LEAVING ROOM FOR NATURE:

CREATING A PLANT SELECTION FRAMEWORK TO MAXIMIZE HABITAT IN THE SUBURBAN LANDSCAPE OF ATHENS-CLARKE COUNTY

by

LANDON WOODWARD

(Under the Direction of Brad Davis)

ABSTRACT

This thesis seeks to utilize theories on habitat fragmentation, and human constructed ecosystems to create a model framework for plant selection that maximizes positive ecological impact for small scale, private, suburban properties. As the built environment continues to grow, it leaves an indelible mark on the landform and its ecology. While many focus on large-scale projects, converting underutilized public spaces, brownfields, and junk spaces into essential wildlife habitat and patchwork connections through heavily fragmented urban areas, there are also extensive possibilities utilizing the yards of property owners in suburban and ex-urban communities. It uses classifications methods to collect, and catalogue land-use characteristics, species habitat requirements, and plant species' ecological functions, and it uses GIS modeling based off of suitability parameters derived from the habitat requirements of the reference ecosystems to assess potential opportunities for each ecosystem archetype to provide habitat patches in the suburban land use matrix. These potential patches and habitat plant requirements were cross-referenced to generate a planting framework.

INDEX WORDS: Native Plants, Ecological Restoration, Habitat, Urban Ecology, Biodiversity, Residential Landscaping

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

As humanity grows, migrates, contracts and expands, it brings its built environment with it. While different types of land use have different impacts on their surrounding environment, the widespread habitat loss caused by human expansion presents an obvious threat for species survival. Habitat loss and fragmentation is such an existential issue for global biodiversity, that if extinction rates continue at their current rate we will see the largest mass extinction in 65 million years. As E. O. Wilson warned:

The current rate of diversity seems destined to approach that of the great catastrophes of the Paleozoic and Mesozoic eras – in other words, the most extreme in the past 65 million years. In at least one important respect, the modern episode exceeds anything in the geological past. In the earlier mass extinctions which some scientists believe were caused by large meteorite strikes, most of the plants survived even though animal diversity was severely reduced. Now, for the first time, plant diversity is declining sharply.

This issue is not only important for the species threatened, but for humanity itself. Decreasing biodiversity mean decreasing ecological services and decreasing resiliency. Where will society be if it loses the pollination provided by the honey bee and monarch butterfly, or the water filtration provided by oysters? This is not only an issue of biodiversity, but of human survival.

In this ever-growing world, with seemingly ever-growing crisis, it is easy to become disillusioned and to feel nothing can be done. It is hard to convince oneself to take action in a world that feels too big to hear individual voices. It is hard to take action when the machinations of systemic issues seem impossibly large and out of reach. It is entirely too easy to fall prey to apathy when it feels like there is nothing to be gained.

On some of these issues however, an individual can have an immediate and locally significant impact, with one such issue being the continued destruction of ecosystems by the creeping sprawl of development. Many individuals are living on the very mechanism by which they can have the most say on their outside world and go about their lives completely unaware of it. People pay hundreds of thousands of dollars for control of their own sliver of earth, and do nothing with it, but leave a sterile carpet of lawn to fret over mowing each week.

Athens-Clarke County is no different. Most yards are swathes of lawn, with exotic foundation plantings, and invasive choked side yards. Downtown is covered in invasive Chinese holly and nandina, and the rural areas outside the loop are made up of either fields, or minimally managed stands of successional forest choked with privet, bamboo, and honeysuckle. By and large the landscape of suburban Athens, like much of suburban America, has been disregarded as largely a nuisance instead of the resource it truly is.

This thesis seeks restore value to that underutilized land and give a voice to those property owners by creating a methodology for restoring ecological function to private suburban lands. This research outlines a process for private land owners to establish wildlife habitat on their property through thoughtful plant selection and design. It will use techniques derived from ecological restoration, suitability analysis, and ecological design to create a multifaceted framework for land owners to follow.

This thesis aims to answer the following questions:

- How might landowners provide improved habitat solely through plant selection and planting design in the suburban context?
- What are the challenges and opportunities for the success of such a design?

Thesis Structure

Chapter 2 explains the methodologies used in this thesis to give background context and answer the thesis questions.

Chapter 3 provides a comprehensive literature review, outlining the current state of biodiversity, the importance of ecosystem services, and efforts to resolve the issue to this point. It then gives a quick overview of a commonly accepted methodology for ecological restoration, as well as some perspectives utilizing the most heavily impacted ecosystems.

Chapter 4 uses the methodologies from ecological restoration outlined in chapter 3 to research and analyze nine ecological references and distill them into 6 habitat archetypes that can be easily implemented by private landowners. These habitat archetypes offer a plant list for the landowner to choose from, as well as a brief description and the suitable maintenance regime.

Chapter 5 defines suitability parameters for each archetype based off of research into requirements for establishment. These parameters are then run through a suitability analysis using GIS to generate a habitat suitability map for Athens-Clarke County.

Chapter 6 uses form based design to outline how a private landowner should take the coarse information of the suitability map, and assign use it to guide their site specific design. The design offers suggestions to maximize ecological function while abiding by aesthetic norms.

Chapter 7 offers the major findings of the thesis, as well as recommendations for future efforts, points out particular weaknesses that were made apparent through the course of the research, and suggestions for continued study.

Limitations and Delimitations

This method has several limitations. As with any model there are questions of its accuracy in the non-idealized scenarios of the real world. It is important to effectively choose the variables and parameters outlined in the model to most effectively represent the scenario modeled. This research will attempt to create effective parameters by borrowing from research on the characteristics and requirements for habitats modeled.

Additionally, the scope of the research, its subsequent framework, model, and design are all limited to Athens-Clarke County. However, the research will be approached with general enough principals for it to be implemented in any similar context.

CHAPTER 2

METHODOLOGY

This thesis conducts research in two phases: the creation of habitat archetypes, and the suitability analysis for the application of those archetypes in Athens-Clarke County. The creation of the habitat archetypes primarily utilizes cataloguing and classification to generate a set of high priority plant species for the creation of animal habitat in the suburban context. The suitability analysis uses modeling and GIS analysis to generate a map specifying which habitat archetype's planting framework is most suited to a given location.

Literature Review

First, a breadth of research in the form of a comprehensive literature review was conducted. Research focused largely on two subjects: the diminishing biodiversity caused by habitat destruction, along with its impacts on ecological services, and the role of private land owners in the mitigation of said impacts; and background information on the characteristics and needs of ecoregions and species found in Athens-Clarke County.

