
| Brevard | 206,561.54 | 53.31% |
| Region | 1,567,624.26 | 59.58% |

Table 5-10. Area of FLUM designations within vacant and greenfield (Vac/GF) parcels, with conservation land and surface water over five acres removed: Orange and Lake Counties

| | ORANGE | | LAKE | |
|---|---|---|---|---|
| FLU | Acres | % of Total Vac/GF | Acres | % of Total Vac/GF |
| AG | 97,169.40 | 56.03% | 21,680.62 | 10.22% |
| COM | 3,458.01 | 1.99% | 2,472.76 | 1.17% |
| CONS | 5,853.59 | 3.38% | 3,598.12 | 1.70% |
| FED | 0.00 | 0.00% | 0.00 | 0.00% |
| IND | 8,191.47 | 4.72% | 2,648.96 | 1.25% |
| INST | 403.22 | 0.23% | 151.03 | 0.07% |
| LOD | 338.15 | 0.19% | 0.00 | 0.00% |
| MU | 21,592.04 | 12.45% | 6,903.44 | 3.25% |
| OFF | 843.01 | 0.49% | 1,311.30 | 0.62% |
| PD | 6,780.91 | 3.91% | 534.54 | 0.25% |
| REC | 1,961.25 | 1.13% | 17.57 | 0.01% |
| RH | 2,019.91 | 1.16% | 461.64 | 0.22% |
| RL | 15,332.38 | 8.84% | 100,439.82 | 47.34% |
| RM | 3,687.88 | 2.13% | 2,728.51 | 1.29% |
| RR | 665.62 | 0.38% | 55,464.75 | 26.14% |
| RVL | 3,631.36 | 2.09% | 6,018.63 | 2.84% |
| UNK | 78.36 | 0.05% | 7,721.52 | 3.64% |
| WAT | 1,424.10 | 0.82% | 11.40 | 0.01% |
| TOTAL | 173,430.68 | 100.00% | 212,164.60 | 100.00% |

Table 5-11. Area of FLUM designations within vacant and greenfield (Vac/GF) parcels, with conservation land and surface water over five acres removed: Osceola and Seminole Counties

| | OSCEOLA | | SEMINOLE | |
|---|---|---|---|---|
| FLU | Acres | % of Total Vac/GF | Acres | % of Total Vac/GF |
| AG | 478,102.71 | 89.55% | 2,774.10 | 11.01% |
| COM | 6,476.00 | 1.21% | 1,116.10 | 4.43% |
| CONS | 7,818.64 | 1.46% | 8,314.00 | 32.98% |
| FED | 0.00 | 0.00% | 0.00 | 0.00% |
| IND | 1,527.16 | 0.29% | 1,161.22 | 4.61% |
| INST | 490.13 | 0.09% | 929.69 | 3.69% |
| LOD | 0.00 | 0.00% | 0.00 | 0.00% |
| MU | 688.18 | 0.13% | 1,580.59 | 6.27% |
| OFF | 7.84 | 0.00% | 94.51 | 0.37% |
| PD | 1,720.46 | 0.32% | 717.63 | 2.85% |
| REC | 213.01 | 0.04% | 9.50 | 0.04% |
| RH | 1,432.88 | 0.27% | 101.87 | 0.40% |
| RL | 19,458.39 | 3.64% | 1,770.33 | 7.02% |
| RM | 3,531.15 | 0.66% | 445.73 | 1.77% |
| RR | 9,529.36 | 1.78% | 4,628.26 | 18.36% |
| RVL | 2,660.83 | 0.50% | 1,243.86 | 4.93% |
| UNK | 91.43 | 0.02% | 298.74 | 1.19% |
| WAT | 154.35 | 0.03% | 19.71 | 0.08% |
| TOTAL | 533,902.53 | 100.00% | 25,205.83 | 100.00% |

Table 5-12. Area of FLUM designations within vacant and greenfield (Vac/GF) parcels, with conservation land and surface water over five acres removed: Volusia and Brevard Counties

| | VOLUSIA | | BREVARD | |
|---|---|---|---|---|
| FLU | Acres | % of Total Vac/GF | Acres | % of Total Vac/GF |
| AG | 118,795.88 | 42.13% | 80,089.50 | 44.88% |
| COM | 3,175.43 | 1.13% | 5,062.82 | 3.18% |
| CONS | 88,022.84 | 31.22% | 1,498.66 | 0.91% |
| FED | 0.00 | 0.00% | 10.21 | 0.00% |
| IND | 4,401.00 | 1.56% | 3,892.10 | 2.31% |
| INST | 375.20 | 0.13% | 461.64 | 0.29% |
| LOD | 91.90 | 0.03% | 0.00 | 0.00% |
| MU | 7,492.84 | 2.66% | 1,447.13 | 0.88% |
| OFF | 645.91 | 0.23% | 90.95 | 0.06% |
| PD | 1,126.31 | 0.40% | 4,973.77 | 2.94% |
| REC | 174.30 | 0.06% | 648.76 | 0.40% |
| RH | 241.98 | 0.09% | 2,415.05 | 1.57% |
| RL | 19,470.02 | 6.91% | 33,710.52 | 20.73% |
| RM | 10,869.40 | 3.86% | 2,098.27 | 1.38% |
| RR | 772.48 | 0.27% | 10,158.89 | 6.02% |
| RVL | 25,741.56 | 9.13% | 23,341.71 | 14.41% |
| UNK | 532.17 | 0.19% | 28.26 | 0.02% |

Table 5-12. Continued

| | VOLUSIA | | BREVARD | |
|---|---|---|---|---|
| FLU | Acres | % of Total Vac/GF | Acres | % of Total Vac/GF |
| WAT | 16.39 | 0.01% | 0.71 | 0.00% |
| TOTAL | 281,945.60 | 100.00% | 169,928.97 | 100.00% |

Table 5-13. Regional area of FLUM designations within vacant and greenfield (Vac/GF) parcels, with conservation land and surface water over five acres removed

| | REGION | |
|---|---|---|
| FLU | Acres | % of Total Vac/GF |
| AG | 798,612.21 | 57.18% |
| COM | 21,761.12 | 1.56% |
| CONS | 115,105.86 | 8.24% |
| FED | 10.21 | 0.00% |
| IND | 21,821.91 | 1.56% |
| INST | 2,810.91 | 0.20% |
| LOD | 430.06 | 0.03% |
| MU | 39,704.22 | 2.84% |
| OFF | 2,993.53 | 0.21% |
| PD | 15,853.62 | 1.14% |
| REC | 3,024.40 | 0.22% |
| RH | 6,673.33 | 0.48% |
| RL | 190,181.45 | 13.62% |
| RM | 23,360.94 | 1.67% |
| RR | 81,219.37 | 5.82% |
| RVL | 62,637.96 | 4.49% |
| UNK | 8,750.47 | 0.63% |
| WAT | 1,626.65 | 0.12% |
| TOTAL | 1,396,578.22 | 100.00% |

Table 5-14. Total area of urban future land use (FLU) designations in vacant and greenfield lands (surface waters and conservation lands removed)

| County | Total urban FLU acres | % of total vacant and greenfield |
|---|---|---|
| Brevard | 87,652.86 | 51.58% |
| Orange | 66,943.97 | 38.60% |
| Osceola | 47,522.39 | 8.90% |
| Seminole | 13,789.78 | 54.71% |
| Volusia | 74,404.03 | 26.39% |
| Lake | 198,337.30 | 82.79% |
| Region | 488,650.34 | 34.32% |

Table 5-15. Conflict analysis of region, including both occupied and vacant and greenfield lands

| CONFLICT | Acres | Percent of Total Land |
|---|---|---|
| Agriculture Preferred | 836,865.51 | 24.73% |
| Conservation Preferred | 609,189.49 | 18.00% |
| Urban Preferred | 862,674.11 | 25.49% |
| Agriculture-Conservation Conflict | 384,765.41 | 11.37% |
| Agriculture-Urban Conflict | 408,859.41 | 12.08% |
| Conservation-Urban Conflict | 83,971.64 | 2.48% |
| High Conflict | 82,822.03 | 2.45% |
| Medium Conflict | 114,759.06 | 3.39% |
| Low Conflict | 117.79 | 0.00% |
| Total | 3,384,024.45 | 100.00% |

Calculations include surface waters and conservation lands.

Table 5-16. Conflict analysis: vacant and greenfield (Vac/GF) land with conservation and surface water removed from analysis: Orange and Lake Counties

| | ORANGE | | LAKE | |
|---|---|---|---|---|
| Preference Category | Acres | Percentage of Vac/GF | Acres | Percentage of Vac/GF |
| Urban Preference | 34,846.57 | 20.09% | 32,110.46 | 15.13% |
| Conservation Preference | 500.35 | 0.29% | 2,104.92 | 0.99% |
| Agriculture Preference | 80,019.45 | 46.14% | 71,321.22 | 33.62% |
| High Conflict | 1,412.22 | 0.81% | 1,624.05 | 0.77% |
| Medium Conflict | 3,048.38 | 1.76% | 9,465.96 | 4.46% |
| Low Conflict | 0.95 | 0.00% | 3.09 | 0.00% |
| Agriculture-Conservation High Conflict | 6,914.13 | 3.99% | 11,552.83 | 5.45% |
| Agriculture-Conservation Medium Conflict | 90.95 | 0.05% | 264.54 | 0.12% |
| Agriculture-Urban High Conflict | 44,419.15 | 25.61% | 79,012.34 | 37.24% |
| Agriculture-Urban Medium Conflict | 615.99 | 0.36% | 2,962.42 | 1.40% |
| Conservation-Urban High Conflict | 862.48 | 0.50% | 781.27 | 0.37% |
| Conservation-Urban Medium Conflict | 700.06 | 0.40% | 961.51 | 0.45% |
| TOTAL | 173,430.68 | 100.00% | 212,164.60 | 100.00% |

Table 5-17. Conflict analysis: vacant and greenfield (Vac/GF) land with conservation and surface water removed from analysis: Osceola and Seminole Counties

| | OSCEOLA | | SEMINOLE | |
|---|---|---|---|---|
| Preference Category | Acres | Percentage of Vac/GF | Acres | Percentage of Vac/GF |
| Urban Preference | 20,946.12 | 3.92% | 5,339.24 | 21.18% |
| Conservation Preference | 2,133.89 | 0.40% | 65.07 | 0.26% |
| Agriculture Preference | 435,408.52 | 81.55% | 6,476.23 | 25.69% |
| High Conflict | 1,913.28 | 0.36% | 1,047.24 | 4.15% |
| Medium Conflict | 9,973.43 | 1.87% | 69.34 | 0.28% |
| Low Conflict | 0.00 | 0.00% | 0.00 | 0.00% |
| Agriculture-Conservation High Conflict | 19,384.54 | 3.63% | 4,597.86 | 18.24% |
| Agriculture-Conservation Medium Conflict | 1,742.54 | 0.33% | 1.19 | 0.00% |
| Agriculture-Urban High Conflict | 39,424.49 | 7.38% | 7,055.42 | 27.99% |
| Agriculture-Urban Medium Conflict | 1,919.46 | 0.36% | 1.90 | 0.01% |
| Conservation-Urban High Conflict | 817.60 | 0.15% | 526.47 | 2.09% |
| Conservation-Urban Medium Conflict | 238.66 | 0.04% | 25.88 | 0.10% |
| TOTAL | 533,902.53 | 100.00% | 25,205.83 | 100.00% |

Table 5-18. Conflict analysis: vacant and greenfield (Vac/GF) land with conservation and surface water removed from analysis: Osceola and Seminole Counties

| | VOLUSIA | | BREVARD | |
|---|---|---|---|---|
| Preference Category | Acres | Percentage of Vac/GF | Acres | Percentage of Vac/GF |
| Urban Preference | 31,320.64 | 11.11% | 32,740.46 | 19.27% |
| Conservation Preference | 14,498.15 | 5.14% | 1,867.45 | 1.10% |
| Agriculture Preference | 124,206.12 | 44.05% | 94,665.06 | 55.71% |
| High Conflict | 2,045.79 | 0.73% | 1,026.58 | 0.60% |
| Medium Conflict | 15,259.00 | 5.41% | 6,719.16 | 3.95% |
| Low Conflict | 0.95 | 0.00% | 11.87 | 0.01% |
| Agriculture-Conservation High Conflict | 42,818.85 | 15.19% | 12,588.91 | 7.41% |
| Agriculture-Conservation Medium Conflict | 3,206.30 | 1.14% | 777.95 | 0.46% |
| Agriculture-Urban High Conflict | 41,605.63 | 14.76% | 15,448.50 | 9.09% |
| Agriculture-Urban Medium Conflict | 556.86 | 0.20% | 2,711.65 | 1.60% |
| Conservation-Urban High Conflict | 1,177.13 | 0.42% | 697.44 | 0.41% |
| Conservation-Urban Medium Conflict | 5,250.19 | 1.86% | 673.93 | 0.40% |
| TOTAL | 281,945.60 | 100.00% | 169,928.97 | 100.00% |

Table 5-19. Regional conflict analysis: vacant and greenfield (Vac/GF) land with conservation and surface water removed from analysis

| Preference Category | REGION Acres | Percentage of Vac/GF |
|---|---|---|
| Urban Preference | 157,303.49 | 11.26% |
| Conservation Preference | 21,169.82 | 1.52% |
| Agriculture Preference | 812,096.60 | 58.15% |
| High Conflict | 9,069.15 | 0.65% |
| Medium Conflict | 44,535.27 | 3.19% |
| Low Conflict | 16.86 | 0.00% |
| Agriculture-Conservation High Conflict | 97,857.12 | 7.01% |
| Agriculture-Conservation Medium Conflict | 6,083.46 | 0.44% |
| Agriculture-Urban High Conflict | 226,965.53 | 16.25% |
| Agriculture-Urban Medium Conflict | 8,768.28 | 0.63% |
| Conservation-Urban High Conflict | 4,862.40 | 0.35% |
| Conservation-Urban Medium Conflict | 7,850.23 | 0.56% |
| TOTAL | 1,396,578.22 | 100.00% |

Table 5-20. Percent age of urban future land use (FLU) designations within specific conflict categories (in vacant and greenfield land with conservation lands and surface waters removed)

| County | % in urban preferred | % in urb-ag high conflict | % in cons-urb high conflict | % in high conflict | Total |
|---|---|---|---|---|---|
| Brevard | 35.57% | 14.76% | 0.49% | 0.99% | 51.81% |
| Orange | 45.29% | 39.27% | 0.98% | 0.67% | 86.21% |
| Osceola | 33.05% | 41.48% | 0.38% | 1.07% | 75.98% |
| Seminole | 32.16% | 40.09% | 1.81% | 3.05% | 77.12% |
| Volusia | 37.34% | 25.39% | 0.97% | 0.50% | 64.21% |
| Lake | 15.55% | 40.23% | 0.53% | 2.97% | 59.28% |
| Region | 28.69% | 34.68% | 0.68% | 1.74% | 65.79% |

Table 5-21. Region vacant and greenfield: Area and percent of select future land use (FLU) within conflict urban, conservation, and agriculture preferred categories (surface water and conservation lands removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 10,446.47 | 1.29% | 4,682.40 | 0.58% | 651,714.34 | 80.79% |
| CONS | 4,314.32 | 3.73% | 12,622.86 | 10.92% | 35,522.64 | 30.73% |
| COM | 15,283.70 | 69.90% | 7.12 | 0.03% | 866.52 | 3.96% |

Table 5-21. Continued

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| IND | 11,939.19 | 53.37% | 7.36 | 0.03% | 2,290.86 | 10.24% |
| INST | 1,157.18 | 39.60% | 1.19 | 0.04% | 747.79 | 25.59% |
| MU | 11,431.25 | 28.75% | 86.20 | 0.22% | 4,866.91 | 12.24% |
| OFF | 1,334.10 | 43.67% | 0.00 | 0.00% | 270.00 | 8.84% |
| PD | 5,632.51 | 35.58% | 14.96 | 0.09% | 1,595.07 | 10.08% |
| RH | 3,789.52 | 56.48% | 12.59 | 0.19% | 954.38 | 14.23% |
| RL | 55,049.89 | 27.38% | 1,959.35 | 0.97% | 53,235.40 | 26.48% |
| RM | 13,411.50 | 56.21% | 116.60 | 0.49% | 2,199.91 | 9.22% |
| RR | 6,526.10 | 7.45% | 973.14 | 1.11% | 32,245.58 | 36.80% |
| RVL | 14,518.10 | 22.97% | 1,037.26 | 1.64% | 17,748.85 | 28.08% |

Table 5-22. Brevard County vacant and greenfield: Area and percent of select future land use (FLU) categories within conflict urban, conservation, and agriculture preferred categories (surface water and conservation lands removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 617.18 | 0.77% | 667.76 | 0.83% | 64,754.27 | 80.85% |
| CONS | 744.70 | 49.69% | 62.93 | 4.20% | 38.23 | 2.55% |
| COM | 3,586.01 | 70.83% | 0.71 | 0.01% | 136.07 | 2.69% |
| IND | 3,431.89 | 88.18% | 0.00 | 0.00% | 206.36 | 5.30% |
| INST | 370.69 | 80.30% | 0.47 | 0.10% | 15.44 | 3.34% |
| MU | 1,427.90 | 98.67% | 0.00 | 0.00% | 0.00 | 0.00% |
| OFF | 75.75 | 83.29% | 0.00 | 0.00% | 1.66 | 1.83% |
| PD | 1,258.58 | 25.30% | 9.74 | 0.20% | 11.64 | 0.23% |
| RH | 1,557.08 | 64.47% | 2.14 | 0.09% | 370.69 | 15.35% |
| RL | 11,426.26 | 33.90% | 328.18 | 0.97% | 13,796.67 | 40.93% |
| RM | 1,682.70 | 80.19% | 3.09 | 0.15% | 27.55 | 1.31% |
| RR | 1,579.40 | 15.55% | 135.12 | 1.33% | 7,047.35 | 69.37% |
| RVL | 4,779.76 | 20.48% | 648.29 | 2.78% | 7,859.49 | 33.67% |

Table 5-23. Orange County vacant and greenfield: Area and percent of select future land use (FLU) within conflict urban, conservation, and agriculture preferred categories (surface water and conservation lands removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 2,857.93 | 2.94% | 227.49 | 0.23% | 69,926.81 | 71.96% |
| CONS | 1,057.21 | 18.06% | 20.18 | 0.34% | 1,824.71 | 31.17% |
| COM | 2,461.12 | 71.17% | 0.00 | 0.00% | 210.63 | 6.09% |
| IND | 4,042.66 | 49.35% | 1.19 | 0.01% | 920.66 | 11.24% |
| INST | 141.06 | 34.98% | 0.00 | 0.00% | 83.35 | 20.67% |

Table 5-23. Continued

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| MU | 5,375.81 | 24.90% | 74.09 | 0.34% | 3,037.46 | 14.07% |
| OFF | 646.86 | 76.73% | 0.00 | 0.00% | 20.18 | 2.39% |
| PD | 3,085.90 | 45.51% | 0.00 | 0.00% | 813.57 | 12.00% |
| RH | 1,506.02 | 74.56% | 1.90 | 0.09% | 35.15 | 1.74% |
| RL | 9,080.79 | 59.23% | 130.85 | 0.85% | 542.38 | 3.54% |
| RM | 2,177.58 | 59.05% | 23.98 | 0.65% | 703.86 | 19.09% |
| RR | 132.74 | 19.94% | 0.00 | 0.00% | 140.58 | 21.12% |
| RVL | 1,515.52 | 41.73% | 6.65 | 0.18% | 439.08 | 12.09% |

Table 5-24. Osceola County vacant and greenfield: Area and percent of select future land use (FLU) within conflict urban, conservation, and agriculture preferred categories (surface water and conservation lands removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 4,187.75 | 0.88% | 1,534.99 | 0.32% | 424,260.34 | 88.74% |
| CONS | 899.05 | 11.50% | 534.78 | 6.84% | 2,178.06 | 27.86% |
| COM | 4,092.77 | 63.20% | 4.75 | 0.07% | 285.91 | 4.41% |
| IND | 814.28 | 53.32% | 0.24 | 0.02% | 123.48 | 8.09% |
| INST | 248.39 | 50.68% | 0.00 | 0.00% | 86.68 | 17.68% |
| MU | 65.07 | 9.45% | 0.00 | 0.00% | 15.44 | 2.24% |
| OFF | 7.84 | 100.00% | 0.00 | 0.00% | 0.00 | 0.00% |
| PD | 606.97 | 35.28% | 0.24 | 0.01% | 0.00 | 0.00% |
| RH | 217.52 | 15.18% | 3.56 | 0.25% | 546.65 | 38.15% |
| RL | 8,109.54 | 41.68% | 52.01 | 0.27% | 3,066.43 | 15.76% |
| RM | 1,208.24 | 34.22% | 0.00 | 0.00% | 451.66 | 12.79% |
| RR | 119.92 | 1.26% | 0.00 | 0.00% | 3,384.40 | 35.52% |
| RVL | 213.96 | 8.04% | 0.71 | 0.03% | 802.17 | 30.15% |