These issues were selected due to a lack of information targeting the utilization of small private land holdings, particularly in Athens-Clarke County. This research was conducted utilizing keyword searches of peer-reviewed literature in GALILEO databases, the University of Georgia library system and its associated collections, and internet search engines like Google Scholar.

This investigation indicated a need for research into better practices for these underutilized lands, and established a foundation of related research on which to build. Additionally, research into the characteristics, and needs of piedmont habitats, or ecoregions, and their associated plant and animal species, generated information essential to understanding habitat needs for species in the area.

Classification

Information on the ecological characteristic of the piedmont region was split into two separate categories defined by lists provided by the Georgia Department of Natural Resources' Wildlife Action Plan: information relating to the regional "Priority Habitat," and information relating to regional "Priority Species."

The list of relevant "Priority Habitats" was generated by removing those habitats which were not pertinent from the list given in the GDNR's Wildlife Action Plan. Of the "priority habitats" initially provided, only ten were listed in this research: beaver ponds or freshwater marshes; bottomland hardwood forests; canebrakes; mesic hardwood forests; montane longleaf pine – hardwood forest; oak woodlands and savannas; oak-hickory-pine forest; rocky/sandy river bluffs; upland depression swamp; and xeric pine woodlands. Because this study focuses on terrestrial habitat specifically, ecoregions focused exclusively on aquatic habitat where eliminated. This includes: medium to large rivers; springs and spring runs; rocky or cobbly river shoals and streams. Additionally, due to the rarity, complexity, and difficulty of establishment serpentine outcrops and granite outcrops were omitted, with the suggestion that existing habitat be conserved and additional habitat be created by restoration experts.

These priority habitats or “ecoregions” were then characterized by moisture type, soil type, and stratozones (i.e. canopy, understory, shrub layer, herbaceous layer, ground layer), and commonly occurring or important plant species were then listed. These characteristics were cross-referenced for commonalities, and where possible combined or simplified into merged “habitat archetypes” that will be more easily implementable by civilian laypersons.

A list was generated cataloguing each terrestrial priority animal species, as well as its associated habitat, its associated plants, its diet, and its migratory status. Species were each assigned relevant “habitat archetypes” based off their associated habitat descriptions. Animal species were then catalogued according to habitat archetype commonalities, and a list of necessary plants for associated animal species was created for each habitat archetype.

All of the plant lists from each initial ecoregion, as well those necessary for associated plants were merged into a single plant master list for each habitat archetype.

In order to assure that these planting frameworks are accessible for laypersons in Athens-Clarke County, all plant species were indexed, and cross checked for availability at all plant retailers and nurseries within 25 miles of Athens, as well as regionally prominent native focused nurseries like Woodlanders and Nearly Native and annual plant sales at the State Botanical Garden of Georgia and Trees Atlanta.

Suitability Analysis

After creating habitat archetypes, a set of parameters was generated based off characteristic needs and limitations gathered in the research of the ecoregions that comprise each habitat archetype. These parameters included: soil type, geological aspect, water obligation, previous and current land-use, necessary management regimes, and relationships to other ecosystems. Once suitability maps for each archetype were created, they were then combined using a weighted overlay to generate a suitability map for all of Athens-Clarke County.

Form Based Design

Finally, a form based design was created to outline ideal implementation of the planting framework. The design focuses on analyzing typical land-use forms from urban to rural at multiple scales. It then generates a set of generalized designs to guide landowners in executing their property's renovation.

CHAPTER 3

LITERATURE REVIEW

Habitat Loss and Fragmentation

There is little doubt the world is experiencing an environmental crisis largely at the hands of humanity. Average global temperatures are rising, waters are warming, glaciers are shrinking, sea levels are rising, and those are just the result of our ceaseless production of carbon emissions (climate.nasa.gov). To be sure these are tremendous and wicked problems that require societies unwavering attention and steadfast action; sadly, however, they are not the only issues facing our imperiled environment. While issues like global warming and oil drilling may occupy the public's consciousness for good reason, humanity is facing another, less publicized but equally significant disaster, the loss of biodiversity due to habitat destruction and fragmentation at the hands of human development (Brown et al 2006; Montagnini 2010; M. Loreau et al 2002; Tzoulas et al 2007; Wilcove 1998). Bio-diversity, or the sum of all the species in a given environment, is perhaps our least appreciated natural resource. Biodiversity and the ecological services it provides must be prioritized, understood, and protected, and it requires efforts at every level of society.

Humanity's population has boomed in the modern era growing by a factor of seven over the past two centuries, from roughly one billion in 1800 to around seven billion today (Mitsch & Jorgonson 2003). This, unsurprisingly, has had a resounding effect on the world's ecosystems. Human intervention since the 1800's has caused a predicted extinction rate 1,000 to 10,000 times greater than before human intervention (Wilson 1988).

While many of these studies focus on species rich ecosystems like tropical rainforests, habitat destruction is a pervasive issue throughout the world. In the U.S. alone, only 3 to 5 percent of land in the lower 48 states remains as undisturbed habitat (Rosenzweig 2003). The dramatic impacts of this type of habitat destruction and fragmentation are present across the country. States like Delaware have lost “78 percent of its freshwater mussel species, 34 percent of its dragonflies, 20 percent of its fish species, and 31 percent of its reptiles and amphibians,” and sizeable portions of its native plant and avian species (Tallamy 2007). In the Southeast, migratory birds and large predators have suffered significant declines with increasing habitat fragmentation (Wilcove 1998). The Florida panther has become restricted to just 5% of its historic habitat range due to development and highway construction, and as a result is at risk of extinction (Frakes 2015).

The destruction isn’t simply limited to habitat disruption directly caused by human development; impacts from our development often cause much further impacts than what can be seen on site. Introduced plants, pests, and diseases often escape development and wreak havoc on distant ecosystems. Exotic plants often out compete native species, starving them of light and nutrients, thus eliminating the first trophic layer on which the entire native food web depends. These invasive exotics are the

Figure 1: Example of invasive Chinese privet and Japanese Honeysuckle choking out the understory on UGA's campus

second leading threat to biodiversity, after habitat fragmentation (McGinley, Mark 2018). One can simply look at the stream banks and gullies choked up with privet or the monolithic carpets of kudzu and English ivy blanketing the Georgia landscape to see the impacts of these species.

These impacts also lie in what is no longer seen, particularly the Eastern Chestnut, a mighty hardwood that used to make up 25% of Appalachian hardwood forests before it was decimated by a blight in the early 20th century (The American Chestnut Society). The loss of this iconic species gives a prime example of what is at stake in a loss in biodiversity. The American chestnut wasn't simply a keystone species in Appalachian ecosystems, but a lynchpin in the culture and livelihood of humans. Not only was the timber from these trees used in construction, but "the edible nut was also a significant contributor to the rural economy. Hogs and cattle were often fattened for market by allowing them to forage in chestnut-dominated forests" (Ibid.). This catastrophic extinction is not singular, but recurrent across the map with the Dutch elm disease's destruction of American Elm (www.missouribotanicalgarden.org), and the current extinction of the Eastern Hemlock at hands of the woolly adelgid (NPS 2015).

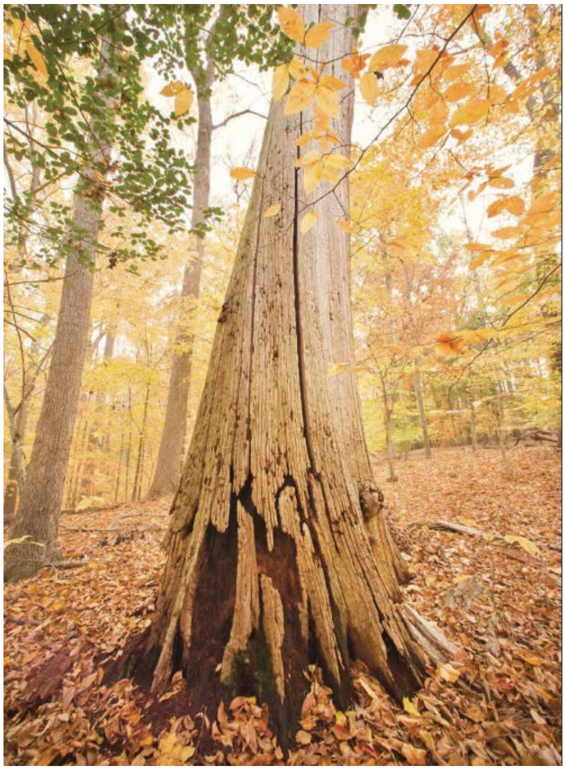


Figure 2: Chestnut killed by blight

Given studies showing a correlation between a 1% increase in the level of human activity across the United States and a .25% increase in the number of species considered at risk of extinction (Brown et al 2006), and a projected U.S. population of 398.33 million by 2050 (www.census.gov), there is a real cause for concern over the health of our ecosystem.

Why It Matters

These growing threats to the health of the various ecosystems of our natural world is not simply an issue of aesthetics or ethics. Even the most pragmatic exploiters of natural resources must come to understand the multiple and varied ecological services provided by natural systems. "Ecosystems running on natural sunlight, wind, and water, are our real support systems, providing a great variety of free public service functions that we do not realize are important until they are gone" (Mitsch and Jorgonson 2004). This is not simply an issue for ecologists and tree huggers, but everyone, from the farmers and fisherman who rely on pollinators and fish stocks for their livelihood, to the city dwellers who rely on the food produced. Douglas Tallamy puts it well when describing unseen dependence of New York City on its surrounding environment:

> Manhattan Island does not have enough of its own water or food to support more than a few thousand people, and it certainly does not produce a surplus of ecological resources needed to export ecosystem services… People can live in New York City only because they take what they need to live from areas of the country that still have a healthy biosphere. [For example,] the water that quenches the thirst of millions of New Yorkers comes entirely from an ecosystem that remains functional: the forested Catskill Mountains north of the city… Every natural resource required to keep New Yorkers alive comes from ecosystems that have not yet collapsed. If urban and suburban sprawl destroys the Catskills, New Yorkers will suffer (Tallamy 2006).

Figure 3: New York City could not exist without the water provided by the ecosystem of the Catskills Mountains

In 1997, the total value of the world's ecosystem services was estimated to be roughly 33-trillion dollars USD. By comparison, the global gross national product at that same time was estimated to be 18-trillion dollars (Costanza et al. 1997). Ecological services are a secret and self-regulating economy that humanity has been drawing from with wanton disregard.

Furthermore, this cannot be viewed as simply a problem of ecological services provided, but an issue of biodiversity. Even when an ecosystem is providing essential services to humanity, it is not necessarily healthy, and unhealthy ecosystems are susceptible to disturbance, and potential failure. Society should not simply focus on propping up the ecological services it relies on, but addressing the issues of decreasing biodiversity in general.

Studies suggest biodiversity is a good indicator of ecosystem health (Tzoulas 2007). Ecosystem health is characterized by an ecosystem's integrity, and whether it's exhibiting typical processes and functions (Rapport 1992). "A healthy ecosystem is thought of as one that is free from distress and degradation, maintains its organization and autonomy over time, and is resilient to stress. (Tzoulas 2007)" A decrease in biodiversity is indicative of stress on an ecosystem and suggestive of its waning vigor and resiliency. The layered ecosystem functions and energy pathways that biodiversity provides in an ecosystem are essential to an environments ability to react and rebound from drastic disturbances (Rapport 2004).

Decreasing biodiversity is exactly what we are witnessing across the U.S. While the ecosystems may not have yet collapsed, the pillars that support their ecological function are being continuously thinned by increasing development and habitat degradation. They are becoming less and less resilient, and eventually when stressed by a significant disturbance – say global climate change – there is no telling the repercussions for both the environment, and the humans that rely upon the ecological service it provides.

Where Do We Go from Here?

The issue of our degraded environment is not a new one. The first "Green Wave occurred in the mid-1960's, and led to the development of many essential pollution mitigation strategies, including the Clean Water Act of 1972, which called for all water in the nation to be fishable and swimmable by 1983. The efforts of this era however focused largely on point source, "end-of-the-pipe technology," and inevitably failed to reach the initial hopes of zero-discharge. By 1983 half the U.S.'s rivers remain too impaired to be swimmable or fishable, despite the Clean Water Act's goals. It became clear that no solely human engineered efforts for remediation would resolve our environmental woes; the solutions must be found in the use of the complex ecological systems that were being impaired. Since the 1970's the issues have only become more complex, with the recognition of problems like acid deposition, greenhouse emissions, and

Figure 4: High School students marching in a 1970's Earth Day parade

habitat destruction and fragmentation. These complicated issues call for equally complex and thoughtful solutions (Mitsch & Jorgenson 2003).

Ecological Restoration

In the case of habitat loss and fragmentation many of the solutions can be found as some form of ecological conservation or restoration. Ecological restoration is "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER International Primer on Ecological Restoration 2004). While this process is site and situation specific, it is driven by a set of principles and guidelines outlined by restoration professionals in documents like the *SER International Primer on Ecological Restoration*, and the *International Standards for the Practice of Ecological Restoration*.