Table 5-25. Seminole County vacant and greenfield: Area and percent of select future land use (FLU) within conflict urban, conservation, and agriculture preferred categories (surface water and conservation lands removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 1.90 | 0.07% | 0.24 | 0.01% | 1,796.45 | 64.76% |
| CONS | 710.27 | 8.54% | 31.35 | 0.38% | 1,983.57 | 23.86% |
| COM | 719.29 | 64.45% | 0.00 | 0.00% | 31.11 | 2.79% |
| IND | 676.31 | 58.24% | 0.00 | 0.00% | 210.40 | 18.12% |
| INST | 8.07 | 0.87% | 0.00 | 0.00% | 547.60 | 58.90% |
| MU | 996.18 | 63.03% | 1.42 | 0.09% | 94.51 | 5.98% |
| OFF | 78.13 | 82.66% | 0.00 | 0.00% | 0.00 | 0.00% |

Table 5-25. Continued

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| PD | 412.48 | 57.48% | 0.00 | 0.00% | 23.51 | 3.28% |
| RH | 74.80 | 73.43% | 0.00 | 0.00% | 0.00 | 0.00% |
| RL | 733.78 | 41.45% | 20.66 | 1.17% | 108.05 | 6.10% |
| RM | 308.00 | 69.10% | 0.47 | 0.11% | 10.45 | 2.34% |
| RR | 133.69 | 2.89% | 2.37 | 0.05% | 1,469.22 | 31.74% |
| RVL | 293.75 | 23.62% | 7.84 | 0.63% | 169.79 | 13.65% |

Table 5-26. Volusia County vacant and greenfield: Area and percent of select future land use (FLU) within conflict urban, conservation, and agriculture preferred categories (surface water and conservation removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 2,524.53 | 2.13% | 2,076.66 | 1.75% | 75,321.14 | 63.40% |
| CONS | 2,491.04 | 78.45% | 1.19 | 0.04% | 91.19 | 2.87% |
| COM | 1,667.74 | 37.89% | 0.95 | 0.02% | 539.05 | 12.25% |
| IND | 275.70 | 73.48% | 0.00 | 0.00% | 11.40 | 3.04% |
| INST | 2,460.17 | 32.83% | 3.80 | 0.05% | 1,200.40 | 16.02% |
| MU | 295.89 | 45.81% | 0.00 | 0.00% | 86.20 | 13.35% |
| OFF | 205.65 | 18.26% | 2.85 | 0.25% | 534.54 | 47.46% |
| PD | 171.45 | 70.85% | 0.00 | 0.00% | 1.19 | 0.49% |
| RH | 6,482.41 | 33.29% | 101.16 | 0.52% | 8,737.41 | 44.88% |
| RL | 6,689.24 | 61.54% | 50.82 | 0.47% | 933.96 | 8.59% |
| RM | 180.24 | 23.33% | 11.16 | 1.44% | 164.80 | 21.33% |
| RR | 6,831.49 | 26.54% | 369.03 | 1.43% | 7,266.77 | 28.23% |
| RVL | 293.75 | 23.62% | 7.84 | 0.63% | 169.79 | 13.65% |

Table 5-27. Lake County vacant and greenfield: Area and percent of select future land use (FLU) within conflict urban, conservation, and agriculture preferred categories (surface water and conservation removed)

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| AG | 257.18 | 0.86% | 175.25 | 0.59% | 15,655.33 | 52.61% |
| CONS | 132.51 | 3.24% | 140.82 | 3.44% | 312.98 | 7.65% |
| COM | 1,933.47 | 75.08% | 0.47 | 0.02% | 111.61 | 4.33% |
| IND | 113.27 | 43.21% | 0.71 | 0.27% | 3.32 | 1.27% |
| INST | 1,106.13 | 15.91% | 6.89 | 0.10% | 519.11 | 7.47% |
| MU | 62.93 | 12.29% | 2.14 | 0.42% | 211.82 | 41.37% |
| OFF | 11.40 | 64.00% | 0.00 | 0.00% | 0.00 | 0.00% |
| PD | 262.64 | 52.82% | 4.99 | 1.00% | 0.71 | 0.14% |
| RH | 1,345.73 | 41.69% | 38.23 | 1.18% | 72.43 | 2.24% |

Table 5-27. Continued

| FLU | Urban Preferred | | Conservation Preferred | | Agriculture Preferred | |
|---|---|---|---|---|---|---|
| | Acres | % of total FLU | Acres | % of total FLU | Acres | % of total FLU |
| RL | 4,380.10 | 7.08% | 808.58 | 1.31% | 20,039.24 | 32.39% |
| RM | 883.62 | 13.43% | 4.75 | 0.07% | 1,211.56 | 18.41% |
| RR | 1,130.82 | 15.37% | 1.90 | 0.03% | 2,364.95 | 32.14% |
| RVL | 10.45 | 78.57% | 0.00 | 0.00% | 0.00 | 0.00% |

Table 5-28. Existing vacant and greenfield area within Lake County

| Land Use | Acres |
|---|---|
| Vacant Platted Residential | 48,441.39 |
| Vacant Platted Service | 5,131.30 |
| Vacant Platted Industrial | 1,235.82 |
| Greenfield | 191,536.22 |
| Total | 246,344.73 |

Table 5-29. Projected population and employment growth through 2035 in Lake County

| Category | Existing population/employment | Projected New Population/Employee Growth through 2035 | Total Population/Employees through 2035 |
|---|---|---|---|
| Residential | 263,642 | 240,858 | 504,500 |
| Commercial | 24,283 | 7,793 | 32,076 |
| Service | 57,493 | 64,620 | 122,113 |
| Industrial | 19,808 | 12,010 | 31,818 |

Source: Adapted from projections created by the Bureau of Economic and Business Research and TAZ data

Table 5-30. Existing land use population, area, and gross density in Lake County

| Land Use | Existing acreage | Existing population | County Gross Density |
|---|---|---|---|
| Single Family | 91,381.72 | 238,897 | 2.61 |
| Multi-Family | 1,452.90 | 24,745 | 17.03 |
| Commercial | 10,161.22 | 24,283 | 2.39 |
| Service | 5,615.38 | 57,493 | 10.24 |
| Industrial | 17,284.88 | 19,808 | 1.15 |

Table 5-31. Trend scenario allocation into vacant platted land; Lake County

| Land Use Category | Acres Allocated | Population/Employees Allocated |
|---|---|---|
| Commercial | 1,024.22 | 4,301 |
| Service | 4,013.29 | 64,627 |
| Industry | 1,235.82 | 2,432 |
| Multi-Family | 843.98 | 14,834 |
| Single Family | 47,273.51 | 111,174 |

Table 5-32. Trend scenario greenfield allocation totals; Lake County

| Land Use | Acreage | Population/Employees | % of Greenfield |
|---|---|---|---|
| Commercial | 506.04 | 3,432 | 0.27% |
| Service | 0.00 | 0 | 0.00% |
| Industry | 11,838.00 | 9,975 | 6.31% |
| Multi-Family | 374.49 | 5,438 | 0.20% |
| Single Family | 43,211.70 | 82,669 | 23.04% |
| Vacant Commercial | 2,404.83 | n/a | 1.28% |
| Vacant Service | 7,712.23 | n/a | 4.11% |
| Vacant Industry | 2,265.68 | n/a | 1.21% |
| Vacant Residential | 96,119.81 | n/a | 46.31% |
| Agriculture | 7,892.94 | n/a | 4.21% |
| Agricultural Preservation | 23,647.00 | n/a | 12.61% |
| Conservation | 848.71 | n/a | 0.45% |

Table 5-33. Summary of trend scenario allocations; Lake County

| Land Use | Vacant Platted (ac) | Greenfield (ac) | Total |
|---|---|---|---|
| Commercial | 1,024.22 | 506.04 | 1,530.26 |
| Service | 4,013.29 | 0.00 | 4,013.29 |
| Industry | 1,235.82 | 11,838.00 | 13,073.82 |
| Multi-Family | 843.98 | 374.49 | 1,218.47 |
| Single Family | 47,273.51 | 43,211.70 | 90,485.21 |
| Vacant Commercial | 0.00 | 2,404.83 | 2,404.83 |
| Vacant Service | 0.00 | 7,712.23 | 7,712.23 |
| Vacant Industry | 0.00 | 2,265.68 | 2,265.68 |
| Vacant Residential | 0.00 | 96,119.81 | 96,119.81 |
| Agriculture | 0.00 | 7,892.94 | 7,892.94 |
| Agricultural Preservation | 0.00 | 23,647.00 | 23,647.00 |
| Conservation | 0.00 | 848.71 | 848.71 |

Table 5-34. Trend scenario combined totals of allocated land (all allocations, including vacant platted and greenfield) plus existing land use area and population

| Land Use | Acres | Population/Employees |
|---|---|---|
| Commercial | 11,691.49 | 32,016 |
| Service | 9,628.67 | 122,120 |
| Industry | 30,358.70 | 32,215 |
| Multi-Family | 2,671.36 | 45,017 |
| Single Family | 181,866.93 | 432,740 |
| Vacant Commercial | 2,404.83 | n/a |
| Vacant Service | 7,712.23 | n/a |
| Vacant Industry | 2,265.68 | n/a |
| Vacant Residential | 96,119.81 | n/a |
| Agriculture | 23,647.00 | n/a |
| Agricultural Preservation | 7,892.94 | n/a |
| Conservation | 202,022.69 | n/a |

Table 5-35. Established overlay environmental protection zones within vacant and greenfield lands; Lake County

| Protection Zone | Acres |
|---|---|
| Green Swamp Area of Critical State Concern | 32,416.00 |
| Ocala National Forest | 1,057.65 |
| Wekiva River Protection Area | 16,100.20 |
| Lake Apopka LDR | 10,712.70 |
| Wekiva Adopted Study Area | 28,992.60 |
| Total | 89,279.15 |

Table 5-36. Existing conservation and recreation green infrastructure; Lake County

| Green Infrastructure Category | Acres |
|---|---|
| Existing Conservation | 201,173.98 |
| Existing FLU "Recreation" | 1,495.21 |

Table 5-37. Alternative scenario gross densities (residents or employees/acre); Lake County

| Land Use | Existing Average Gross County Density | Mixed Use Density | Minimum Density within Protection Zones | Minimum Density Outside Protection Zones |
|---|---|---|---|---|
| Commercial | 2.39 | 3.11 | 2.39 | 2.87 |
| Service | 10.24 | 13.31 | 10.24 | 12.29 |
| Industry | 1.15 | n/a | 1.15 | 1.38 |
| Multi-Family | 17.03 | 25.55 | 17.03 | 20.44 |
| Single Family | 2.61 | n/a | 2.61 | 3.14 |

Table 5-38. Vacant platted land use alternative scenario allocations (acres); Lake County

| Land Use | Mixed Use Vacant Residential | Mixed Use Vacant Service | Vacant Residential | Vacant Service | Vacant Industrial |
|---|---|---|---|---|---|
| Commercial | 1,535.24 | 960.74 | 0.00 | 0.00 | 0.00 |
| Service | 1,556.26 | 1,103.47 | 0.00 | 1,426.97 | 0.00 |
| Industrial | 0.00 | 0.00 | 0.00 | 0.00 | 1,137.26 |
| Multi-Family | 1,721.61 | 372.03 | 0.00 | 40.61 | 0.00 |
| Single Family | 0.00 | 0.00 | 32,014.45 | 480.41 | 0.00 |
| Conservation | 1,440.04 | 0.71 | 897.17 | 124.67 | 5.46 |
| Agricultural Preservation | 103.06 | 0.71 | 8.79 | 0.95 | 1.19 |
| Total | 6,356.20 | 2,437.66 | 32,920.41 | 2,073.61 | 1,143.91 |

Table 5-39. Vacant platted land use alternative scenario allocations (population and employees); Lake County

| Land Use | Mixed Use Vacant Residential | Mixed Use Vacant Service | Vacant Residential | Vacant Service | Vacant Industrial | Total |
|---|---|---|---|---|---|---|
| Commercial | 4,770 | 2,985 | 0 | 0 | 0 | 7,754 |
| Service | 20,714 | 14,687 | 0 | 29,246 | 0 | 64,647 |
| Industrial | 0 | 0 | 0 | 0 | 3,004 | 3,004 |
| Multi-Family | 43,982 | 9,504 | 0 | 698 | 0.00 | 54,185 |
| Single Family | 0 | 0 | 117,331 | 2,339 | 0.00 | 119,670 |
| Conservation | n/a | n/a | n/a | n/a | n/a | n/a |
| Agricultural Preservation | n/a | n/a | n/a | n/a | n/a | n/a |

Table 5-40. Alternative scenario greenfield allocations; Lake County

| Land Use | Acreage | Population/Employees | % of Greenfield Area |
|---|---|---|---|
| Commercial | 0.00 | 0 | 0.00% |
| Service | 0.00 | 0 | 0.00% |
| Industry | 572.78 | 8,994 | 0.45% |
| Multi-Family | 0.00 | 0 | 0.00% |
| Single Family | 10,145.32 | 42,971 | 7.89% |
| Vacant Commercial | 2,545.00 | n/a | 1.98% |
| Vacant Service | 1,947.99 | n/a | 1.52% |
| Vacant Industry | 3,815.24 | n/a | 2.97% |
| Vacant Residential | 27,511.48 | n/a | 21.41% |
| Agriculture | 70,819.43 | n/a | 55.10% |
| Agricultural Preservation | 10,886.00 | n/a | 8.47% |
| Conservation | 280.46 | n/a | 0.22% |

Table 5-41. Summary of alternative scenario allocations into vacant platted and greenfield land (acres); Lake County

| Land Use | Vacant Platted (ac) | Greenfield (ac) | Total |
|---|---|---|---|
| Commercial | 2,495.98 | 0.00 | 2,495.98 |
| Service | 4,086.69 | 0.00 | 4,086.69 |
| Industry | 1,137.26 | 572.78 | 1,710.04 |
| Multi-Family | 2,134.24 | 0.00 | 2,134.24 |
| Single Family | 32,494.85 | 10,145.32 | 42,640.18 |
| Vacant Commercial | 0.00 | 2,545.00 | 2,545.00 |
| Vacant Service | 0.00 | 1,947.99 | 1,947.99 |
| Vacant Industry | 0.00 | 3,815.24 | 3,815.24 |
| Vacant Residential | 0.00 | 27,511.48 | 27,511.48 |
| Agriculture | 0.00 | 70,819.43 | 70,819.43 |
| Agricultural Preservation | 114.70 | 10,886.00 | 11,000.70 |
| Conservation | 2468.06 | 280.46 | 21,716.36 |

Table 5-42. Alternative scenario combined totals of allocated land (all allocations, including vacant platted and greenfield) plus existing land use area and population; Lake County

| Land Use | Acres | Population/Employees |
|---|---|---|
| Commercial | 12,657.21 | 32,037 |
| Service | 9,702.07 | 122,140 |
| Industry | 18,994.92 | 31,806 |
| Multi-Family | 3,587.14 | 78,930 |
| Single Family | 134,021.90 | 401,538 |
| Vacant Commercial | 2,545.00 | n/a |
| Vacant Service | 1,947.99 | n/a |
| Vacant Industry | 3,815.24 | n/a |
| Vacant Residential | 27,511.48 | n/a |
| Agriculture | 70,819.43 | n/a |
| Agricultural Preservation | 11,000.70 | n/a |
| Conservation | 222,890.34 | n/a |

Table 5-43. Spatial comparison of Lake County FLUM and growth scenario allocations: urban vs. non-urban land use designation

| | Trend Scenario | | Alternative Scenario | |
|---|---|---|---|---|
| Result | Acres | Percent of total | Acres | Percent of Total |
| "-1": Urban in FLUM; Non-urban in scenario | 20,888.13 | 8.81% | 72,029.12 | 41.56% |
| "0": Both urban or both non-urban | 184,469.98 | 77.82% | 91,332.59 | 52.70% |
| "1": Non-urban in FLUM; Urban in scenario | 31,695.52 | 13.37% | 9,946.56 | 5.74% |
| TOTAL | 237,053.62 | | 173,308.27 | |

Table 5-44. Spatial comparison of Lake County FLUM and growth scenario allocations: residential vs. non-residential land use designation

| | Trend Scenario | | Alternative Scenario | |
|---|---|---|---|---|
| Result | Acres | Percent of total | Acres | Percent of Total |
| "-1": Non-res in FLUM; Res in scenario | 32,687.21 | 13.79% | 11,758.00 | 6.78% |
| "0": Both res or both non-res | 159,833.34 | 67.42% | 81,696.17 | 47.14% |
| "1": Res in FLUM; Non-res in scenario | 44,533.07 | 18.79% | 79,854.10 | 46.08% |
| TOTAL | 237,053.62 | | 173,308.27 | |