Establishing Context

When beginning a restoration project, it is necessary to first identify the restoration site, and delineate its boundaries. Understanding a site's scale, and surrounding context is essential to developing a restoration plan that is likely to succeed. "Ecological restoration can be conducted at a wide variety of scales, but in practice all ecosystem restoration should be approached with a spatially explicit landscape perspective, in order to ensure the suitability of flows, interactions and exchanges with contiguous ecosystems," including "organisms, energy, water, and nutrients" (Ibid.). A project can focus on restoring a stream bank, a mile of stream corridor, or an entire watershed; but each of those scales presents different and increasingly complex issues and therefore needs to be established from the outset. Often controlling the flows of nutrients, water, and organisms are as significant to a restoration project as the initial composition of the biota.

The type of ecosystem, impairment, and active stakeholders can determine what scale must be used. Ecosystems with intensely impacted abiotic factors, like an eroded stream system, may require significant money and effort to reestablish desired ecological function. These projects may need to focus on a smaller site scale, particularly if it's a small stakeholder group. For example, the restoration of Karnowsky Creek in the Pacific Northwest required intensive efforts to re-channel a historic creek meander that had been diverted and filled to make way for farming (Clewell and Aronson 2013). The project limited its focus to a three-mile stretch of the creek, rerouting the stream, reshaping its banks, and establishing vegetation along the channel. While only 3 miles of the stream were restored, it had much further reaching impacts, providing habitat for beaver and migrating Coho Salmon, as well as raising groundwater levels (Ibid.).

Figure 5: Karnowsky Creek after restoration

Projects which focus on a massive reestablishment of preexisting matrix ecosystems, may require a much larger scale of focus, in part because the restoration methods often utilize the re-propagation of key plant species to re-establish the 1st trophic layer which is more easily and cheaply done than say, the restructuring of an impaired stream bank, but also because the ecosystem by its nature exists as large swaths of uninterrupted habitat and needs to exist on such a scale to function as a healthy ecosystem (Ibid.). The mass replanting of longleaf pine savanna in northern Florida is a good example of restoration at this scale. The Nature Conservancy has been mass planting longleaf pines and seeds from associated grass and forb communities on its 6,295-acre parcel of land (Ibid.). This technique focuses primarily on the reestablishment of the historic plant community, and the reintroduction of its associated management technique, periodic burning.

Once a site has been selected and its boundaries outlined, it is essential to take inventory of the site and its surrounding conditions. This inventory includes current species composition, and structure, and abundance, as well as other biotic and abiotic factors like site hydrology and soil composition; it will be used to determine the site's state of impairment, as well as it's necessary restoration extent, methods, and trajectory (Clewell and Aronson 2013). At this stage, potential stakeholders in the project should also be identified (Clewell, Rieger, and Munro 2005) (Clewell and Aronson 2013). These stakeholders are members of the property owners, interested members of the community, and potential funders, who will help implement and maintain the project going forward. Once this context is established the restorationist can began outlining the design and implementation.

Ecological Reference

In order to create a restoration plan it is necessary to create a reference on which to base the design. This ecological reference contains information including: "species composition, community structure, physical conditions of the abiotic environment, exchanges of organisms and materials that occur with the surrounding landscape, and anthropogenic influences in semi-cultural ecosystems" (Clewell and Aronson 2013); all of this information is used to synthesize a reference model offering specifications for the site's design. References can be from primary or secondary resources, where the primary resources are actual ecosystems called "reference sites"

(Ibid.). These sites can be classified into four distinct types based on their physical and temporal scale and placement: "contemporary information from the site to be restored (same place, same time)"; "historical data from the site to be restored (same place, different time)"; "contemporary information from reference sites (different place, same time)"; and "historical data from reference sites (different time, different place)" (White and Walker 1997).

One can see these methods in the previously described river restoration and the long leaf pine savanna restoration. The river restoration used both same place, different time and different place same time, restoring the Karnowsky Creek to its historical floodplain, and basing its geomorphology on a nearby healthy creek (Clewell and Aronson 2013). The long leaf pine savanna restoration simply used different place, same time to gather seeds of an appropriate species composition from a regionally close site (Ibid.).

Where previous ecosystems have been completely destroyed and the historical trajectory lost secondary sources can be used in the synthesis of a reference model (Clewell and Aronson 2013). "More recent sources of secondary evidence can be helpful to develop reference models for restoring semi-cultural ecosystems and also original ecosystems that were obliterated relatively recently. These sources include lists of native species from published floras and faunas and specimens deposited in herbaria and museum" (Ibid.).

Establishing Goals and Objectives

When beginning an ecological restoration effort, it is important to understand what one is working to accomplish. Ecosystems are not static entities, but complex systems that are constantly changing and evolving. In fact, efforts to bridle ecosystems and make them static often become an impairment themselves, as in the case of stream armoring. The goals of ecological restoration are more of a moving target. One should never seek to roll back time to the previous state of things; it would be both impossibly difficult and ill-conceived. Instead efforts should seek to restore ecological complexity and functions, and reset an ecosystem on its "historic trajectory," meaning the "biophysical conditions that were affected have been corrected and ecological processes have resumed. (Clewell & Anderson 2013)"

Because the concept of a "restored landscape" is something of a moving target, it is important to set achievable standards as metrics of a project. *Ecological Restoration* by Clewell and Aronson draws from the *SER Primer* to outline a list of ecological attributes of restored ecosystems. This list contains four attributes that are a direct result of the restoration efforts, and seven that are generated by the forces outside of the direct manipulations of the restoration. The four directly attained attributes are: species composition, community structure, abiotic environment, and landscape context. The seven indirectly attained attributes are: ecological functionality, historic continuity, self-organization, resilience, self-sustainability, and biosphere support. It is important to note that while there are eleven listed attributes, it is not essential to include every one in a project's goals, particularly the seven indirect attributes. "In most ecological restoration projects, some of these attributes can only be partially satisfied, if at all, for unavoidable technical and pragmatic reason" (Clewell and Aronson 2013). For this reason, this thesis primarily focuses on the four directly attained attributes.

Species Composition

Species composition is the make-up of the species of plants and animals for a given site. In the case of ecological restoration, the focus is placed on the reestablishment of a sites plant species, because they form the first trophic level of the ecosystem and therefore ultimately direct the other ecosystem attributes. Due to their mobility and penchant for finding niches of healthy habitat, animal species rarely need to be introduced to a restoration site (Clewell and Aronson 2013; Tallamy 2007). Plant species composition should be from well-established groupings that have coevolved, as these groups are co-adapted such that each species serves different functional groups within the ecosystem and benefits the “collective survival, fecundity, and capacity for self-organization (Ibid.).”

In addition to establishing coevolved species, it is important to eliminate exotic invasive species from a site as well. These species have not co-evolved with the native ecosystem and often out compete and impede the establishment of native species (Ibid.).

Community Structure

Community structure is the three dimensional space arrangement of biotic and abiotic features within an ecosystem. This includes vertical stratification of vegetation, and topographic characteristics like rock outcroppings. Structural complexity typically provides more opportunity for organisms to interact (Clewell and Aronson 2013). This is shown to be the case with ground nesting birds which require thick ground cover, shrub layers. and canopy forest to complete their lifecycle (McClure et al. 2013).

Abiotic Environment

The abiotic environment includes “hydrology, water quality, and soils” (Clewell and Aronson 2013). For example, soil inundation has a tremendous impact on the success or failure of a bottomland forest or wetland. These factors can often have extensive impacts on other aspects of a restoration like the species composition and community structure.

Landscape Context

This is the least concrete of the directly attained attributes. Landscape context is how a restored site fits in the greater ecological matrix. This determines flows of nutrients, biota, and water, and can be the deciding factor in a project's success. It can also determine how much of an impact, good or bad, a project can have on its surrounding environment (Ibid.).

Before the implementation of a restoration project the desired attributes for the restored site should be appraised, and measurable goals should be established. These goals can act as guidance for stakeholders and practitioners executing the design plan.

Defense of Using Human Constructed Ecosystems as a Partial Answer

The notion that ecosystems are some immaculate ideal set in a jewel case and isolated from human impacts is growing be a less and less defensible myth. Indeed, many important ecosystems like the piedmont savanna require intensive management regimes for their continued existence. Simply looking at restoration sites reclaimed from invasive species, one sees a persistent regime of invasive removal and native replanting (Rainer & West 2015). In his essay *The Role of Horticulture in a Changing World*, Peter Del Tredici asks, "Can we put the invasive species genie back in the bottle, or are we looking at a future in which nature as we know it becomes a cultivated entity?" The answer to this question on a global or regional scale is a tricky and highly contested subject, embroiled in different perceptions of the goals of ecology (Del Tredici 2007); however, in landscapes as heavily impacted and irreversibly changed as suburban and urban development, the answer appears to be clearer. If we want landscapes that support our natural ecosystems, it will take a conscious effort and persistent maintenance. Perhaps it is time to begin to craft a cultural landscape in our urban and suburban contexts that benefits ecological function similar to the efforts in the precolonial Americas. "A new way of thinking is emerging. It does not eek nature in remote mountain tops, but instead in the midst of our cities and suburbs. It looks at our degraded built landscape with unjaded eyes, seeing the archipelago of leftover land – suburban yards, utility easements, parking lots, road right of ways, and municipal drainage channels – not as useless remnants, but as territories of vast potential (Rainer & West 2015)."

With the world's fragmented and dwindling habitat, continued loss of biodiversity, increasing carbon emissions, and ever more chaotic weather events, society can no longer afford to squander this "third landscape" as Gilles Clément calls it (Ibid.). Land owners can no longer afford to maintain roughly 40 million acres of sterile and ecologically useless lawn (Milesi et. al. 2005). Suburban households cannot afford to be apathetic towards their yards when they make up roughly 55% of the land-cover in the continental U.S. (Tallamy 2007). Unquestionably ecosystems have been impaired by societies unencumbered over-development, but a complete disregard for the landscapes ecological role after development has not aided healing.

Ecological restoration "attempts to return an ecosystem to its historic trajectory" (SER International Primer on Ecological Restoration 2004). Because of its significant impairment, and continued residential, commercial, and industrial function, much of the suburban landscape cannot be reverted to its pre-development historical trajectory, and may not be considered ecological restoration. However, many of the same principles of ecological restoration can be applied in methods to restore some of this landscape's ecological services.

> The historic trajectory of a severely impacted ecosystem may be difficult or impossible to determine with accuracy. Nevertheless, the general direction and boundaries of that trajectory can be established through a combination of knowledge of the damaged ecosystem's preexisting structure, composition and functioning, studies on comparable intact ecosystems, information about regional environmental conditions, and analysis of other ecological, cultural and historical reference information (Ibid.).

By shifting the goals away from the expectations of traditional restoration, efforts are no longer limited to less impacted landscapes outside the scope of intensive human activity. With over 69 million acres in the U.S. already converted to heavily managed urban and suburban landscapes, this taps the ecological possibilities for a significant portion of the U.S. land area (Grey & Deneke 1986). Add to this the fact that these areas are already receiving substantial funds for maintenance and upkeep, and there is a potential for tremendous leverage to redirect existing funding to restore, perhaps not a complete ecosystem, but at least ecosystem functions in the urban and suburban landscape. These landscapes, important not for their condition, but for their sheer vastness present an important opportunity to utilize the principles and processes of ecological restoration in the design if not a true ecosystem restoration.

Rosgen style stream restoration is perhaps a reasonable comparison to given perspective necessary on the type of restoration efforts suited to the suburban context. The legitimacy of Rosgen's stream restoration methods is often debated by ecologists and restorationists, many of who feel a formulaic approach to stream restoration is contrary to the very nature of ecological restoration (Lave 2014; Ross 1996). Ecosystems by their very nature are transient, and recent history is riddled with failed attempts to control a river's course; however, Rosgen's methodology offers the ability to potentially resolve the ecological needs of a river system with the needs of surrounding humans (Ibid.). One could certainly make an argument that the suburban landscape, which is much less individually significant and far more prevalent than impaired stream courses, is a much less contentious outlet for a similarly formulaic and modular system. When the only sacrifice is a blanket of lawn and sterile foundation planting of invasive exotics, it is hard to criticize native alternatives, even if their implementation is formulaic.

Furthermore, while some may contend that the state of the suburban landscape in Athens, and the United States in general, is to impaired to effectively be restored to significant ecological value, there is a strong argument that increased adoption of small scale efforts like these by individual landowners across the landscape, can knit together patchwork habitats to create connectivity between larger and healthier habitat "mother nodes". Even if the small properties themselves offer only small benefits to biodiversity, their role as stepping stones between larger greenspaces may act as an invaluable boon to native species colonization and gene exchange. Similar efforts to create connectivity through small habitats on private lands have already been successfully implemented for pollinators through programs like the National Pollinator Garden Network's Million Pollinator Garden Campaign (www.wildones.org) or the pollinator super highway in Oslo (www.smithsonianmag.com).