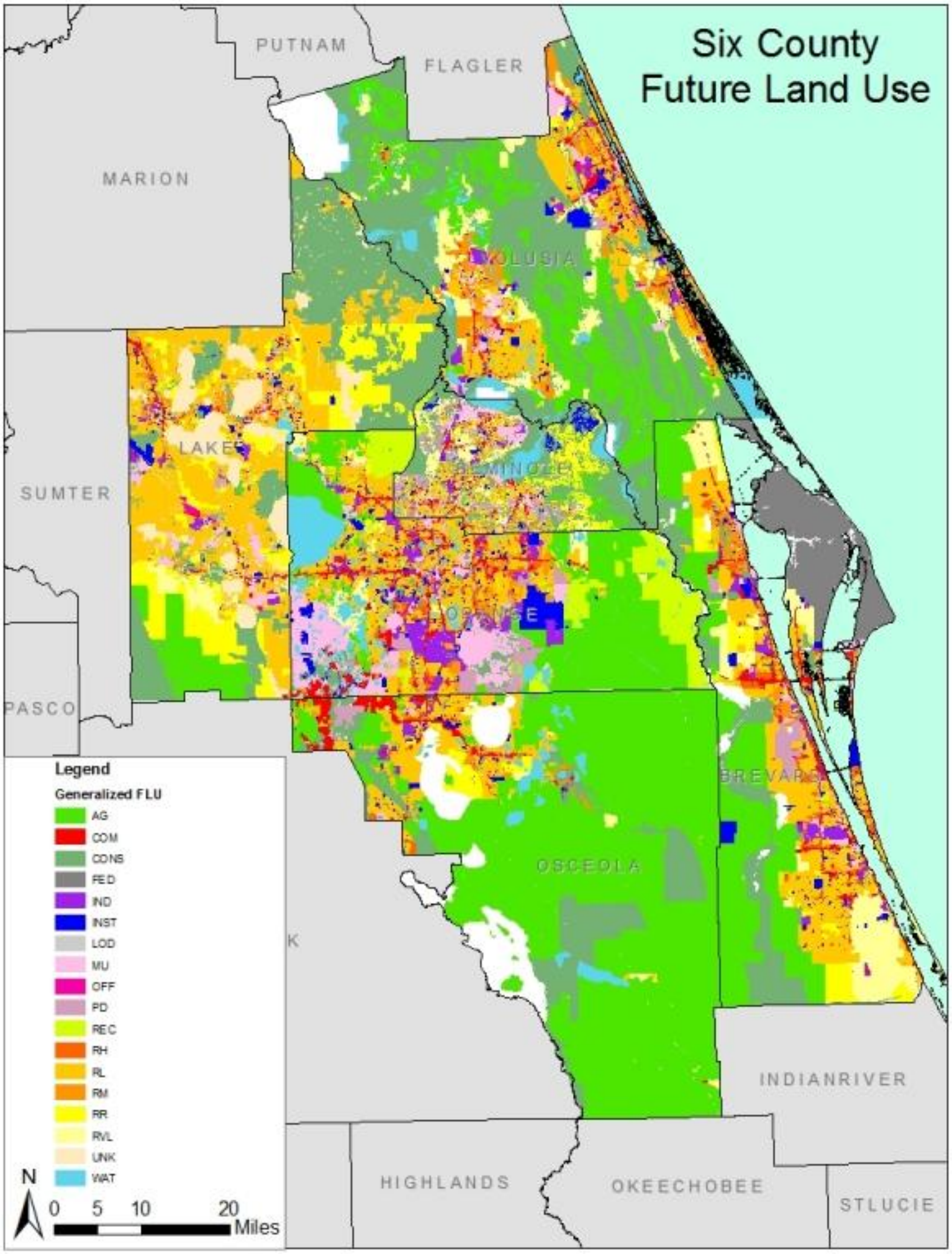


Figure 5-1. Six county generalized future land use map

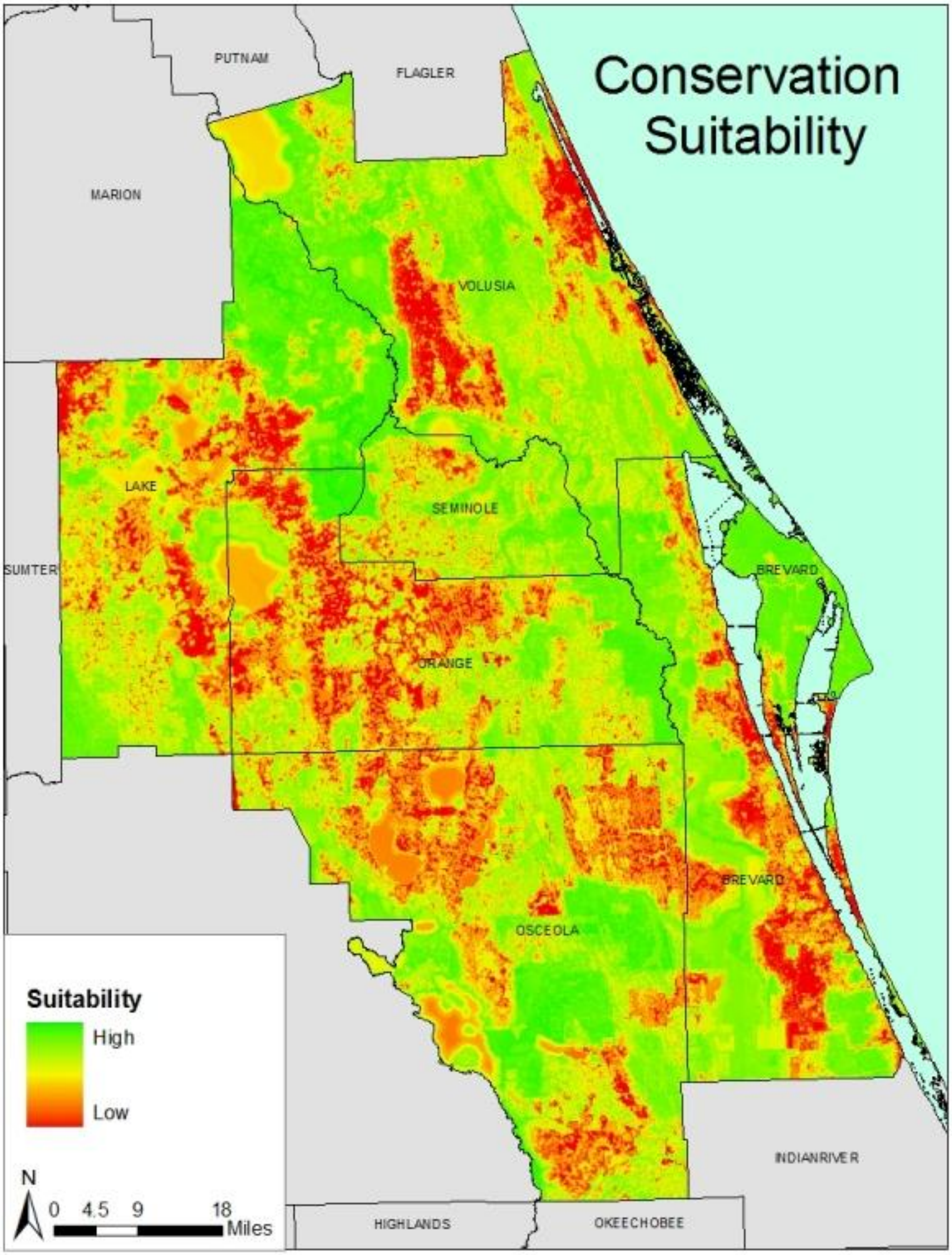


Figure 5-2. Six county conservation suitability map

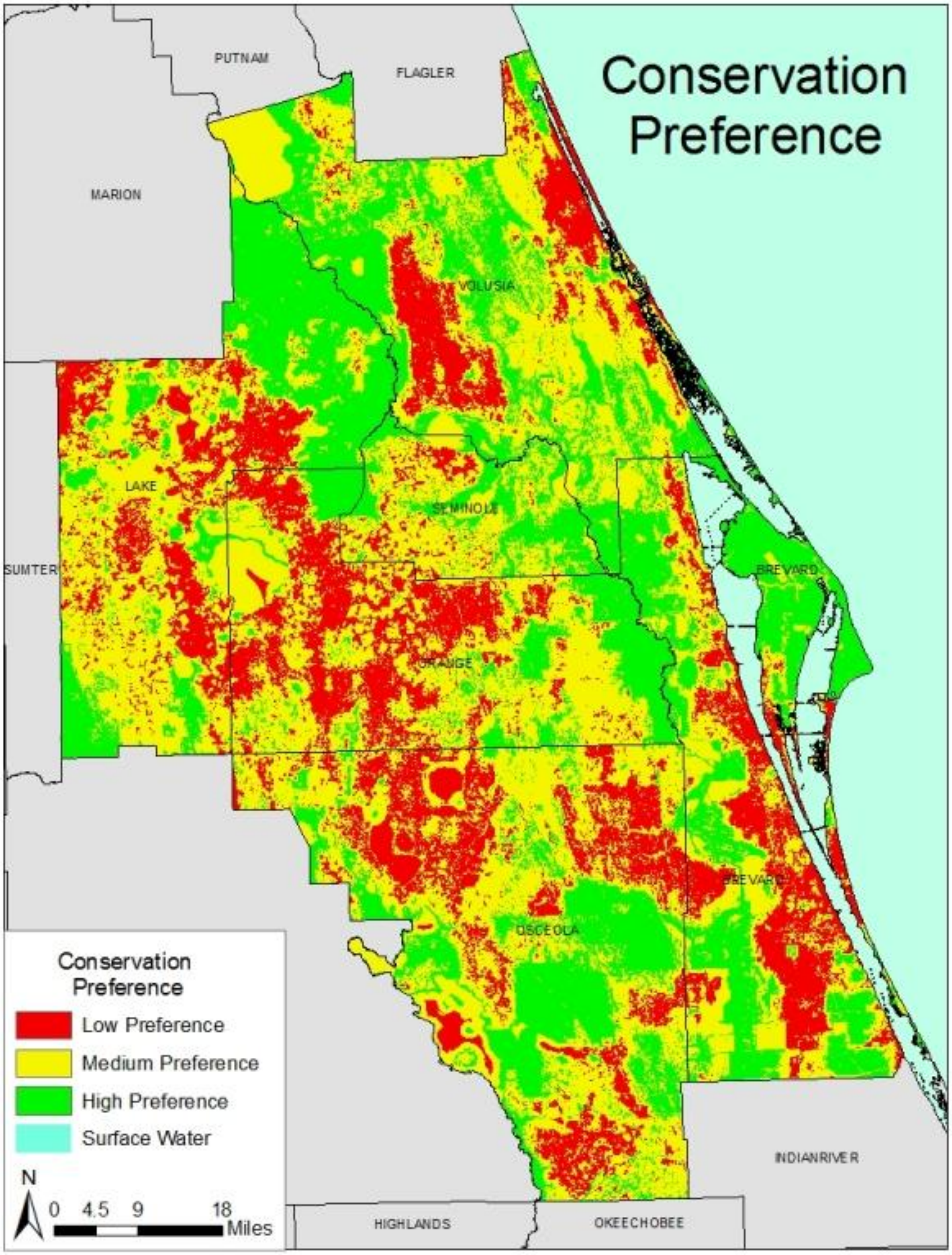


Figure 5-3. Six county conservation preference map

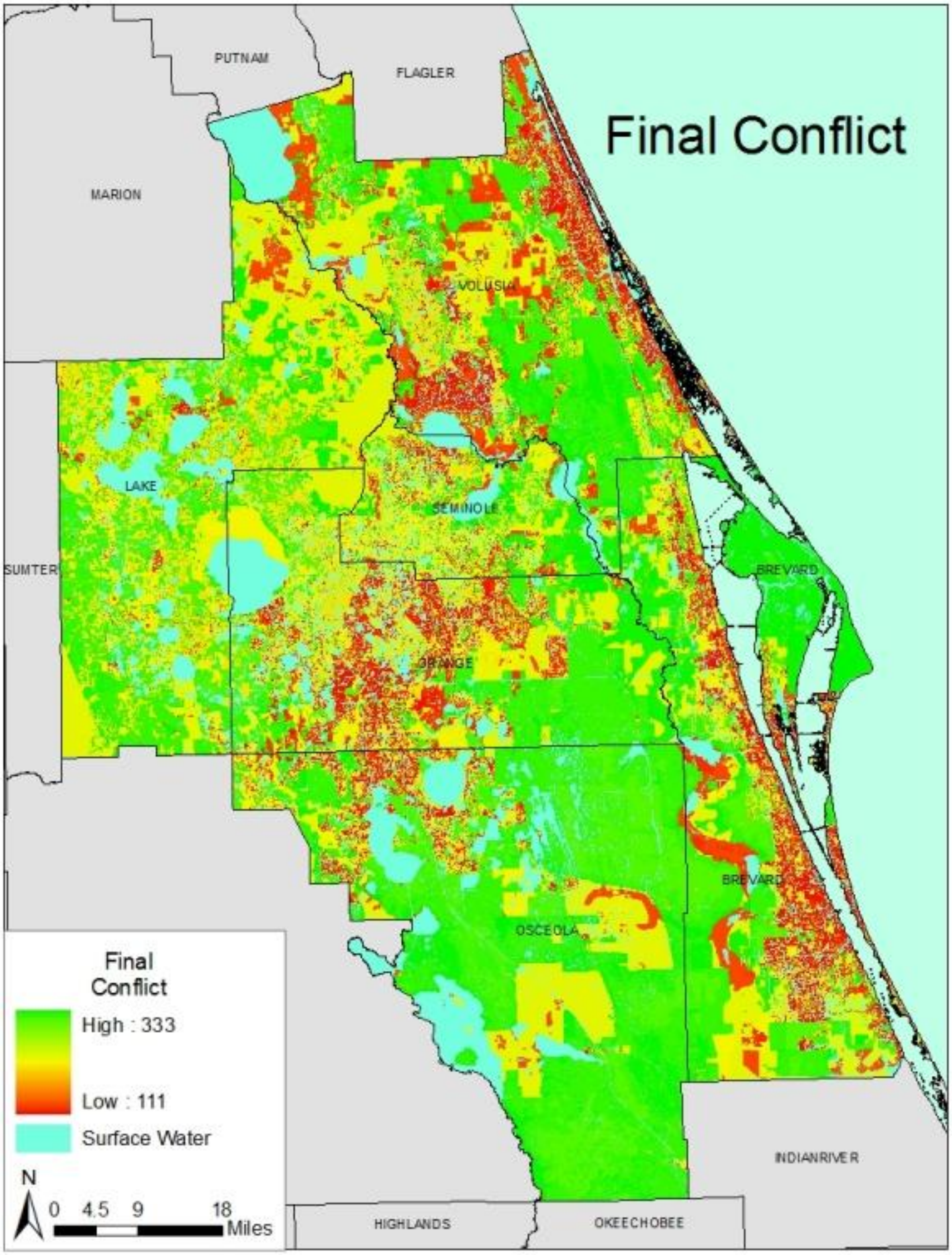


Figure 5-4. Six county final conflict map

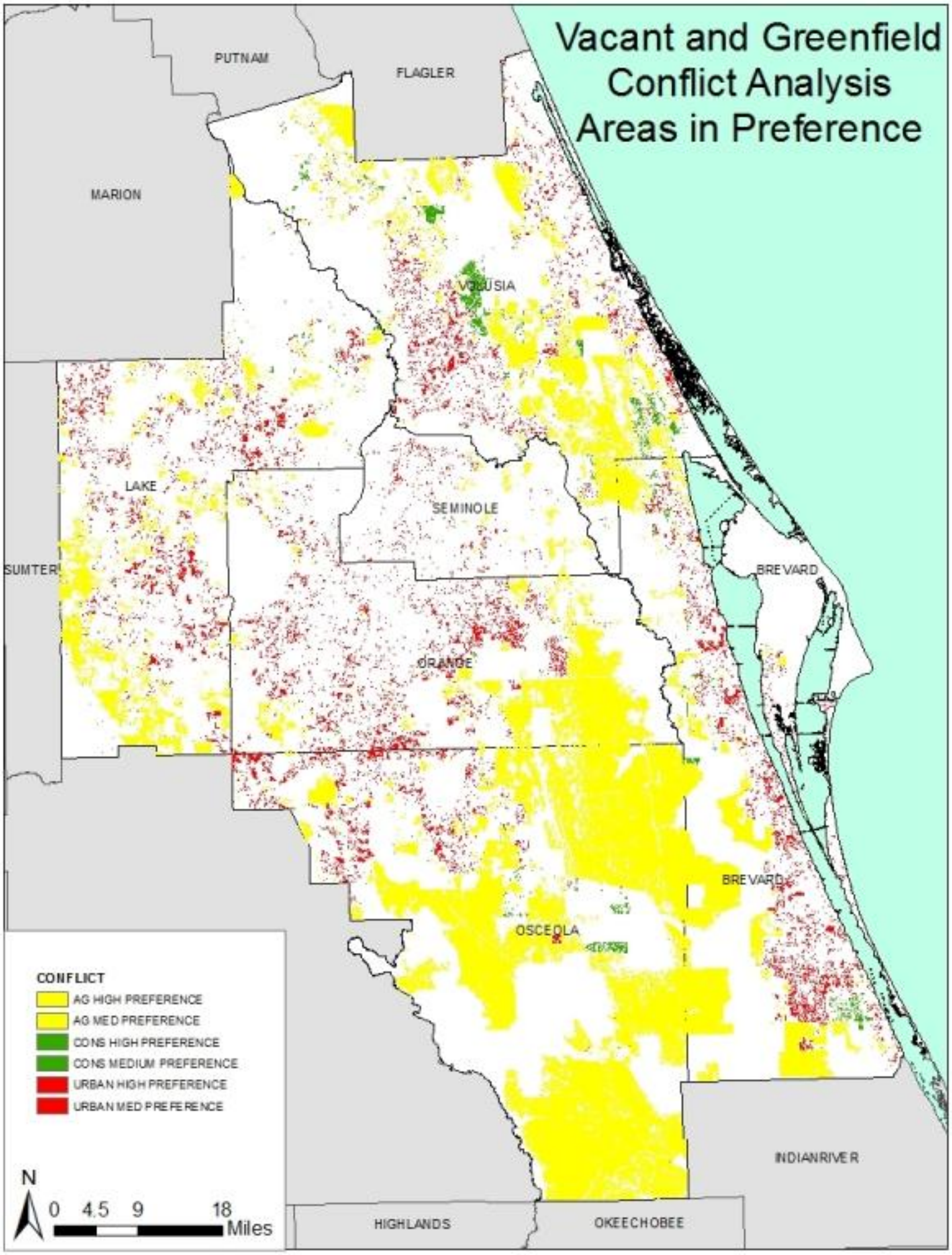


Figure 5-5. Six county vacant and greenfield areas of agricultural, conservation, and urban preference