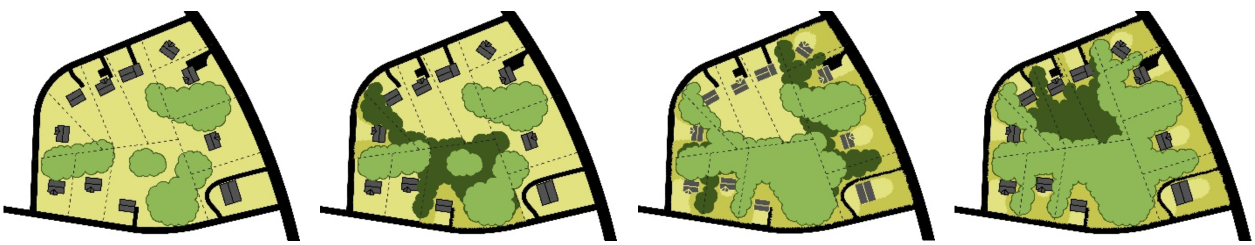


Figure 6: Illustration of how habitat might expand across property boundaries with continued adoption by landowners

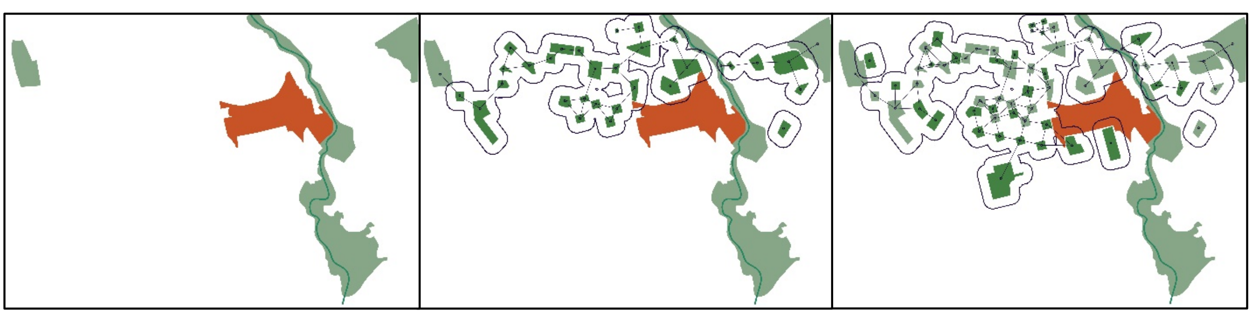


Figure 7: Illustration of patchworks habitat creating connectivity

CHAPTER 4

GENERATING A FRAMEWORK

Site Selection and Stakeholder Identification

In keeping with the principals of ecological restoration described in the literature review the first step of this research is to establish the site and boundaries of the project. Because this research focuses principally on using methods based in ecological restoration to generate a framework to motivate private landowners to restore properties to ecologically functioning semi-wild habitat, this study takes place at the county scale. This scale is large enough to necessitate a generalized, multifunctional, and adaptable outline in order to incorporate a wide swath of landforms and landowners, and it is small enough to fit within the same general ecoregion of Georgia Piedmont, and therefore share a similar ecological history (Edwards, Ambrose, Kirkman 2013) (Georgia DNR 2015). Because of the focus on private land owners, legal property lines are a significant factor in the implementation of any design generated from this research, and the site boundaries for this study will similarly be the legal boundaries of the Athens-Clarke County's borders.

In addition to its ideal size, regional placement, and land-use, Athens-Clarke County was also selected for its proximity to the institute of research, the University of Georgia, and its familiarity with researchers. Additionally, as a classic college town Athens-Clarke County has historically shown some propensity for a progressive mindset when it comes to subjects like conservation and restoration. With existing projects like the restoration efforts at the Sandy Creek Nature (www.athensclarkecounty.com/2774/Sandy-Creek-Nature-Center), the Mimsie

Lanier Center for Native Plants at the State Botanical Garden of Georgia (botgarden.uga.edu/conservation-science/mimsie-lanier-center-native-plant-studies/), and numerous efforts from various departments at UGA, there is clearly an existing network of interested stakeholders to utilize in the mobilization of restoration efforts. These organizations, in conjunction with the private landowners and the local government, make up the stakeholders of this project.

Site Inventory

While a small scale site inventory must be undertaken by an individual homeowner according to the suggested design framework laid out later in this thesis (Chapter 6), a general inventory must be taken from a large scale view. This study uses census data, GIS data, historical, and observational analysis as tools for inventorying the general state of the ecosystems.

Athens-Clarke County is the smallest of Georgia's counties at roughly 122 square-miles in area, and the population as of 2015 was 123,912 (Athens Clarke County by the Numbers). The land-use varies from the high density urban setting of the downtown district, to the surrounding suburban and peri-urban residential, and finally the sparsely populated agricultural region in the green belt outside the perimeter (The Jaegar Company).

In terms of ecological impairment, the state of the historical systems in Athens-Clarke can generally be characterized as degraded and often even destroyed, where "degradation or damage removes all macroscopic life, and commonly ruins the physical environment as well" (SER International Primer on Ecological Restoration 2004). In the urban landscape of the downtown district this state is obvious. Historic vegetation has long since been cut, hills leveled and paved, and grids of multi-story dense construction erected. However, this level of destruction is not limited to the downtown district; given the state of much of Athens land-use history, there is a strong argument that a significant portion of both the suburban and rural landscapes have had their historical ecosystems destroyed. Modern methods of suburban development clear cut vegetation and use large graders to scrape away top soils, leaving barren swaths of subsoil devoid of native microbes, and ready to be covered with grass lawns or invaded by opportunistic foreign flora.

Even rural sites in Georgia, and the southeast in general, have debatably suffered from the complete destruction of their historic ecology. Irresponsible agricultural practices of the southern plantation and share-cropping systems of the 19th and early 20th centuries led to the misuse and loss of much of Georgia's topsoil. In the early 20th century, "nearly 100 million acres were in cultivated row crops and much of that land was losing soil in every rain. The Piedmont lost an average of about seven inches of its topsoil, but in many places all of it was lost" (Trible and Brown 2017). This depletion of topsoil and subsequent exposure of the silica clay subsoil, is the cause of the distinctive "Georgia red clay" with which most Georgia mothers are all too familiar. While many of these historically agricultural fields have been left fallow and allowed to return to forest, it is far from safe to assume these forests are a reliable reference for the historic ecosystem. First, many ecosystems take centuries to establish, so it is probable most of these forests are in some successional stage as opposed to a climax sere, or stage successional development which has reached ecological equilibrium (Clewell and Aronson 2013). Furthermore, with the elimination of topsoil, there is little reason to believe that the species that volunteer for reestablishment are of the same composition as those preexisting agricultural use.

Generally speaking, spaces which have been left to their own devices have been repopulated with dense mats of invasive species like kudzu, privet, honeysuckle and nandina.

Generating Ecosystem Archetypes for Use as Reference Models

Once the site boundaries have been selected and the site inventoried, it is important to create a reference model to guide practitioners in their restoration effort. This study generates a planting framework gathered from secondary sources of Georgia Piedmont ecosystems for two reasons. First, the heavily degraded nature of the ecosystems in Athens-Clarke County makes it very difficult to find a "same place, same time" reference around the site, thus making it necessary to use secondary resources to produce a description of similar sites, their plant composition, and abiotic and biotic factors. Second, because of the generalized nature of the efforts in this research, it is impossible to generate an exact set of restoration specifics for each property owner's land. Instead, this research focuses on creating a general framework which, once implemented, can work as the bones on which a more site specific ecosystem can develop and grow. This method depends heavily on an ecosystems ability to self-organize, allowing "tightly operational feedback loops [to] increase ecological efficiency and stability within an ecosystem" (Clewell and Aronson 2013), and the land owners' use of the design framework (Chapter 6) to tailor their efforts to an individual site. By re-establishing the first trophic level through thoughtful planting design, one encourages the colonization of more mobile animal species higher up the food chain. These species then bring predators and potentially colonizing native seeds, thus increase the initial ecosystems complexity, redundancy, and resiliency (Doody et al. 2013; Clewell and Aronson 2013). Furthermore, while each ecosystems' functional groups are not outlined, those key to maintenance regimes, like the wire grasses which provide fuel for

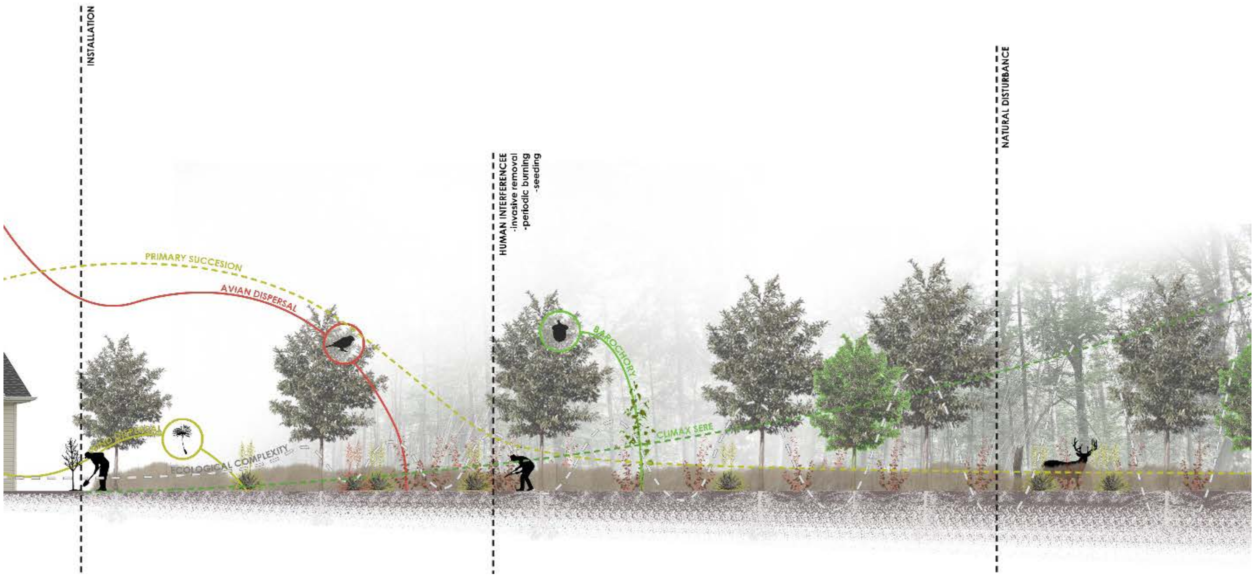


Figure 8: Illustration of ecosystem self-organizing after installation

periodic burns, are included.   Additionally, plant lists are extensive, with the intent that there will be functional redundancies, and that competition will select for the fittest species in a given circumstance (Clewell and Aronson 2013) or create resiliency within the ecosystem (Sundstrom et al. 2012).

Because the specific goals of this research are the creation habitat for priority animal species, priority habitats outline the Georgia DNR's Wildlife Action Plan were used in the construction of reference models. The ten habitats used in this research were: beaver ponds or freshwater marshes; bottomland hardwood forests; canebrakes; mesic hardwood forests; montane longleaf pine – hardwood forest; oak woodlands and savannas; oak-hickory-pine forest; rocky/sandy river bluffs; upland depression swamp; and xeric pine woodlands. Ecoregions focused exclusively on aquatic habitat where eliminated because this study focuses on terrestrial habitat specifically. This includes: medium to large rivers; springs and spring runs; rocky or cobbly river shoals; river bluffs; and streams. Additionally, because this research focuses on mobilizing laymen in restoration efforts serpentine outcrops and granite outcrops were omitted due to their rarity, complexity, and difficulty of establishment. It is suggested that these existing habitats be conserved and additional habitat be created by restoration experts.

Goals

Before beginning the process of creating a reference model or implementing a design, it is important to establish a vision and a set of goals. Since this study centers on mobilizing typically indifferent stakeholders to amend an underutilized and forgotten landscape the goals have a slightly different priority than traditional ecological restoration projects. Generally, these goals can be split into two categories focused on either increased ecological function on a mass scale for private property in Athens-Clarke County, and increased awareness of decreasing habitat due to human development, and its impact on biodiversity and ecosystem health.