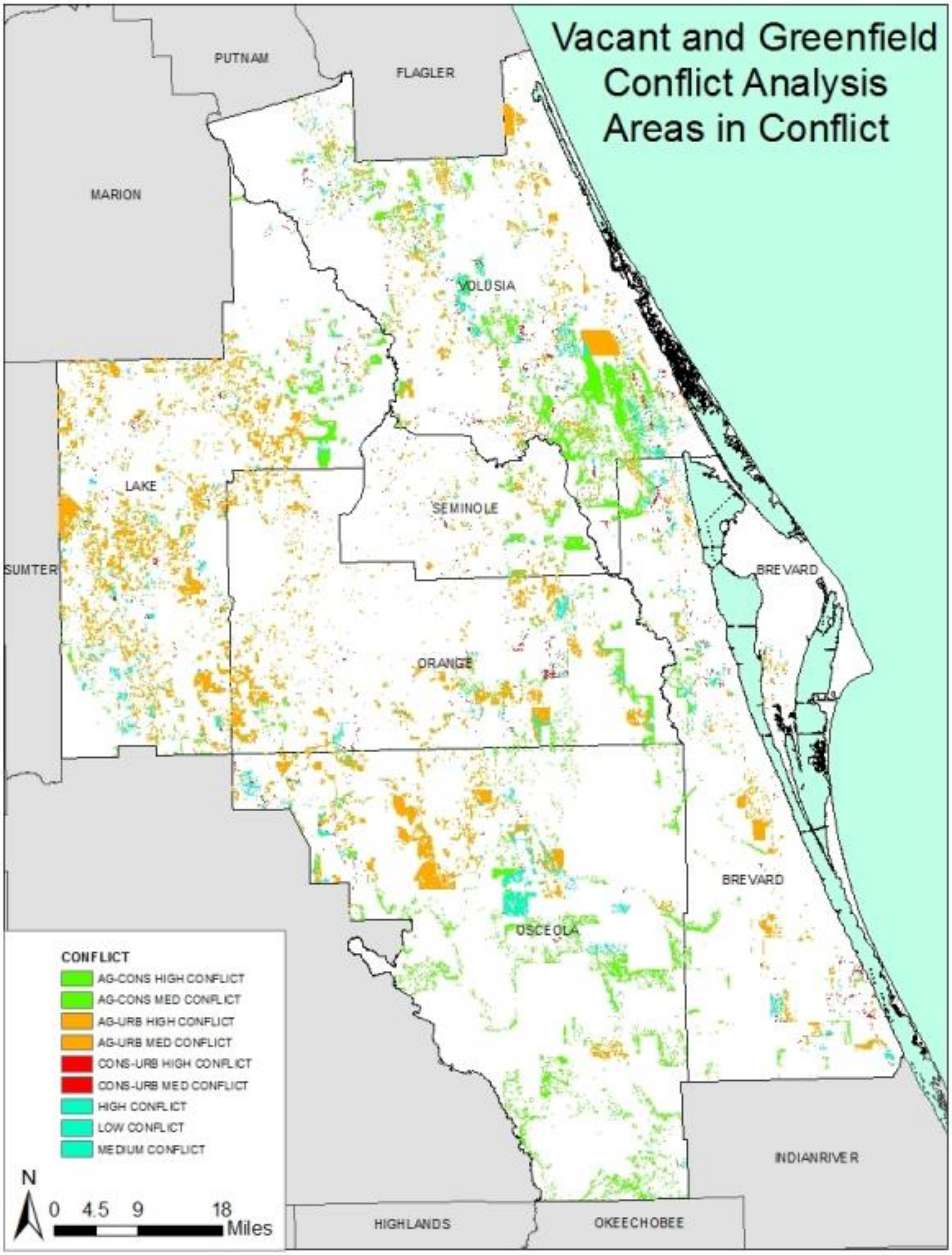


Figure 5-6. Six county vacant and greenfield areas in conflict

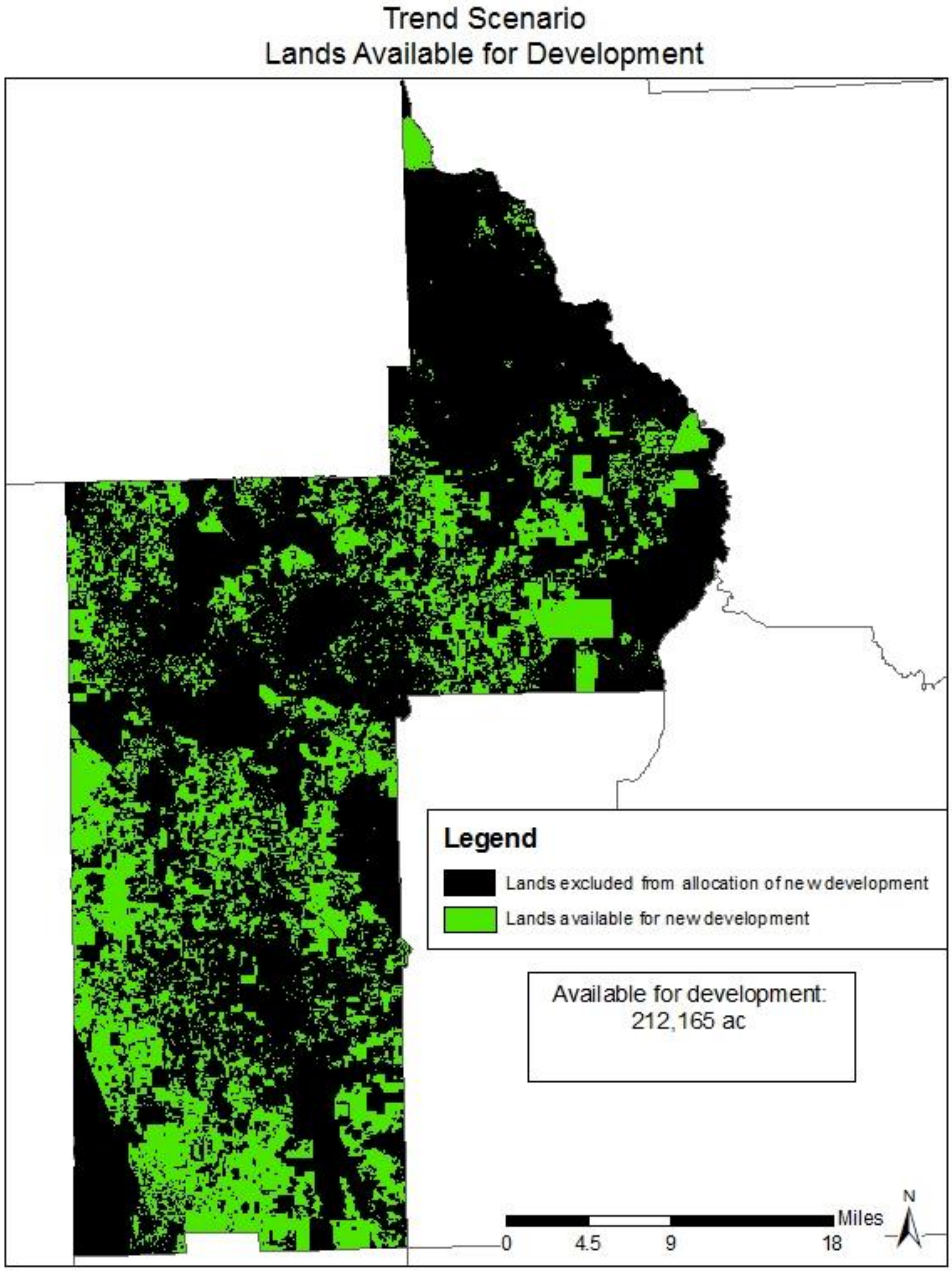


Figure 5-7. Trend scenario land considered available for new urban development

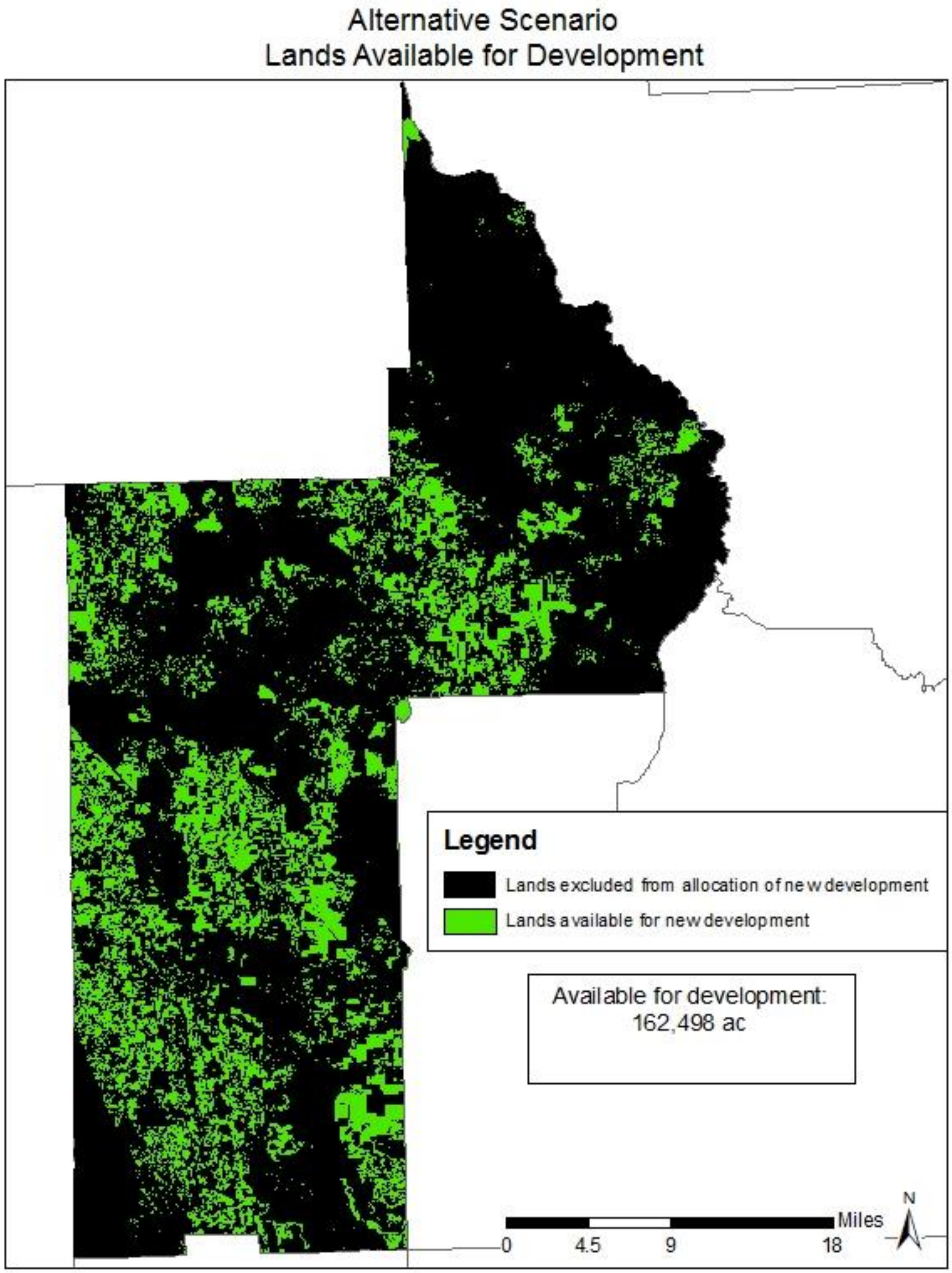


Figure 5-8. Alternative scenario land considered available for new urban development

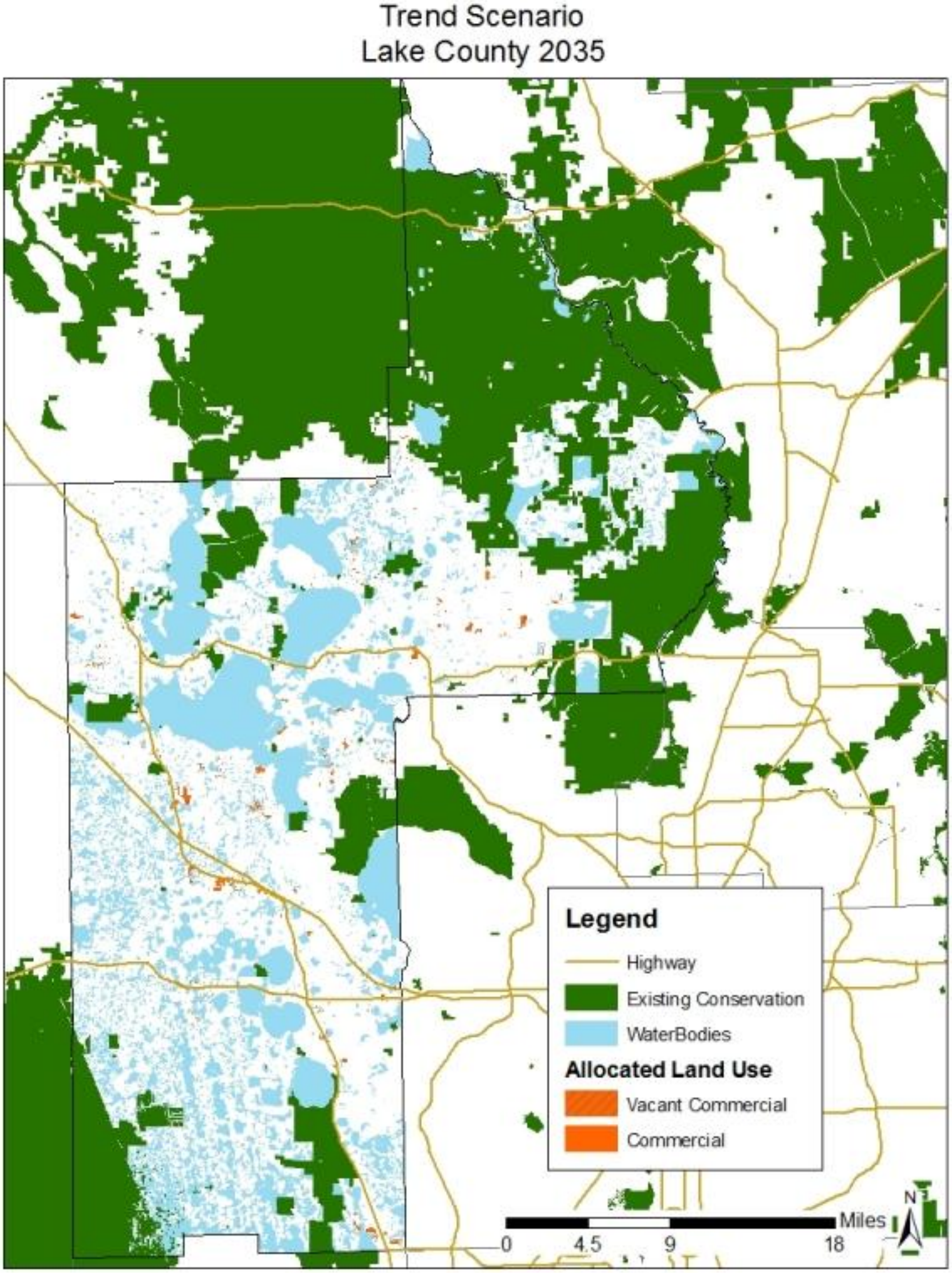


Figure 5-9. Trend scenario commercial land use allocation

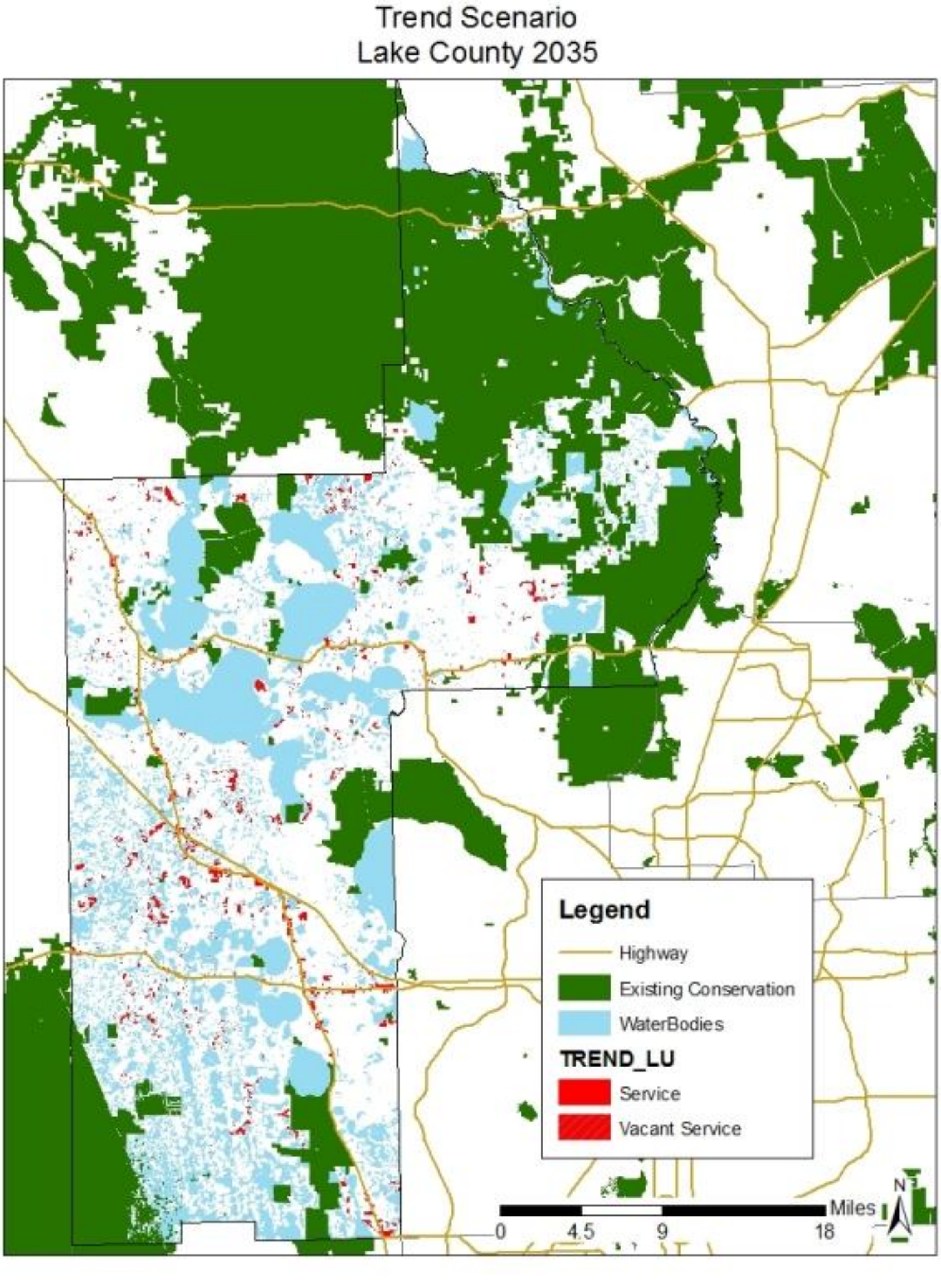


Figure 5-10. Trend scenario service land use allocation

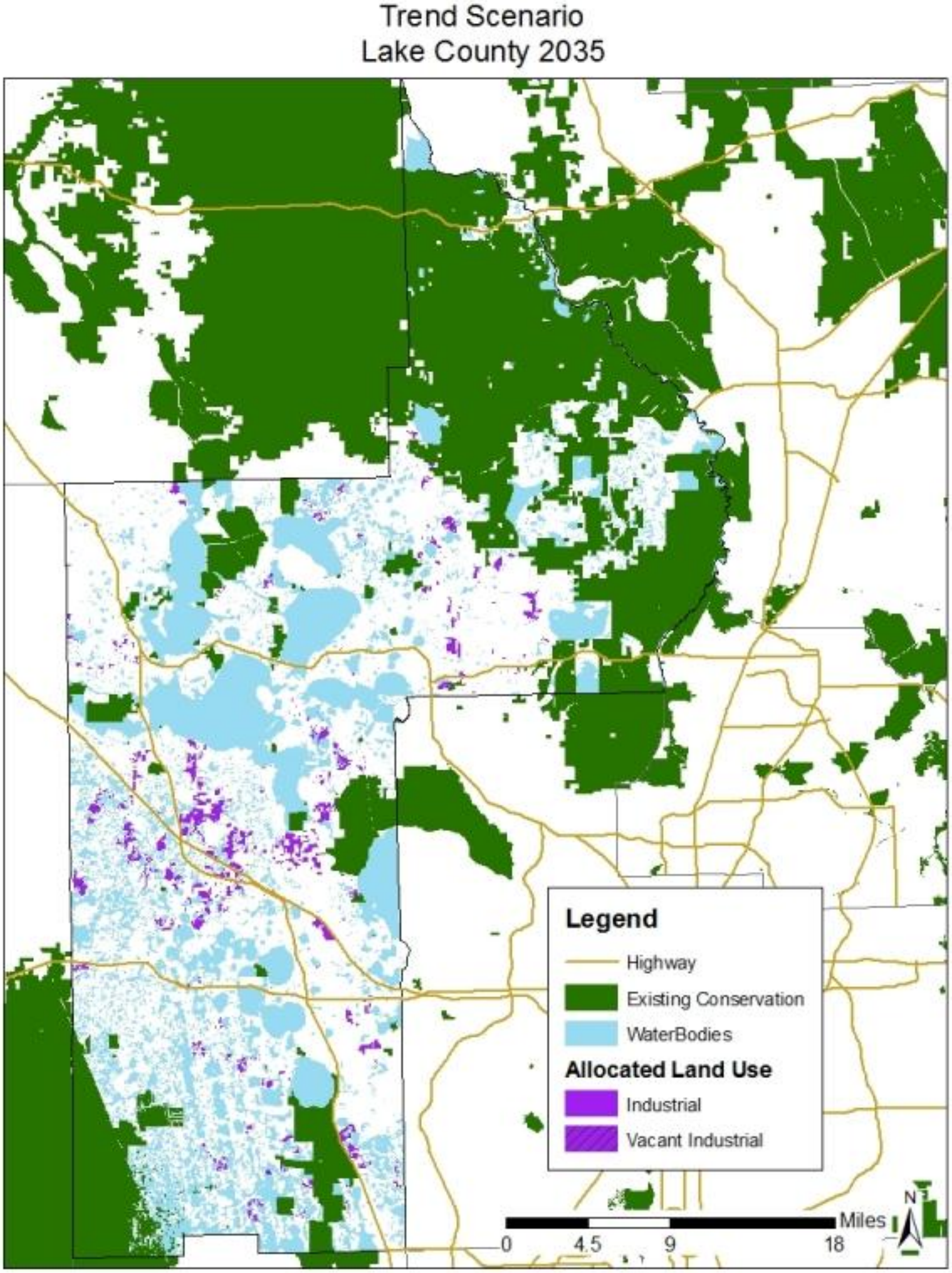


Figure 5-11. Trend scenario industrial land use allocation

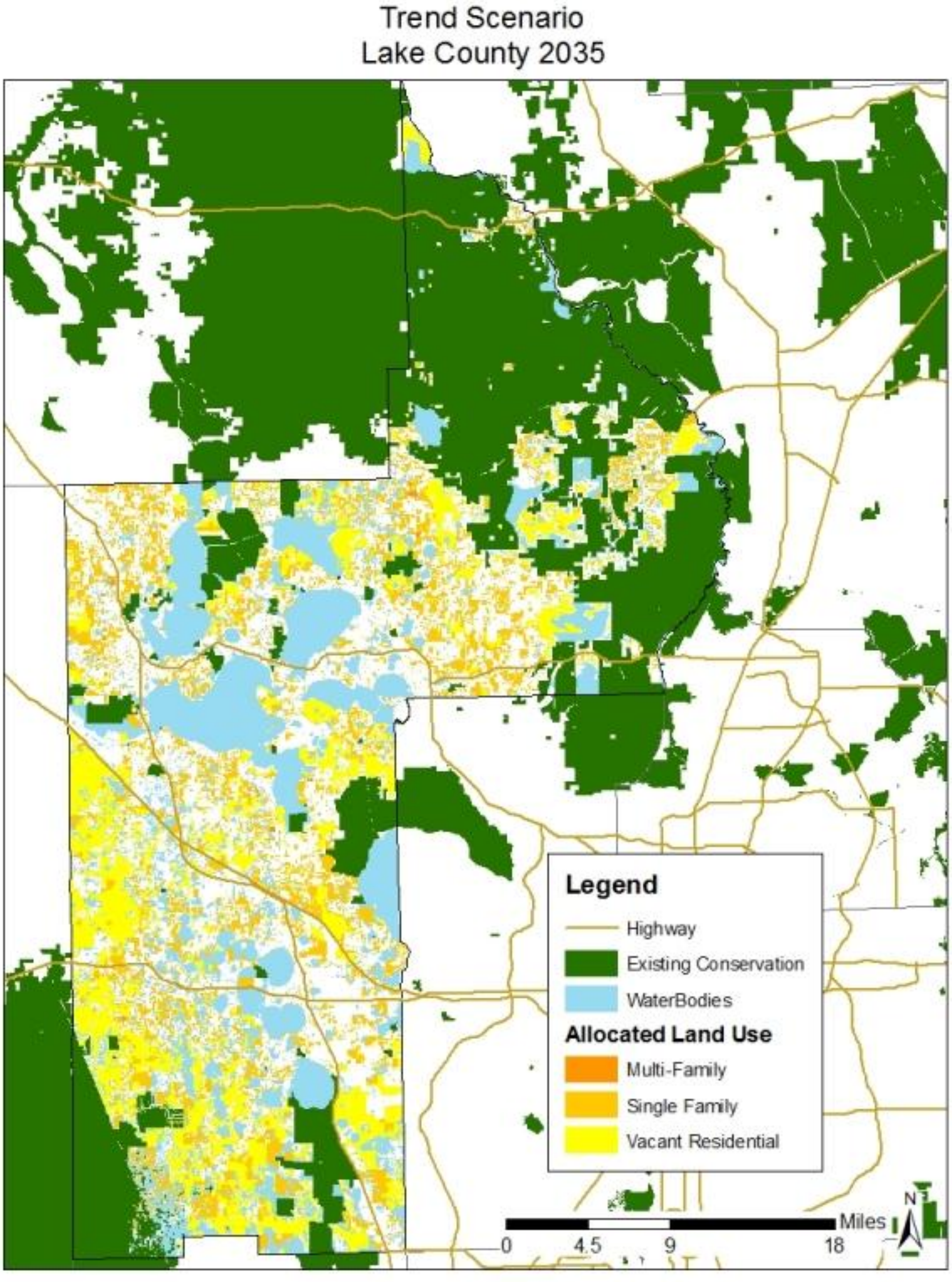


Figure 5-12. Trend scenario residential land use allocation

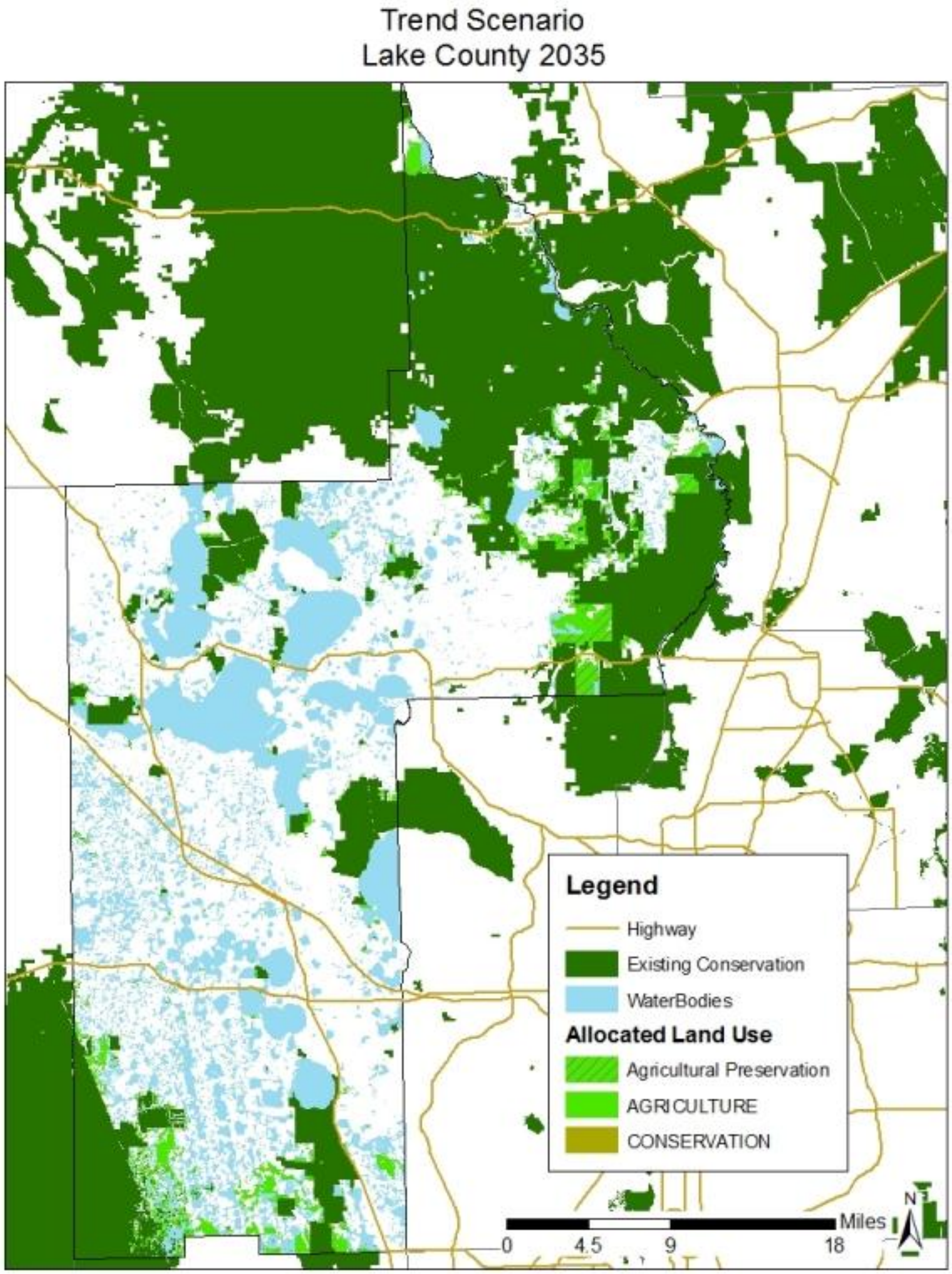


Figure 5-13. Trend scenario agricultural preservation, agriculture, and conservation land use allocation

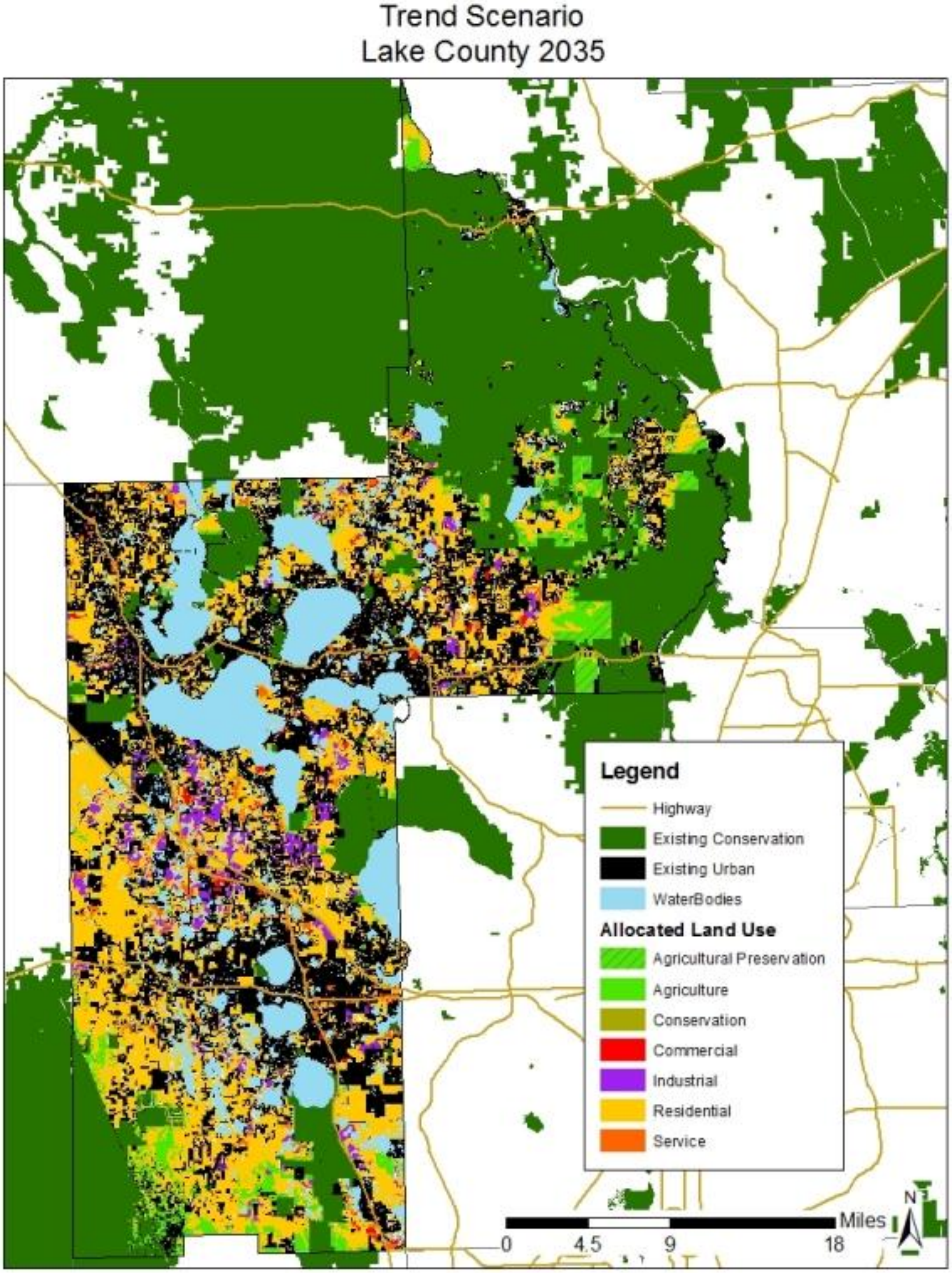


Figure 5-14. Trend scenario all allocations

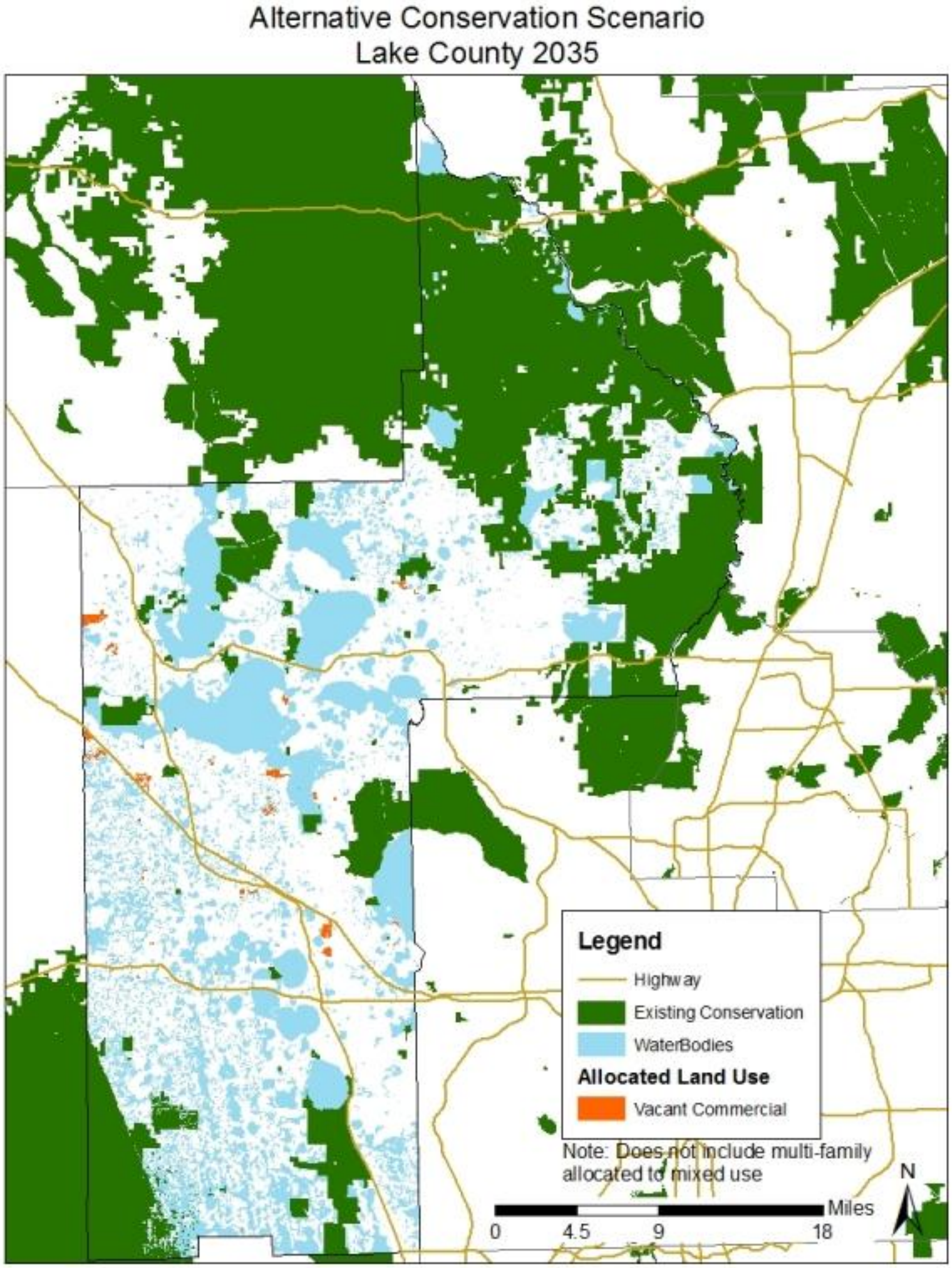


Figure 5-15. Alternative scenario commercial land use allocation

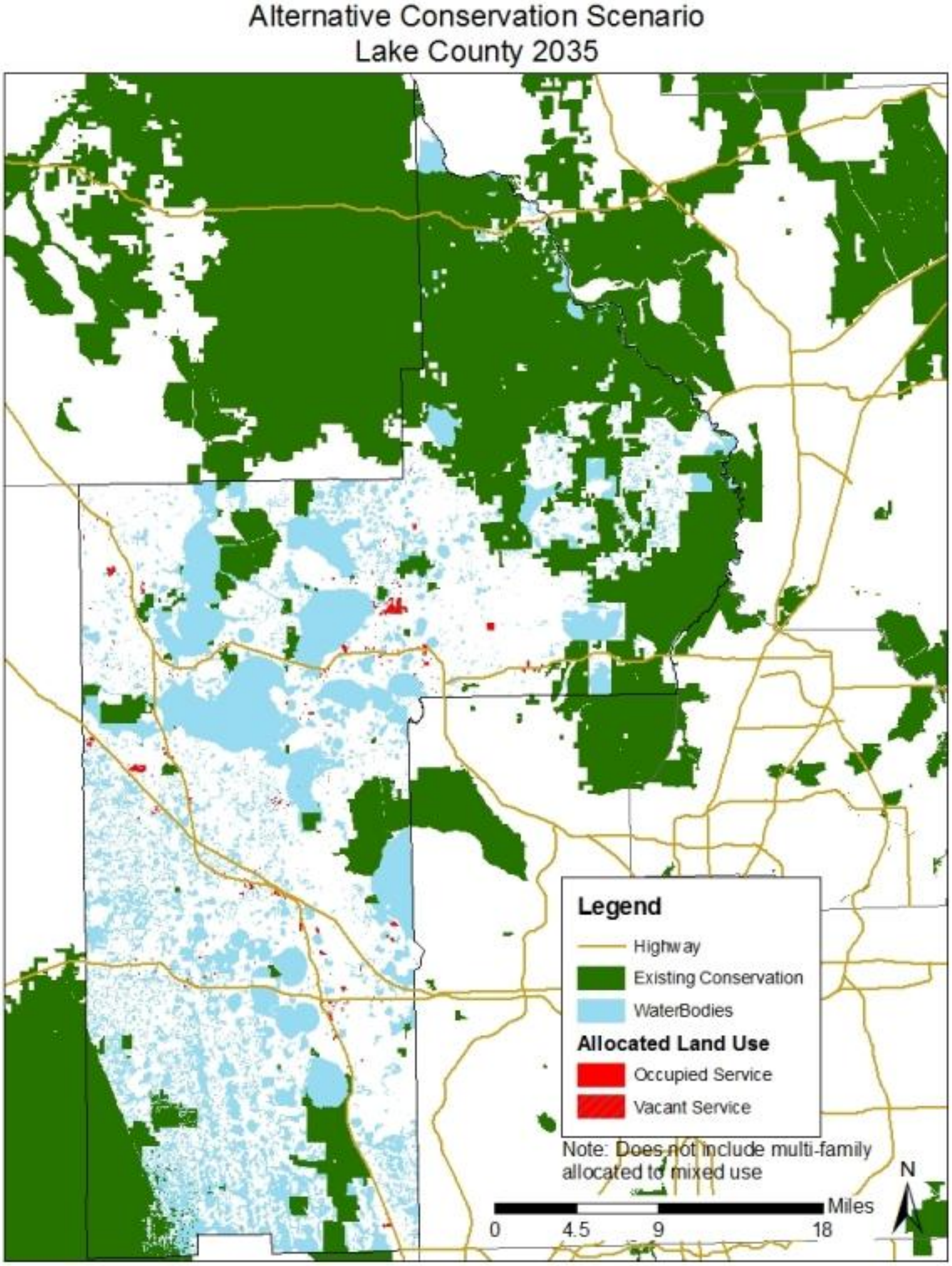


Figure 5-16. Alternative scenario service land use allocation

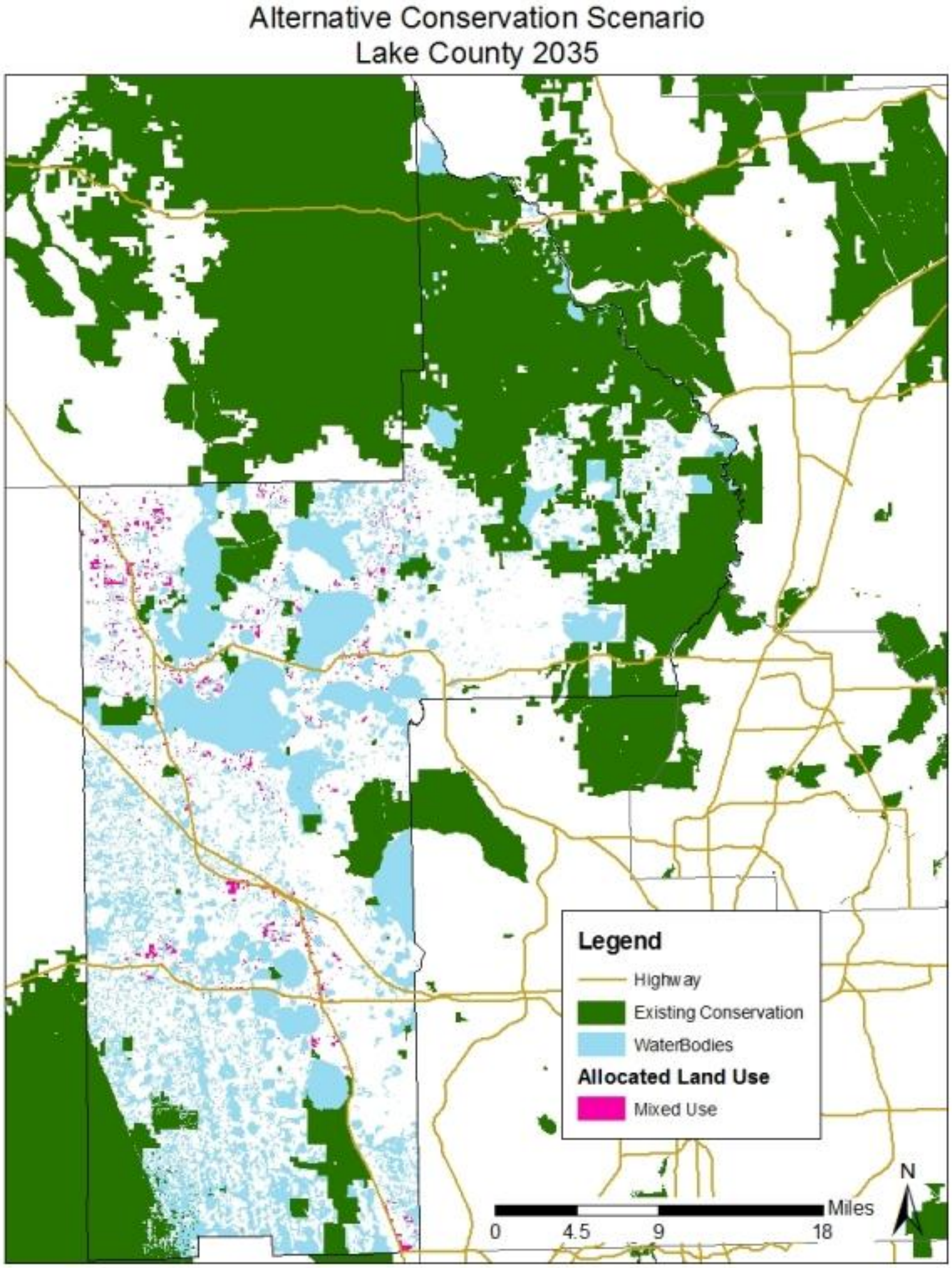


Figure 5-17. Alternative scenario mixed use land use allocation

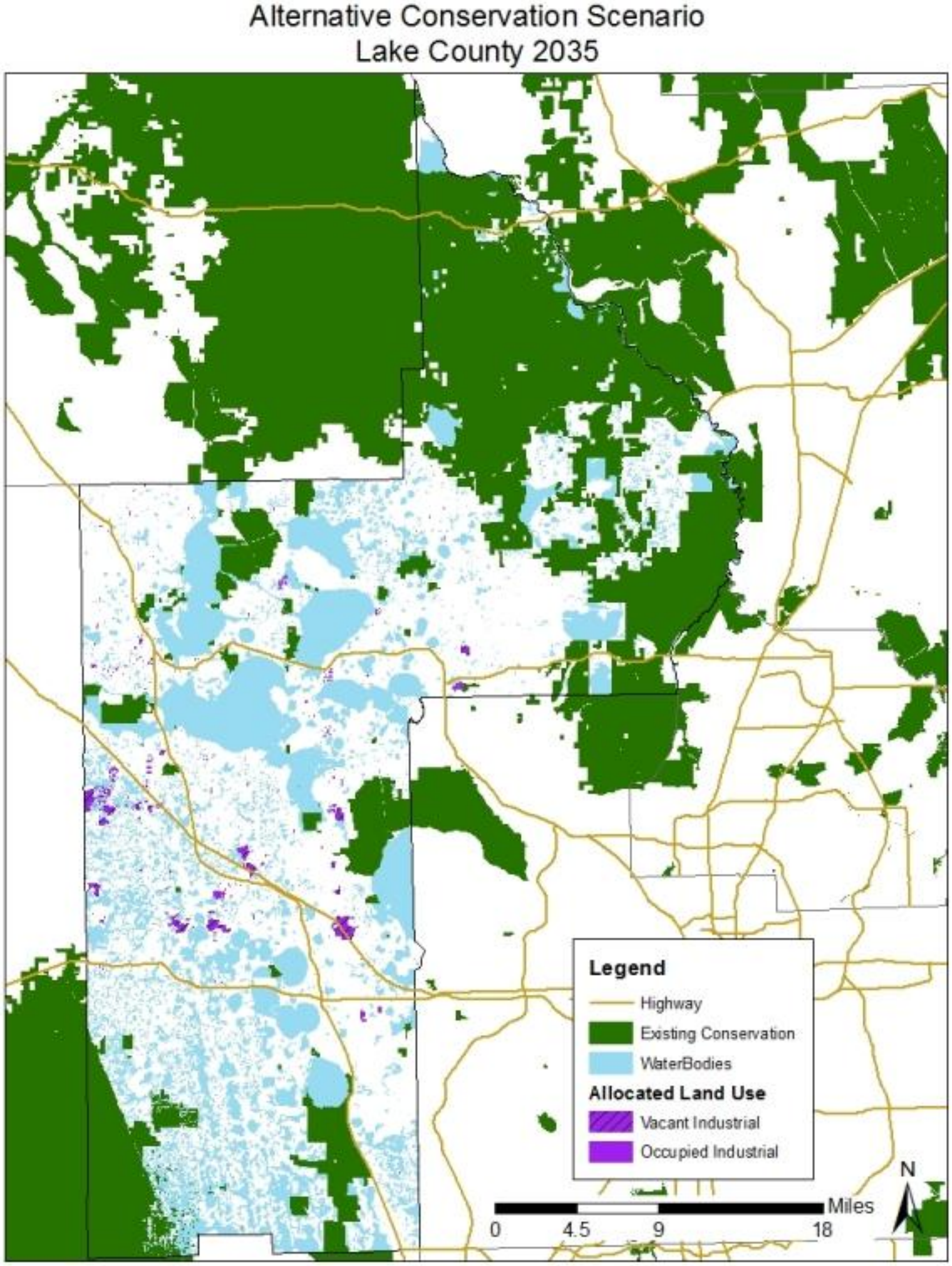


Figure 5-18.  Alternative scenario industrial land use allocation

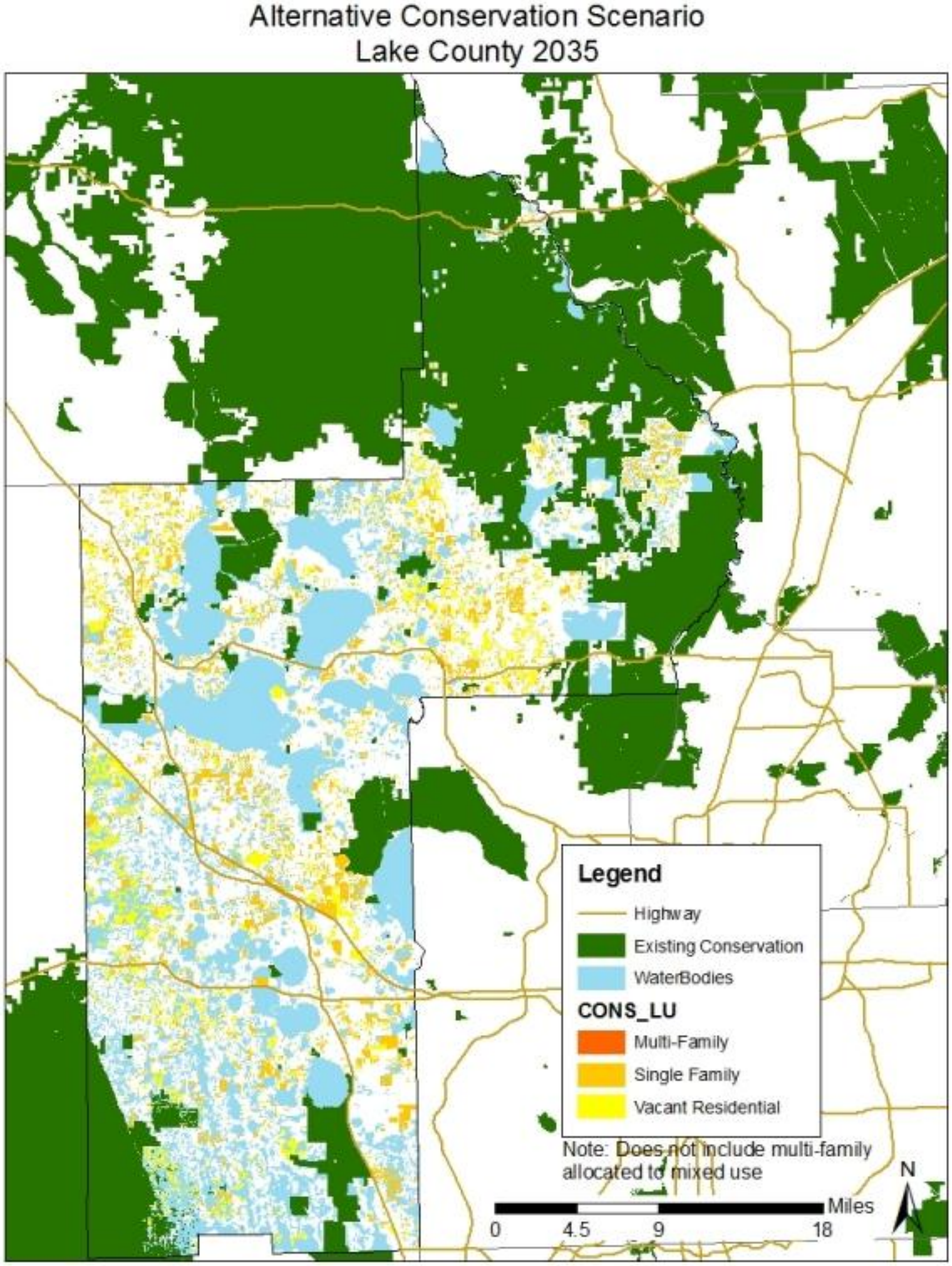


Figure 5-19. Alternative scenario residential land use allocation

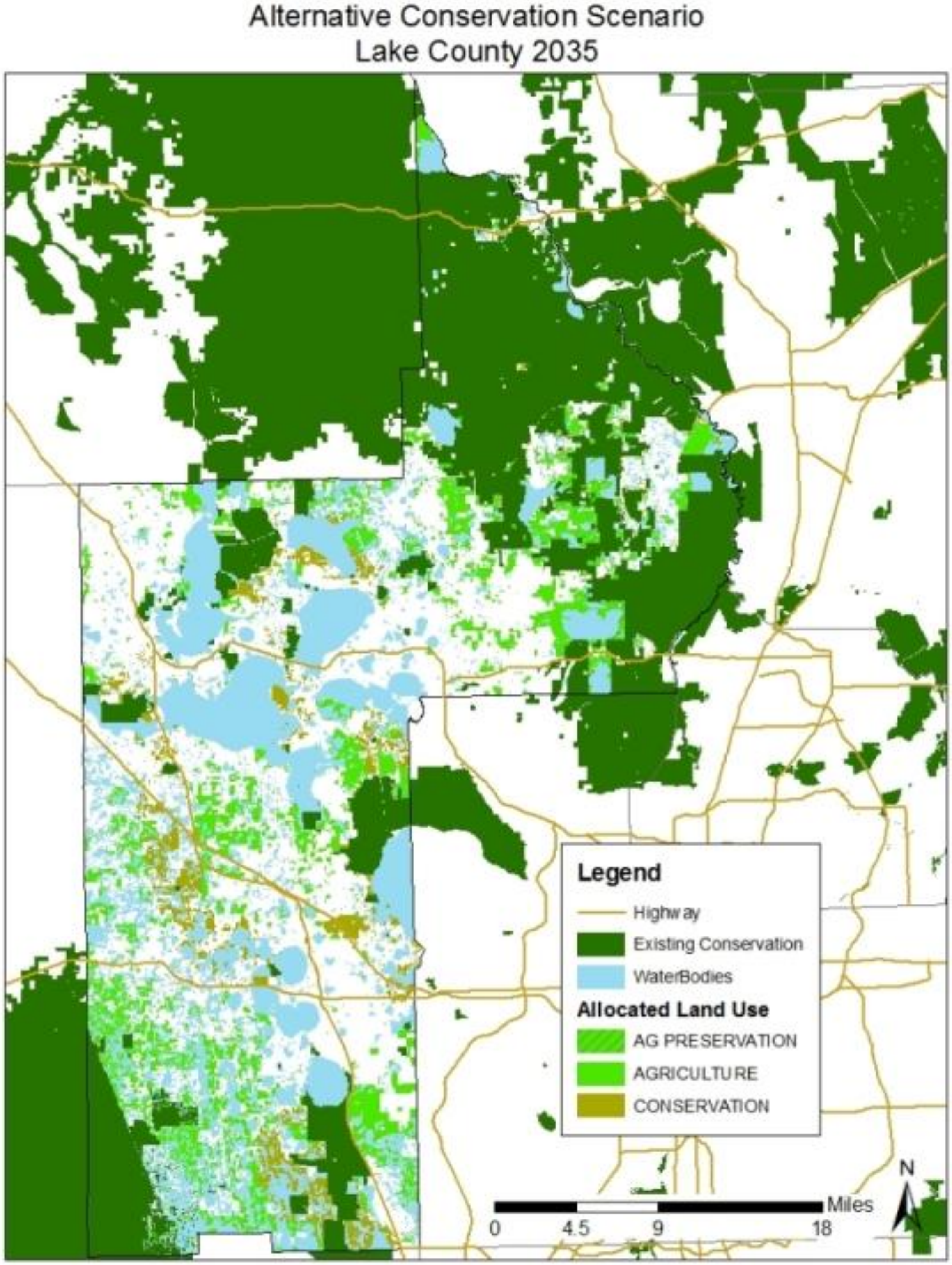


Figure 5-20. Alternative scenario agricultural preservation, agriculture, and conservation land use allocation

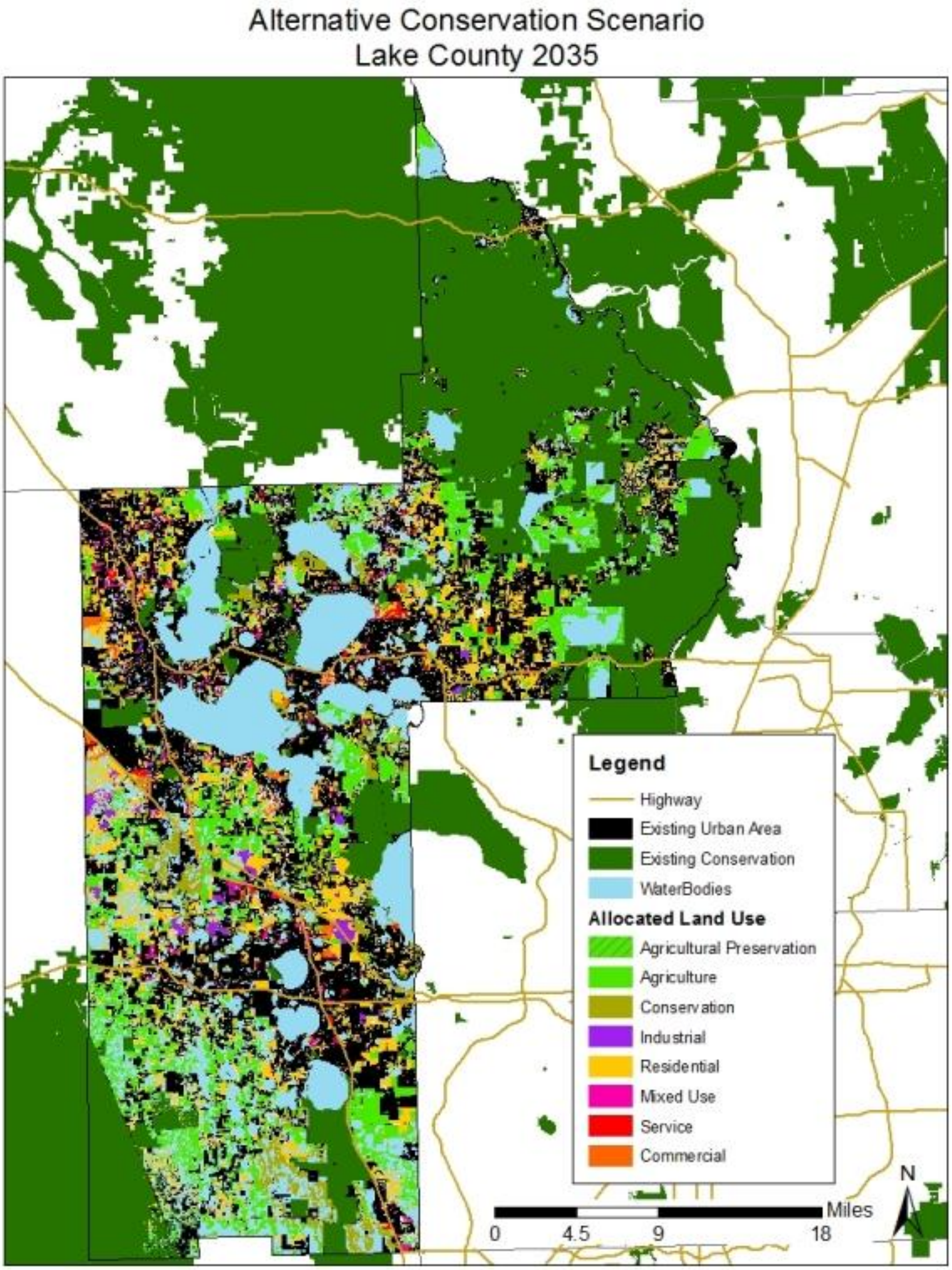


Figure 5-21. Alternative scenario all allocations

# CHAPTER 6
# DISCUSSION

## Overview

This study addressed the relationship between land use conflict and environmental impacts in the Central Florida region. It examined the protection of ecosystems and guidance of development patterns using green infrastructure, and sought to predict cumulative impacts of development decisions by modeling the outcomes of long-term development patterns. Existing Future Land Use Map (FLUM) policy was evaluated in relation to land use conflict as well as to the development scenarios to identify potential deviations from existing policy and the extent to which FLUMs supported identified regional goals (as found through the LUCIS process). Results demonstrated that FLUM policy is relatively effective at reflecting land use suitability in undeveloped areas, but policy often supports urban development over agricultural or conservation uses in areas of conflict between these uses. Agricultural lands were found to be particularly at risk of development. FLUMs in Lake County were found to support a future of low density sprawl. Unless policy is altered continuation of development trends will result in the loss of significant natural resources and infringe on significant areas of land use conflict.

## Examining Existing Land Use Designations

### Future Land Use Analysis

FLUM category acreages were calculated for each county and for the entire six-county region. Examination of the entire region's FLUM showed the region has much land in conservation, with 24% of all land legally protected. Remaining lands were primarily rural, with 35% of the land in agriculture FLU and most residential land use being lower density allocations – low density residential (low density residential, very low residential, and rural residential) accounted for 86% of all residential uses and 24% of all land use in the region. These large expanses of low density development in a rapidly growing region suggest sprawling development.

County by county analyses bring differences in policy to light, as well as demonstrate which counties are more urbanized and built-out. Seminole County, for example, has the lowest percentage of land area allocated to agricultural uses at 2.4%, suggesting the area is one of the most urbanized in the region. Lake County showed the highest percentage of land attributed to residential land uses (primarily low density). This suggests much residential development of the region is happening here; the low density pattern demonstrates this is occurring as sprawling residential development.

Seminole and Volusia County were two counties with FLUM lands designated as conservation remaining after removal of legally protected conservation land from the analyses, meaning they have officially and legally identified potential conservation areas. Both have taken steps in the comprehensive plan to identify land most suitable for conservation. Officially designating potential conservation in the FLUM demonstrates a step not taken by other counties in the region to identify potential green infrastructure, using it to guide development to other (assumedly more suitable) areas or place stricter regulations on development to protect natural resources. Other counties do have environmental protection measures, such as the overlay zones of the Wekiva Protection Area, to establish regulations to prevent adverse development impacts in those areas. These are not identified within the generalized FLUM, though they are represented within the individual jurisdictional FLUM’s. The generalized FLUM is effective at providing a base from which to compare local regulations, but results in the loss of some subtleties of land use regulation employed by local governments.

**Parcel Analysis**

Parcel analysis revealed that there are 238,736 acres – 15.2% – of vacant land already platted for residential use. Lake, Volusia, and Brevard Counties had the highest percentages of vacant platted residential land. These counties, as well as the region, exhibited primarily low density residential land. In a rapidly growing area, this pattern suggests urban sprawl.

Sixty percent of the region's developable land (land not in conservation or containing surface waters over five acres in area) is considered available for development, meaning approximately 40% of the region is already developed for urban uses. Approximately two million additional residents are expected in the region by the year 2035, in addition to the existing three million residents[1]. With new residents come the needs for new infrastructure, employment, recreation, and other uses. If agricultural lands and additional conservation lands are expected to be maintained or preserved in the region, careful planning must take place to accommodate these residents and all associated urban land uses while maintaining lands for agriculture and conservation.

**Parcel/FLUM Analysis: Area of FLUM within Vacant and Greenfield**

Regionally, agriculture FLU accounted for the largest area at 57.2% of land available for development, leaving approximately 43% of the land for urban

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[1] All county 2015 to 2035 population forecasts are based on BEBR totals recorded in the document - "Florida Population Studies, Volume 41, Bulletin 150, March 2008" except for Orange, Osceola, and Seminole which were provided by the counties through the METROPLAN ORLANDO 2030 SE data forecasting efforts.

development. Residential FLUM categories regionally accounted for approximately 26% of vacant and greenfield land.

Lake County had by far the highest percentage of area dedicated to residential FLU at 77.8%. The next highest was Brevard County at 42.2%. Lake County also had the lowest percentage (10.2%) dedicated to agricultural FLU. Lake County's low agriculture and high residential FLU designations demonstrate a policy decision, whether stated or not in the comprehensive plan, to promote residential land use development over agricultural uses.

## LUCIS Process

### Conflict

High agriculture-urban conflict was the largest category of conflicting land uses for the region and most of the counties, with the exception of Volusia County. This reflects the history of agricultural use in the region, the development pressures on agricultural lands, and the potential loss of agriculture industry.

Volusia and Brevard County, the two coastal counties in the study area, demonstrated the largest amount of high conflict between conservation and urban land uses. Coastal areas generally experience high development pressures; this may thus reflect the high pressures for development on the coast in areas considered ecologically sensitive.

The relatively low total area in the conservation preference category throughout the region (1.5%) may reflect the history of preservation of environmentally sensitive lands. Existing conservation lands in fact make up 24.1% of the entire region.

Results suggest where development should be focused, assuming integration of the results of the conflict analysis (which reflect regional goals of land use distribution) into land development patterns. Areas such as Osceola County, which conflict analysis has shown to be preferable for agricultural uses (81.6%), should not be the focus of high intensity urban development. Instead, Orange, Seminole, and Brevard Counties, which show the highest percentages of land preferred for urban uses, may be better suited as the regional focus for higher intensity development.

**FLUM Comparison to the LUCIS Conflict Analysis**

Comparison of the FLUM and conflict within vacant and greenfield (developable) land demonstrated spatial correlations between FLU designations and conflict categories. Regionally, agriculture and urban FLU designations were generally in areas highly preferred for agriculture and urban uses, or areas demonstrating conflict with one of those uses. High correlation was demonstrated in FLUM conservation areas as well: almost 60% of land found to be preferred for conservation land use across the region was designated as conservation in the FLUM, and another 20% of the category was located in agriculture FLU. Local governments' decisions on land use allocation across the region, then, are generally in keeping with results of the conflict analysis in these areas. However, urban FLU designations regionally accounted for 19.5% of lands preferred for conservation use, and 14.5% of lands preferred for agricultural use, highlighting areas where land will potentially be developed into urban uses while the land may actually be better suited for agricultural or conservation uses.

Orange County showed the highest correlation between high urban suitability and location of urban FLUs in lands available for development; it is also one of the densest and most built out counties. Based on LUCIS analysis, urban suitability will be higher near existing urbanized areas, so its high percentage of land preferred for urban uses would be expected. Lake County showed low correlation of urban FLUs and lands preferred for urban use, and had the fewest percent of its urban FLUs in land preferred for urban uses, suggesting the County is attempting to create urban uses in areas determined better suited for agriculture or conservation.

The quantified divergences in developable lands between FLUM designations and land preferences identified through LUCIS may have to do with the total amount of land preferred for urban uses available within each county. In all counties the total area of urban FLUs in developable lands was significantly greater than the amount of urban preferred land available for allocation. Urban FLUs accounted for 34.3% of the region's developable lands, and ranged from 8.9% to 82.8% per county. However, lands preferred for urban uses within the region accounted for just 11.3% of developable lands, and ranged from 3.9% to 21.8% across the counties. Presence of urban FLUs in areas not preferred for urban land use or in areas of conflict between preferred land uses is thus inevitable.

Inclusion of areas of high urban conflict (areas highly suitable for urban uses as well as either agricultural or conservation uses, or highly suitable for all three uses) in the analysis, however, did encompass more land designated in FLUMs as urban FLUs. The majority of all urban FLU's were within lands preferred for urban uses or areas with high urban conflict, showing that the majority of FLUM designations are in areas generally suitable for urban uses. The majority of the remaining FLUM urban designations were primarily within agriculture preferred land. Relatively little land preferred for conservation use was available within developable lands. This lack of opportunity may explain why little urban FLU was allocated into lands preferred for conservation or areas of high conservation suitability.

FLUM designations in developable lands were not always consistent with conflict analysis in evaluation of individual counties. The most apparent divergence was the placement of the conservation FLU in areas not exhibiting high preference or suitability for conservation land use; in Brevard, Lake, Volusia, Orange, and Osceola Counties between twenty and almost 50% of conservation FLUs were located in lands considered preferred for urban uses, agricultural uses, or in areas preferred for both urban and agricultural uses. This was the most glaring inconsistency, and suggests that perhaps careful analysis of relative environmental sensitivity is not being undertaken in the evaluation of urban suitabilities during policy formation.

As another example, 41.4% of planned development FLU in Lake County's developable lands was located in land preferred for agricultural use. This again demonstrates potential expansion of urban uses into areas not selected by regional land use goals as desired for urban use. Additionally, 12.2% of the regional mixed use FLUM located in developable lands is located in land found to be preferred for agricultural use. Spatial location of mixed use FLU by local governments reflects their policy decisions on where to place mixed urban centers or areas. Based on the conflict analysis, however, those areas may not in fact be the most suitable places for mixed use and may instead be more appropriate for uses such as agriculture. Visual analysis demonstrated that mixed use FLU designations are within city limits, and are abutting existing mixed use FLU areas. Therefore, either the conflict analysis failed to take into account enough urban features to assign higher relative suitability to these areas, or the cities have expanded into areas better suited for agricultural uses rather than increasing densities and focusing higher intensity development into urban cores.

The placement of residential uses in areas found to be preferred for agricultural uses is not a big surprise in the region; agricultural uses are often converted to residential due to factors such as low land costs and ease of land clearing (as vegetation is generally already cleared for prior agricultural uses). With the region's agricultural history, there is much agricultural land available for development. However, if the region wishes to retain its agricultural industry, it must pay close attention to how much agricultural land is being lost to urban development.

Lake County has the largest percentage of the region of its developable land allocated for urban (primarily residential) development, and equals a full 40.6% of all developable urban FLU in the *region*. 92% of Lake County's urban FLU designations in developable lands are residential – 97.9% of which is low density residential, very low density residential, or rural residential. In fact, Lake County has more than twice the area of residential FLU of any county. Lake County is thus prepared to lose most of its agricultural and open space to low density residential land uses and sprawl. Further, this amount of residential land allocation is either more than Lake County needs for its future growth projections or reflects extremely low population densities. For example, 240,858 new residents are expected in Lake County through the year 2035. Even if residential development occurred at an extremely low density of two people per acre (approximately one unit per acre), there would be enough land to accommodate 351,125 people. Other counties have far less land designated for residential FLU, though not a correspondingly lower amount of projected new residents. The assumption would thus be that Lake County will develop at a much less dense pattern than the rest of the region.

## Creating Alternative Scenarios of Future Development in Lake County

Creation of two different scenarios allowed application of two different sets of policy. Introducing the LUCIS methodology into the process allows for a standardized way to spatially allocate land use based on policy and other decisions affecting land use. Cumulative impact of individual development decisions have resulted in sprawling development and environmental impacts. The trend scenario represents the continuation of these patterns, as it replicates existing development patterns. The alternative scenario presents an example of how development pattern outcomes might differ if policy reflected a prioritization of green infrastructure. Spatially demonstrating the impacts of development decisions may help local decision makers to recognize their role in regional land development patterns and prevention of environmental impacts. Further, studies such as Brody, Highfield, and Thornton's (2006) demonstrated policy deviations primarily occurring as urban sprawl. Identifying potential deviations may identify potential urban sprawl.

The final outcomes of the trend and alternative green infrastructure scenario demonstrated levels of correlation to the FLUM, differences in total land use, and effects on environmentally sensitive features. Results and comparisons are discussed below.

## Growth Scenarios and FLUM

Comparing the growth scenarios to the FLUM provides an opportunity to predict potential deviations from spatial policy – areas where actual development patterns may not reflect policy expressed in the FLUM. The growth scenarios reflect policy assumptions and goals of land use distribution. Assuming the growth scenario reflects probable patterns, a comparison of FLUM to the scenario may identify areas where development might deviate from the FLUM land use designations. Similarly, analysis of the extent to which the FLUM supports each growth scenario demonstrates how well the FLUM supports the outcome of each (urban sprawl or green infrastructure). The spatial correlation between the FLUM and each growth scenario thus suggests the level of implementation of the original FLUM, or “success,” that may occur based on assumptions of probable future growth patterns. These results could show governments areas where their FLUM may need revamping, highlight cumulative impacts, or identify undesired growth patterns. For example, governments may be able to better prevent land use conversion of agricultural or environmentally sensitive lands that are under high development pressure (demonstrating land use conflict) if the threat of this occurrence and the cumulative impact of these conversions is understood. Understanding how density affects land needs, and thus development patterns, for future development can show governing bodies how to control patterns by adjusting density. Modeling future impacts and growth can provide an opportunity to adjust policy based on desired or undesired impacts of the model.

The trend scenario utilized more land for allocation of urban uses than the total area of FLU urban designations in developable land. This suggests that even the FLUM, which has a seemingly large amount of developable land allocated to urban uses, is not enough to maintain existing development patterns. Interestingly, residential acreage allocation in the scenario and in the FLUM was almost exactly the same, with the trend scenario utilizing 187,825 acres for residential uses, and the FLUM designating 183,464 acres to residential land use. Based on these observations, the FLUM is not prepared to handle the projected amount of employment growth at current density patterns.

Within the trend scenario, 77.8% of all developable land showed spatial urban use correlation (either both urban or both urban), suggesting that the majority of spatial policy will be implemented. Of the remaining 22.2% not demonstrating spatial correlation, some discrepancies may be attributed to the fact that the trend scenario allocated 20,487 more acres to urban uses than the FLUM, necessarily resulting in some areas designated as urban in the trend but non-urban in the FLUM. If development occurs in keeping with the trend scenario, deviations in policy implementation may occur in the form of land designated as agriculture or other non-urban uses being converted to urban uses to accommodate employment growth not accommodated in the FLUM. Overall, the trend scenario reflected FLU designations fairly well (at least in generalization of urban versus non-urban location), even though policy was not a contributing factor to the suitability analyses or allocation process. The high correlation suggests that if development patterns continue, land use policy as identified in the FLUM for Lake County will be implemented (again, in terms of urban versus non-urban lands), with changes to approximately 20% of the FLUM.

The alternative scenario utilized just 46.2% of vacant and greenfield to allocate urban uses, 129,937 acres less than the trend scenario. This is also far less land than is allocated to urban uses than within the FLUM. This change demonstrates the efficacy of the density increase in residential and employment allocations. Spatial policy deviation would be expected because of the difference in urban land use needs.

Spatial correlation of urban and non-urban uses in developable lands between the alternative scenario and the FLUM was 52.7%. Reasons for this include the fact that less land is allocated to urban use in the alternative scenario than the FLUM, as well as general disagreement on spatial land use suitability. Spatial policy implementation may therefore be expected within the alternative scenario policy in some urban areas, but not as strongly related in the remaining areas allocated to agriculture, agricultural preservation, and conservation. If development occurs consistent with the alternative scenario, approximately 50% of the existing FLUM would have to be altered from either urban to non-urban or vice versa (predominantly converting from urban to non-urban).

Correlation between residential uses and non-residential uses in developable lands between the FLUM and growth scenarios showed similar patterns. The trend growth scenario and FLUM provide an interesting evaluation because both allocate almost the same total amount of land to residential use. Despite consistency in overall area, only 67.4% of all land use allocations in this situation were spatially correlated, showing disagreement in 32.6% of allocations. Some of this may be attributed to allocation of residential FLU to areas of agricultural preference, as revealed in the FLU-conflict analysis. The allocation process utilized in scenario creation allocated in areas of agricultural preference only when necessary; the FLUM may have had other priorities.

Residential correlation in developable lands was less prevalent when the FLUM was compared to the alternative scenario. This decline in correlation may be attributed to the reduced area used for residential uses in the alternative scenario, which allocated 103,277 acres less residential land than was present in the FLUM. The FLUM has over twice the amount of land designated to residential than the alternative scenario.

Comparison of new development in the FLUMs to that in the growth scenarios thus demonstrates the extent to which the FLUMs support the goals of each scenario, as well as potential deviations from policy should each scenario be followed. The existing policy in the form of the FLUM in Lake County currently most closely supports trends of low density development and loss of agricultural and environmental resources.

Results somewhat paralleled those of the study conducted by Brody, Highfield, and Thornton (2006), though their analysis was regressive in nature. Their study found that the majority of land development correlated with FLUM policy, but still resulted in urban sprawl. They highlighted potential factors for these undesired impacts, such as low land value. As that study noted areas at higher risk of nonconforming development, this thesis similarly highlights spatial locations of potential nonconforming development and urban sprawl.

**Comparison of Growth Scenario Impacts**

40.6% of land that was developed in the trend scenario was instead allocated to conservation, agriculture, and agricultural conservation uses in the alternative scenario. Setting aside green infrastructure and agricultural areas first, and using these boundaries to guide urban development, proved effective at preserving environmentally sensitive land. Increasing density by approximately 20% and assigning minimum densities was highly effective at lessening the needs for vacant and greenfield land to accommodate new urban development.

The more land used for development, the more infrastructure required to extend out to this new development. It may be assumed, therefore, that the alternative scenario would result in fewer costs and land needs associated with extending infrastructure such as roads, water, and sewer to new development in far-reaching areas.

The alternative scenario allocated 26,867 more acres to conservation and 62,964 more acres to agriculture than the trend scenario. The trend scenario allocated 215%

more land to agricultural preservation than the alternative scenario, because of the agricultural preservation allocated in the trend scenario, 59% was within the waterbodies data that was removed as from the alternative scenario analysis and set aside as additional conservation. Much of the agricultural preservation allocated in the trend scenario, then, is classified as wetlands or waterbodies.

Integrating concepts of green infrastructure into the alternative scenario development analysis proved effective at mitigating direct environmental impacts of development, compared to the trend scenario. Water resources were protected from development pressures, new conservation lands were created, and existing conservation lands expanded. More agricultural lands were preserved, with specific restrictions on agricultural areas of high environmental value. Overlay protection zones were kept intact, specifying special development provisions in ecologically sensitive areas to mitigate and prevent impacts of development. Much land identified for protection in the land use allocation process spatially correlated with priority environmental lands as identified in the Critical Lands and Waters Identification Project (CLIP). All of this was accomplished while accommodating projected population and employment growth, suggesting that environmental threats may be lessened through specific growth management and land use policies.

## Scales of Environmental Protection

Literature states the most effective way to protect individual components of the environment is to protect the entire ecosystem, understanding the level of interconnection between habitats at the regional level. Ecological protection should, however, occur at all scales. Urban ecology has the potential to contribute the integrity of the larger regional systems and greenway connections. Green roofs, for example, help to offset the heat island effect[2], provide temporary habitat to migrating birds, and reduces the amount of polluted runoff entering waterways (Green Roofs for Healthy Cities, 2009). This and other low impact design tools, trails, urban parks, and other green infrastructure techniques may not be identifiable at the regional land use scale, but their overall effects can be. In the same way that small land use decisions incrementally lead to large-scale ecological impacts, the cumulative effect of local-scale environmental protection techniques can have a large impact. Cumulative runoff from urban areas, for example, has been demonstrated to affect the overall health of hydrologic systems (United States Environmental Protection Agency, 2008). Legislation and governmental objectives, then, should take all levels of ecological protection into account; localized environmental protection techniques will benefit regional efforts. As urban areas become denser and population increases, the need for new techniques to offset impacts will become increasingly important.

**Limitations to and Opportunities for Implementing Green Infrastructure**

Detailed ecological information must be available to create a network of green infrastructure. To implement it in ways described in this study, it must be made available electronically, specifically for use in GIS or other tool able to visually represent and analyze spatial information. Funding, as well as agencies or groups to implement the task, must be available for the collection of regional data, ensuring its validity and comprehensiveness. This is often completed collaboratively through data collection by a number of organizations (such as in Florida). Not everywhere has these abilities or

[2] The heat island effect is the phenomenon where urban, built up environments maintain a higher air temperature than their surrounding, less urbanized land. This occurs because the sun heats up surfaces such as roofs, asphalt, and pavement to temperatures much warmer than the surrounding air. Cumulatively, this can increase the air temperature of the urban area (Environmental Protection Agency, n.d.)

resources, however, and their studies may be limited. When resources limit information availability, best available information should still be utilized to make the best possible decisions on how to guide development for future growth while protecting valuable resources. Luckily, this information is becoming more common over time and the information more readily available in the public forum.

Plan implementation and approval may mean limiting or preventing development on private land to create conservation land, as suggested in certain areas of the alternative development scenario. Such an act would most likely face issues of private property rights due to limiting current allowable development. Property rights are a sensitive issue that often spurs legal battles, even reaching the U.S. Supreme Court[3] due to questions surrounding the Fifth Amendment of the Constitution, which states that when the government takes action on land, regulatory or otherwise, that removes its value, it is considered "taken" and the owner is subject to compensation (Congressional Research Service, 2000). Additionally, Florida has taken steps in the Florida Statutes to further protect property rights with the Bert J. Harris Private Property Rights Protection Act (Fla. Stat. § 70.001). Removing the right to develop would challenge these legal rights and any regulatory steps to institute a green infrastructure network should take this into account. Incentive-based techniques such as transfer of development rights, tax incentives, or less than fee acquisition (conservation easements) may provide opportunities to preserve green infrastructure while avoiding property rights issues.

Implementation of overlay zones that allow development with specific provisions to protect environmental features, such as the Green Swamp Area of Critical State

[3] See: Lucas v. South Carolina Coastal Council; Kelo v. City of New London; Stop the Beach Renourishment, Inc. v. Florida Department of Environmental Protection

Concern and the Wekiva Protection Area, are another way to provide for green infrastructure without completely removing development rights. In this way, Lake County has made strides towards mitigating impacts of development. These areas are suitable for protection tools such as low impact design, conservation subdivisions or cluster development, or increased open space requirements. Careful analysis of the protection area is necessary appropriate to determine goals and understand what steps to take to best protect the resources; for example, protection of groundwater and surface water quality might focus on techniques of low impact design tools to mitigate effects of development on groundwater recharge and runoff. Studies of appropriate measures for protection zones continue in Lake County, demonstrating the necessarily adaptive nature of ecosystem management.

Governmental coordination is another potential limitation to implementing green infrastructure. Because ecosystems do not follow jurisdictional boundaries, protection measures must be undertaken by all affected jurisdictions. Cooperation and collaborative government processes provide opportunities to establish common goals and a means to achieve them. The merits or limitations of collaborative governance or regional collaborative approaches is not the purpose of this study, but is recognized as a step that should be evaluated for its ability to help mitigate the effects of cumulative impacts of local development decisions.

## Further Research

While the comparison of development scenario allocations to the FLUM shed light on spatial conformity, the research was limited by the inconsistent use of land use categories by each group. The FLUMs, TAZ data, and parcel data all held different definitions of land use categories, limiting the degree of equal analysis possible. To resolve this, existing FLUM policy could be studied to determine specific definitions of commercial, office, and other urban definitions to appropriately place them in the categories recognized by TAZ data. The development scenarios could then be compared to FLUMs on more levels than simply urban versus non-urban or residential versus non-residential to determine spatial correlation among land uses and how well FLUMs reflect identified land use preference and conflict.

The alternative scenarios allocated growth associated with residential, commercial, service, and industrial uses. However, other uses such as institutional uses and associated roads and infrastructure are associated with urban development. Future research might quantify these needs as well to gain a more accurate estimation of land required for urban growth patterns.

Future research may also investigate the most effective way to preserve land for green infrastructure, such as incorporating other policy decisions affecting land use, such as mass transportation systems or high density activity centers. Exercises such as this could shed light on the potential efficacy of different policy approaches in implementing community goals.

Impacts of the growth scenarios were quantified in terms of direct impacts to land area, including land use conversion and conservation. Future research could quantify other environmental impacts, such as the potential results of fragmentation on ecosystems and wildlife migrations, the impacts of vegetation loss on the ability of the region to sequester carbon, and the water quality associated with runoff from impervious surfaces.

Brody, Highfield, and Thornton's (2006) study pinpointing potential factors leading to nonconforming development and urban sprawl. Future research might evaluate the areas of nonconforming development or sprawling development as predicted in the development scenarios for these factors. Correlations between the two could lead to increased understanding of factors leading to urban sprawl and environmental degradation, as well as the reliability of land use modeling exercises.

# CHAPTER 7
# CONCLUSION

Ian McHarg (1992) once completed a spatial growth study for the Washington, D.C. area through the year 2000. Regarding the results, he stated, “It is most disconcerting to conclude that not only does uncontrolled growth fail to recognize intrinsic suitabilities and unsuitabilities for urban growth, but that the formal planning process is almost as culpable” (p. 155). This statement embodies the problem of sprawling development and reflects the results of this study. Regionally, future land use map (FLUM) policy often places urban future land uses (FLUs) in areas preferred for uses other than urban, meaning valuable agricultural and conservation land could be lost or inappropriately developed. Results of the conflict analysis reflect preferences in land use distribution goals; areas where this deviates reflects areas where policy does not support regional goals of land use distribution. The case study demonstrated that if urban growth policy in Lake County does not take into account relative suitabilities for land uses or adopt new goals of green infrastructure, policy will encourage continuation of existing trends and promulgate low density development at the expense of ecosystem functioning. Existing legislation assists these trends by calling for vast areas of low density residential development into environmentally sensitive areas. To protect biological diversity and ecological resources from continued intrusion of urban development, ecological planning must be conducted hand in hand with urban planning. As McHarg (1992) states, “the formulation of a plan…should respond to an understanding of natural processes. It should plan with nature” (p. 161).

Green infrastructure provides a way to increase the role of environmental planning in the land planning process. The concept connects principles of environmental health and benefits to humans by planning concurrently for both environment and human systems. It is not a new concept, but is one that literature suggests is commonly absent in Florida. Despite a history of conservation land acquisition and strong regulations to protect natural resources, land use changes in Florida are over time resulting in large scale environmental impacts, fragmenting habitats, harming water quality, and reducing water recharge to the aquifer. Central Florida has seen a history of sprawling development patterns, exacerbating these impacts of urban growth. People will continue to move to the area, necessitating the need for new development. How this development will occur, and how policy might support goals of development, are the questions at hand.

Modeling outcomes of land use decisions provides a way to demonstrate potential patterns of this new development, and can reveal potential cumulative impacts of policies over time. Patterns can be projected by using suitability analyses to identify land use conflict, using the LUCIS process. The assumption is that new development will be distributed first to areas of least conflict, funneled to its most appropriate and preferred locations. Identification of conflict can also expose threats to agricultural or ecological resources. This study demonstrates how growth models can utilize LUCIS to model likely patterns of development based on differing policies.

The study of Central Florida’s existing FLUM policies demonstrated a strong correlation between urban FLU designations and areas identified as high urban suitability. However, it also demonstrated urban FLU designations taking place in areas that while showing high urban suitability, also show high conflict with conservation, and agriculture uses. Urban land uses are shown preference by the FLUM over other uses in areas with conflicting land use interests, placing land suitable for agriculture and conservation land uses at risk of development.

Modeling growth patterns in Lake County demonstrated that continuation of low density development trends reflects patterns identified in the FLUM and necessarily intrudes on areas of land use conflict, continues sprawling, low density development, and impacts a large amount of environmentally sensitive lands. Conversely, by selecting land based on “intrinsic suitability” (McHarg, 1992, p. 155) and using natural resource values to guide development, some of the negative cumulative outcomes of haphazard, disjointed decision making are avoided. FLUMs will need significant revision if the County wishes to move towards a future of green infrastructure rather than that of urban sprawl.

# APPENDIX A
# LUCIS CONSERVATION GOALS AND OBJECTIVES

Conservation Goals and Objectives

Goal 1: Native Biodiversity

1.1 Identify lands important for protecting native focal species

1.1.1 Identify species hotspots

1.1.2 Identify areas important for protecting wide-ranging species

1.1.3 Identify areas important for protecting viable populations of focal species

1.2 Identify areas important for protecting natural communities

1.3 Identify areas important for protecting or restoring intact landscapes

Goal 2: Protection of Water Quality

2.1 Identify areas important for protecting surface water bodies

2.1.1 Identify all riparian systems, lakes, and ponds as well as special and unique surface water features

2.1.2 Identify floodplains

2.1.3 Identify wetlands and wetland buffers

2.2 Identify areas important for protecting groundwater resources

2.2.1 Identify recharge zones for groundwater

2.2.2 Identify unconfined aquifers (springs) and sinkholes

Goal3: Ecological Processes

3.1 Identify land important for the maintenance of the process of flooding and flood storage in the landscape

3.1.1 Identify lands near wetlands that are more prone to flooding

3.1.2 Identify areas that are within floodplains

3.1.3 Identify surface waters and associated buffers of a size sufficient to protect their flood storage function

3.2 Identify lands dependent on fire for natural function and buffers

3.2.1 Identify fire maintained communities

Goal 4: Enhancing Existing Conservation Areas

4.1 Identify lands proximal to existing conservation lands

4.2 Identify areas of continuous native vegetation most likely to facilitate functional connections between existing conservation lands

Goal 5: Resource Based Recreation

5.1 Identify potential areas used for resource based recreation

5.1.1 Identify existing and potential trail systems

5.1.2 Identify cultural and historic sites potentially compatible with outdoor recreation

5.1.3 Identify areas that provide access to resource based recreation

5.2 Identify all surface water features with the potential for the use for outdoor recreation

5.3 Identify areas more suitable for wilderness based experiences and hunting

APPENDIX B
PARCEL LAND USE CODES, DESCRIPTIONS, AND ASSIGNED TAZ CATEGORIES

| Parcel Land Use Code | Description | TAZ Category |
|---|---|---|
| 11 | STORES ONE-STORY | COMMERCIAL |
| 13 | DEPARTMENT STORES | COMMERCIAL |
| 14 | SUPERMARKET | COMMERCIAL |
| 15 | REGIONAL SHOPPING MALLS | COMMERCIAL |
| 16 | COMMUNITY SHOPPING CENTERS | COMMERCIAL |
| 28 | PARKING LOTS, MOBILE HOME SALES | COMMERCIAL |
| 30 | FLORIST, GREENHOUSES | COMMERCIAL |
| 12 | MIXED USE, I.E., STORE AND OFFICE | COMMERCIAL/SERVICE |
| 29 | WHOLESALE, MANUFACTURING, AND PRODUCE OUTLE | INDUSTRIAL |
| 41 | LIGHT MANUFACTURING | INDUSTRIAL |
| 42 | HEAVY MANUFACTURING | INDUSTRIAL |
| 43 | LUMBER YARDS, SAWMILLS, PLANNING MILLS, | INDUSTRIAL |
| 44 | FRUIT, VEGETABLES, AND MEAT PACKING | INDUSTRIAL |
| 45 | CANNERIES, DISTILLERIES, AND WINERIES | INDUSTRIAL |
| 46 | OTHER FOOD PROCESSING | INDUSTRIAL |
| 47 | MINERAL PROCESSING | INDUSTRIAL |
| 48 | WAREHOUSES, AND DISTRIBUTION CENTERS | INDUSTRIAL |
| 49 | INDUSTRIAL STORAGE (FUEL, EQUIP, AND MATERI | INDUSTRIAL |
| 67 | POULTRY, BEES, TROPICAL FISH, RABBITS, ETC | INDUSTRIAL |
| 68 | DAIRIES, FEED LOTS | INDUSTRIAL |
| 69 | ORNAMENTALS, MISC. AGRICULTURE | INDUSTRIAL |
| 92 | MINING, PETROLEUM, AND GAS LANDS | INDUSTRIAL |
| 93 | SUBSURFACE RIGHTS | INDUSTRIAL |
| 3 | MULTI-FAMILY | MULTI-FAMILY |
| 4 | CONDOMINIA | MULTI-FAMILY |
| 8 | MULTI-FAMILY LESS THAN 10 UNITS | MULTI-FAMILY |
| 17 | ONE-STORY NON-PROFESSIONAL OFFICES | SERVICE |
| 18 | MULTI-STORY NON-PROFESSIONAL OFFICES | SERVICE |
| 19 | PROFESSIONAL SERVICE BUILDINGS | SERVICE |
| 20 | AIRPORTS, MARINAS, BUS TERMINALS, AND PIERS | SERVICE |

| Parcel Land Use Code | Description | TAZ Category |
|---|---|---|
| 21 | RESTAURANTS, CAFETERIAS | SERVICE |
| 22 | DRIVE-IN RESTAURANTS | SERVICE |
| 23 | FINANCIAL INSTITUTIONS | SERVICE |
| 24 | INSURANCE COMPANY OFFICES | SERVICE |
| 25 | REPAIR SERVICE SHOPS | SERVICE |
| 26 | SERVICE STATIONS | SERVICE |
| 27 | AUTOMOTIVE REPAIR, SERVICE, AND SALES | SERVICE |
| 33 | NIGHT CLUBS, BARS, AND COCKTAIL LOUNGES | SERVICE |
| 39 | HOTELS, MOTELS | SERVICE |
| 72 | PRIVATE SCHOOLS | SERVICE |
| 73 | PRIVATE HOSPITALS | SERVICE |
| 74 | HOMES FOR AGED | SERVICE |
| 75 | ORPHANAGES | SERVICE |
| 81 | MILITARY | SERVICE |
| 83 | PUBLIC SCHOOLS | SERVICE |
| 84 | COLLEGES | SERVICE |
| 85 | PUBLIC HOSPITALS | SERVICE |
| 91 | UTILITIES | SERVICE |
| 1 | SINGLE FAMILY | SINGLE FAMILY |
| 2 | MOBILE HOMES | SINGLE FAMILY |
| 0 | VACANT RESIDENTIAL | VACANT RESIDENTIAL |
| 10 | VACANT COMMERCIAL | VACANT SERVICE |
| 40 | VACANT INDUSTRIAL | VACANT INDUSTRIAL |
| 70 | VACANT INSTITUTIONAL | VACANT INSTITUTIONAL |

LIST OF REFERENCES


Ali, A.K. (2007). Understanding local planning agency power in Florida. *Journal of Architectural and Planning Research,* 24(4), 325-337.

Alexander, E.R. & Faludi, A. (1989). Planning and plan implementation: Notes on evaluation criteria. *Environment and Planning B: Planning and Design, 16*(2), 127-140.

Allen, C.R. (2006). Sprawl and the resilience of humans and nature: An introduction to the special feature. *Ecology and Society, 11*(1), article 36. Retrieved from http://www.ecologyandsociety.org/vol11/iss1/art36/

Alterman, R. & Hill, M. (1978). Implementation of urban land use plans. *Journal of the American Institute of Planners, 33,* 274-285.

Beatley, T. (2000). Preserving biodiversity: Challenges for planners. *APA Journal*, *66*(1), 5-19.

Bedford, B.L. & Preston, E.M. (1998). Developing a scientific basis for assessing cumulative effects of wetland loss and degradation on landscape functions: Status, perspectives, and prospects. *Environmental Management, 12*(5), 751-771.

Benedict, M.A. & McMahon, E.T. (2001). *Green infrastructure: Smart conservation for the 21st century*. Washington, D.C.: Sprawl Watch Clearinghouse.

Bengston, D.N., Fletcher, J.O., & Nelson, K.C. (2004). Public policies for managing growth and protecting open space: Policy instruments and lessons learned in the United States. *Landscape and Urban Planning, 69,* 271-286.

Ben-Zadock, E. (2003, October). Growing smart is hard to do. *Planning*, (October 2003), 32-34.

Ben-Zadok, E. (2007). Consistency, concurrency and compact development: Three faces of growth management implementation in Florida. In T.S. Chapin, C.E. Connerly, & H.T. Higgins (Eds.), *Growth management in Florida: Planning for paradise* (pp. 21-50). Hampshire: Ashgate.

Brody, S.D. & Highfield, W.E. (2005). Does planning work? Testing the implementation of local environmental planning in Florida. *Journal of the American Planning Association, 71*(2), 159-175.

Brody, S.D. (2003, July). Implementing the principles of ecosystem management through local land use planning. *Population and Environment*, *24*(6), 511-540.

Brody, S.D., Davis, S.E., Highfield, W.E., & Bernhardt, S.P. (2008, March). A spatial-temporal analysis of section 404 wetland permitting in Texas and Florida: Thirteen years of impact along the coast. *Wetlands, 28*(1), 107-116.

Brody, S.D., Highfield, W.E., & Thornton, S. (2006). Planning at the urban fringe: An examination of the factors influencing nonconforming development patterns in southern Florida. *Environment and Planning B: Planning and Design, 33,* 75-96.

Burchell et al. (2002). *The costs of sprawl-revisited.* Washington, DC: Transportation Cooperative Research Program.

Calkins, H.W. (1979). The planning monitor: An accountability theory of plan evaluation. *Environment and Planning A, 11*(7), 745-758.

Campbell, P. (1997, May). *Population projections: States, 1995-2025.* U.S. Census Bureau Publication No. P25-1131. Retrieved from http://www.census.gov/population/www/projections/reports.html

Carr, M.H. & Zwick, P. (2005). Using GIS suitability analysis to identify potential future land use conflicts in North Central Florida. *Journal of Conservation Planning Vol. 1,* 58-73.

Carr, M.H., & Zwick, P. (2007). *Smart land use analysis: The LUCIS model.* Redlands, CA: ESRI Press.

Carruthers, J.I., Boarnet, M.G., & McLaughlin, R.B. (2007). Growth management and the spatial outcome of regional development in Florida, 1982-1997. In T.S. Chapin, C.E. Connerly, & H.T Higgins (Eds.). *Growth management in Florida: Planning for paradise* (pp. 101-118). Burlington: Ashgate.

Chapin, T.S., Connerly, C.E., & Higgins, H.T. (2007). Introduction. In T.S. Chapin, C.E. Connerly, & H.T Higgins (Eds.). *Growth management in Florida: Planning for paradise* (pp. 1-4). Burlington: Ashgate.

Dahl, T.E. (2006). *Status and trends of wetlands in the coterminous United States 1998 to 2004*. Washington, DC: U.S. Department of the Interior; Fish and Wildlife Service.

Daniels, S. & Walker, G. (1996). Collaborative learning: Improving public deliberation in ecosystem-based management. *Environmental Impact Assessment Review, 16,* 13-30.

Data Transfer Solutions. (2008, February 15). 2035 Long range transportation plan (LRTP) – Socioeconomic data forecasting assumptions. Submitted to Florida Department of Transportation District 5.

Downs, A. (1992). *Stuck in traffic: Coping with peak hour traffic congestion.* Washington, DC: Brookings Institution; and Cambridge, MA: Lincoln Institute of Land Policy.

Dramsted, W.E., Olson, J.D., & Forman, R.T.T. (1996). *Landscape ecology principles in landscape architecture and land-use planning.* Washington, DC: Island Press.

East Central Florida Regional Planning Council. (2008, July). [Metadata from Generalized Future Land Use Shapefile]. Retrieved from http://www.cfgis.org/

Endter-Wada, J., Blahna, D., Krannich, R. & Brunson, M. (1998, August). A framework for understanding social science contributions to ecosystem management. *Ecological Applications*, *8*(3), 891-904.

Environmental Protection Agency. (2001). *Our built and natural environments: A technical review of the interactions between land use, transportation, and environmental quality* (EPA Publication No. 231-R-01-002).

Ewing, R. (1997). Is Los Angeles style sprawl desirable? *Journal of the American Planning Association, 63*(1), 107-124.

Ewing, R., Pendall, R., & Chen, D. (2002). *Measuring sprawl and its impact: Volume I.* Washington, DC: Smart Growth America.

Florida Department of Environmental Protection. (2002). [GIS shapefile map of 303(d) Group 1 Impaired Waters]. *DEP Geographic Information Systems.* Retrieved from http://www.dep.state.fl.us/gis/datadir.htm

Florida Department of Environmental Protection. (2009a, July 10). *Watershed Management.* Retrieved from http://www.dep.state.fl.us/water/watersheds/

Florida Department of Environmental Protection. (2009b). *Ocklawaha River Watershed.* Retrieved from http://www.protectingourwater.org/watersheds/map/ocklawaha/

Florida Department of Environmental Protection. (2009c). *Middle St. Johns River Watershed.* Retrieved from http://www.protectingourwater.org/watersheds/map/middle_st_johns/

Florida Natural Areas Inventory. (n.d.). *Conservation lands*. Retrieved from http://www.fnai.org/conservationlands.cfm

Grumbine, R. E. (1994, March). What is ecosystem management? *Conservation Biology, 8*(1), 27-38.

Hasse, J.E. & Lathrop, R.G. (2003). Land resource indicators of urban sprawl. *Applied Geography, 23,* 159-175.

Hoctor, T, Oetting, J., & Beyeler, S. (2008, May). *CLIP (final draft): Critical lands & waters identification project: Report on completion of the CLIP database version 1.0.* Retrieved from https://www.communicationsmgr.com/projects/1349/docs/CLIPRptJune08.pdf

Holland, C.C., Honea, J., Gwin, S.E., & Kentula, M.E. (1995, December). Wetland degradation and loss in the rapidly urbanizing area of Portland, Oregon. *Wetlands*, *15*(4), 336-345.

Jantz, C.A., Goetz, S.J., & Shelly, M.K. (2003). Using the SLEUTH urban growth model to simulate the impacts of future policy scenarios on urban land use in the Baltimore-Washington metropolitan area. *Environment and Planning B, 30,* 251-271.

Joerin, F., Theriault, M., & Musy, A. (2001). Using GIS and outranking multicriteria analysis for land-use suitability assessment. *International Journal of Geographical Information Science, 15*(2), 153-174.

Kahn, A. E. (1966). The tyranny of small decisions: market failures, imperfections, and the limits of economics. *Kylos, 19*, 23-47.

Kautz, R., Stys, B., & Kawula, R. (2007). Florida vegetation 2003 and land use change between 1985-89 and 2003. *Florida Scientist, 70*(1), 12-23.

King County, Washington. (2008, October 08). *2008 King County comprehensive plan update.* Retrieved from http://www.kingcounty.gov/property/permits/codes/growth/CompPlan.aspx

Lackey, R. T. (1998). Seven pillars of ecosystem management. *Landscape and Urban Planning, 40,* 21-30.

Lake County Water Atlas. (2009a). *Ocklawaha River Watershed.* Retrieved from http://www.lake.wateratlas.usf.edu/watershed/default.asp?wshedID=3

Lake County Water Atlas. (2009b). *Palatlakaha River*. Retrieved from http://dev.lake.wateratlas.usf.edu/river/?wbodyatlas=river&wbodyid=1123.

Lake County. (2009, September 18). *Lake County comprehensive plan.* Retrieved from http://www.lakecountyfl.gov/departments/growth_management/planning_and_community_design/comprehensive_planning/

Lyle, J.T. (1985). *Design for human ecosystems*. New York: Van Nostrand Reinhold Company Inc.

McHarg, I. (1992). *Design with nature.* New York: John Wiley & Sons.

Meeter, P.D. & Niu, X. (2000, October). *A nonparametric procedure for listing and delisting impaired waters based on criterion exceedances*. Retrieved from http://www.p2pays.org/ref/41/40276.pdf

MyRegion.org. (n.d.). *How shall we grow? Central Florida regional vision project.* Retrieved from http://www.ecfrpc.org/Document-Library/Regional-vision.aspx

MyRegion.org. (2005). *Central Florida regional indicators report 2005.* Retrieved from http://myregion.org/Default.aspx?tabid=65

MyRegion.org. (2006, September). *How shall we grow? Creating a shared vision for Central Florida: Mid project report.* Retrieved from http://www.myregion.org/Default.aspx?tabid=65#wawd

MyRegion.org. (2009). *Where in the world are we? 2009 progress report for the Central Florida region.* Retrieved from http://www.myregion.org/Default.aspx?tabid=65#wawd

National Oceanic and Atmospheric Administration. (2008, March 25). *Nonpoint source pollution.* Retrieved from http://oceanservice.noaa.gov/education/kits/pollution/05areas.html

National Resource Conservation Service. (2003, July). *National Resources Inventory 2001 annual NRI: Urbanization and development of rural lands*. Retrieved from http://www.nrcs.usda.gov/technical/NRI/2001/urban.pdf

Nicholas, J.C. & Chapin, T.S. (2007). The fiscal theory and reality of growth management in Florida. In T.S. Chapin, C.E. Connerly, & H.T Higgins (Eds.). *Growth management in Florida: Planning for paradise* (pp. 51-66). Burlington: Ashgate.

Norton, R.K. (2008). Using content analysis to evaluate local master plans and zoning codes. *Land Use Policy, 25*, 432-454.

Noss, R.F., & Scott, J.M. (1997). Ecosystem protection and restoration: The core of ecosystem management. In M. Boyce & A. Hanley (Eds.), *Ecosystem management: Applications for sustainable forest and wildlife resources* (pp. 239-264). New Haven: Yale University Press.

Odum, W.E. (1982, October). Environmental degradation and the tyranny of small decisions. *Bioscience, 23*(9), 728-729.

Olson, R.T. & Lyson, T.A. (1999). *Under the blade: The conversion of agricultural landscapes.* Boulder, CO: Westview Press.

Orton Family Foundation. (2009). CommunityViz 4.0. Retrieved October 05, 2009 from http://www.orton.org/tools/community_viz

Peck, S. (1998). *Planning for biodiversity: Issues and examples.* Washington, D.C.: Island Press.

Pierce, S.M., Cowling, R.M., Knight, A.T., Lombard, A.T., Rouget, M., & Wolf, T. (2005). Systematic conservation planning products for land-use planning: Interpretation for implementation. *Biological Conservation, 125,* 441-458.

PennDesign. (2005, September). *Our region in the year 2050.*

PennDesign. (2007, May). *An alternative future: Florida in the 21st century 2020 2040 2060*. Retrieved from http://metrocenter.ucf.edu

Pierce, S.M., Cowling, R.M., Knight, A.T., Lombard, A.T., Rouget, M., & Wolf, T. (2005). Systematic conservation planning products for land-use planning: Interpretation for implementation. *Biological Conservation, 125,* 441-458.

PlaceMatters. (n.d.). Computer tool: California urban futures model second generation (CUF-2). Retrieved October 05, 2009 from http://www.smartgrowthtools.org/index.php

President's Council on Sustainable Development. (1999, May). *Towards a sustainable America: Advancing prosperity, opportunity, and a healthy environment for the 21st century*. Washington, DC: U.S. Government Printing Office.

Radeloff, V.C., Hammer, R.B., & Stewart, S.I. (2005, June). Rural and suburban sprawl in the U.S. Midwest from 1940 to 2000 and its relation to forest fragmentation. *Conservation Biology, 19*(3), 793-805.

Randolph, J. (2004). *Environmental land use planning and management.* Washington: Island Press.

Ryan, M. (2005, August). The Green Swamp: Florida's liquid heart. In *Naturally Central Florida: Fitting the pieces together.* Retrieved from http://metrocenter.ucf.edu/assets/docs/Naturally_Central_Florida.pdf

Salvesen, D.A. & Porter, D.R. (1995). Introduction. In D.R. Porter & D.A. Salvesen (Eds.), *Collaborative planning for wetlands and wildlife: Issues and examples* (pp. 1-6). Washington, D.C.: Island Press.

Sanchez, T.W. & Mandle, R.H. (2007). Growth and change Florida style: 1970 to 2000. In T.S. Chapin, C.E. Connerly, & H.T Higgins (Eds.). *Growth management in Florida: Planning for paradise* (pp. 101-118). Burlington: Ashgate.

Schue, K. (2005, August). The Wekiva-Ocala Greenway: A unity of water and earth. In *Naturally Central Florida: Fitting the pieces together.* Retrieved from http://metrocenter.ucf.edu/assets/docs/Naturally_Central_Florida.pdf

Seminole County. (2008, December). *Future Land Use Element of the Comprehensive Plan*. Retrieved from http://seminolecountyfl.gov/pd/planning/compplan.asp.

Smart Growth Network. (n.d.). *Getting to smart growth II: 100 more policies for implementation.*

State of Massachusetts. (2000). *Building vibrant communities: Linking housing, economic development, transportation, and the environment.* Retrieved from http://commpres.env.state.ma.us/content/publications.asp

Steiner, F. (1991). *The living landscape: An ecological approach to landscape planning.* New York: McGraw-Hill, Inc.

Steinitz, C., Arias, H., Bassett, M, Flaxman, T., Goode, T., Maddock, D., . . . Shearer, A. (2003). *Alternative futures for changing landscapes: The Upper San Pedro River Basin Arizona and Sonora.* Covelo, CA: Island Press.

Stephenson, R.B. (1997). *Visions of Eden: Environmentalism, urban planning, and city building in St. Petersburg, Florida, 1900-1995.* Columbus, OH: Ohio State University Press.

Talen, E. (1996a, February). Do plans get implemented? A review of evaluation in planning. *Journal of Planning Literature, 10*(3), 248-259.

Talen, E. (1996b). After the plans: Methods to evaluate the implementation success of plans. *Journal of Planning Education and Research, 16*, 79-91.

Terris, J. (1999). *Unwelcome (human) neighbors: The impacts of sprawl on wildlife.* Retrieved from http://www.nrdc.org/cities/smartgrowth/pwild.asp

Theobald, D.M., Miller, J.R., & Hobbs, N.T. (1997). Estimating the cumulative impacts of development on wildlife habitat. *Landscape and Urban Planning*, *39,* 25-36.

U.S. Fish and Wildlife Service. (2009a, October 27). *Summary of listed species reports and population plans.* Retrieved October 27, 2009 from http://ecos.fws.gov/tess_public/TESSBoxscore.

U.S. Fish and Wildlife Service. (2009b, July 28). *Red-cockaded woodpecker recovery.* Retrieved from http://www.fws.gov/rcwrecovery/

Upper Ocklawaha Basin Working Group. (2007, August 14). Basin management action plan: For the implementation of total maximum daily loads adopted by the Florida Department of Environmental Protection in the Upper Ocklawaha Basin. Retrieved from http://www.dep.state.fl.us/Water/watersheds/docs/bmap/AdoptedUpOcklawahaBMAP.pdf

UrbanSim. (2009, May 09). *UrbanSim.* Retrieved October 05, 2009 from http://www.urbansim.org/Main/UrbanSim

Volusia County. (2008, November). *Future Land Use Element of the Comprehensive Plan*. Retrieved from http://volusia.org/growth/planinfo.htm

Waddel, P. (2002). UrbanSim: Modeling urban development for land use, transportation, and environmental planning. *Journal of the American Planning Association, 68*(3), 297-314.

Weber, T. & Aviram, R. *Forest and green infrastructure loss in Maryland 1997-2000, and implications for the future*. Retrieved from http://dnr.maryland.gov/greenways/gi/fgil/fgil.pdf

Willamette Valley Livability Forum. *Alternative transportation futures.* Retrieved October 05, 2009 from http://docs.lcog.org/wvlf/atf.html

Wildavsky, A. (1973). If planning is everything, maybe it's nothing. *Policy Sciences, 4*(2), 127-153.

Wilson, E.O. (1999). *The diversity of life.* New York, NY: W.W. Norton & Company.

Xian, G. & Crane, M. (2005). Assessments of urban growth in the Tampa Bay watershed using remote sensing data. *Remote Sensing of Environment, 97,* 203-215.

Yaffee, S., Phillips, A., Frentz, I., Hardy, P., Maleki, S., & Thorpe, B. (1996). *Ecosystem management in the United States: An assessment of current experience.* Washington, D.C.: Island Press.

## BIOGRAPHICAL SKETCH

Emily Stallings was born and raised in Clermont, Florida. She graduated from Rollins College in 2004 with a degree in environmental studies, where she learned the importance of urban and environmental planning in the protection of ecological resources. Upon graduation Emily went on to work the next two and a half years as a planner in Central Florida for a private firm and then moved to the public sector to work as a planner for the City of Clermont. In 2007, eager to expand her knowledge of urban planning, Emily enrolled in the Urban and Regional Planning master's program at the University of Florida. Here she was awarded the Judith Mucci Scholarship Award from the Central Florida Chapter of the American Planning Association, was active and held office in the Student Planning Association, and worked with professors as a research assistant studying transportation issues, LUCIS applications, and environmental policy in the Everglades. She now resides in North Carolina and looks forward to continuing to put her knowledge and experience to use to better the landscape around her, preserving community and environment for present and future populations.