Goals for Increased Ecosystem Function

- Increased biodiversity on sites after adopting planting framework
- Increase in native species on sites adopting planting framework
- Increase connectivity across Athens-Clarke County for native wildlife
- Increase in habitat for Georgia Wildlife Action Plan priority species across Athens-Clarke County
- Increase in pollinator habitat across Athens-Clarke County

Goals for Increased Awareness

- Increasing implementation of planting framework across Athens-Clarke County, with the eventual goal of 100% adoption
- Elimination of the use of invasive exotics in private landscaping
- Increased participation in county wide projects and events relating to local ecology

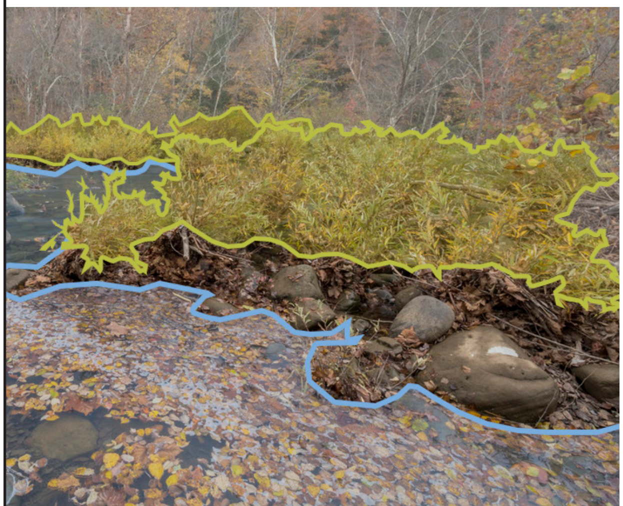
Before a site implements the framework data should be taken on the site biota. Success for a project at a given site will be defined as a statistically significant increase in native animal species biodiversity in subsequent years after implementation. Additionally, an increase in sightings of the Georgia Wildlife Action Plan’s priority animal species in Athens-Clarke County as a whole would be considered a success.

Reference Ecosystem Analysis

These reference habitats outline a set of unique ecosystems essential to the species outlined in the Georgia Wildlife Action Plan. However, because the intent of this study is to generate a formulaic approach implementable by laymen private landowners, it is essential to convert this information down to as simple and easily understood a framework as possible.

Canebrake

Priority Habitat



Soils: Rich Moist to Wet Soils
Fire Regime Necessary: Yes
Description: These thickets of native cane occur canopy openings along waterways throughout the southeast (Wildlife Action Plan). Once prevalent, this ecoregion has become rare, and often invaded by exotic species like Chinese privet. (Peters 2013)

Plant List

Ground Layer

River Cane *Arundinaria gigantea*
Switch Cane *Arundinaria tectata*

Figure 6: Canebrake Characteristics

Beaver Pond/Freshwater Marsh

Priority Habitat

Soils: Wet to Soaked Soils
Maintenance Regime: Naturally created by beaver dam; can also be replicated by human constructed dams
Description: The wetlands occur in beaver impoundments on small and mid-size streams, and along ponds and lakes. They are dominated by sedges, rushes, grasses, and forbs with occasional shrubs and small trees. Often invaded by Murdannia (Wildlife Action Plan).

Plant List

Canopy Trees

Box Elder *Acer negundo*
Red Maple *Acer rubrum*
River Birch *Betula nigra*
Southern Hackberry *Celtis laevigata*
Green Ash *Fraxinus pennsylvanica*
Sweet Gum *Liquidambar styraciflua*
Tulip-tree *Liriodendron tulipifera*
Sycamore *Platanus occidentalis*
Water Oak *Quercus nigra*
Black Willow *Salix nigra*

Shrubs and Vines

Tag Alder *Alnus serrulata*
Buttonbush *Cephalanthus occidentalis*
Swamp Dogwood *Cornus amomum*
Stiff Dogwood *Cornus stricta*
Virginia Sweetspire *Itea virginica*
Crossvine *Bignonia capreolata*
Climbing Hydrangea *Decumaria barbara*

Ground Layer

Common Ground Nut *Apios americana*
False Nettle *Boehmeria cylindrica*
Mist flower *Conoclinium coelistinum*
Orange jewelweed *Impatiens capensis*
Cardinal flower *Lobelia cardinalis*
Great blue lobelia *Lobelia siphilitica*
*Alternate leaf seedbox *Ludwigia alternifolia*
Climbing hempweed *Mikania scandens*
Monkey flower *Mimulus ringens*
Green arrow arum *Peltandra virginica*
*Arrowleaf tearthumb *Persicaria sagittata*
Rustweed *Polypremum procumbens*
Meadow beauty *Rhexia mariana*
Cutleaf coneflower *Rudbeckia laciniata*
Broadleaf arrowhead *Saggitaria latifolia*
Lizard's-tail *Saururus cernuus*
*Cattail *Typha latifolia*
Bushy bluestem *Andropogon glomeratus*
River cane *Arundinaria gigantea (bottomland)*
Shallow sedge *Carex lurida*
River oats *Chasmanthium latifolium*
Common rush *Juncus effusis*
Sensitive fern *Onoclea sensibilis*
Royal fern *Osmunda spectabilis*
Cinnamon fern *Osmundastrum cinnamomeum*
Netted chain fern *Woodwardia areolata*
*=Not Included in Bottomland Hardwood Forest

Figure 7: Beaver Pond/ Freshwater Marsh Characteristics

Bottomland Hardwood Forest

Priority Habitat

Soils: Rich Wet Soils
Fire Regime Necessary: No
Description: These forests occur in the alluvial soils of floodplains. They have a canopy largely dominated by a oaks and hickories, and a shrub layer of varying densities. These habitats are often impacted by invasive species such as Chinese privet (Wildlife Action Plan).

Plant List

Canopy Trees

Box elder *Acer negundo*
Red maple *Acer rubrum*
River birch *Betula nigra*
Southern hackberry *Celtis laevigata*
Musclewood *Carpinus caroliniana*
Bitternut hickory *Carya cordiformis*
Green ash *Fraxinus pennsylvanica*
Common silverbell *Halesia tetraptera*
Sweet gum *Liquidambar styraciflua*
Tulip-tree *Liriodendron tulipifera*
Sycamore *Platanus occidentalis*
Overcup oak *Quercus lyrata*
Swamp chestnut oak *Quercus michauxii*
Water oak *Quercus nigra*
Cherrybark oak *Quercus pagoda*
Willow oak *Quercus phellos*
Shumard oak *Quercus shumardii*
Black willow *Salix nigra*

Shrubs and Vines

Tag alder *Alnus serrulata*
Beautyberry *Callicarpa americana*
Sweet shrub *Calycanthus floridus*
Buttonbush *Cephalanthus occidentalis*
Swamp dogwood *Cornus amomum*
Stiff dogwood *Cornus stricta*
Strawberry bush *Euonymus americanus*
Witch-hazel *Hamamelis virginiana*
Virginia sweetspire *Itea virginica*
Hairy northern spicebush *Lindera benzoin*
Swamp azalea *Rhododendron viscosum*
Elderberry *Sambucus canadensis*
Yellowroot *Xanthorhiza simplicissima*
Crossvine *Bignonia capreolata*
Trumpet vine *Campsis radicans*
Climbing hydrangea *Decumaria barbara*
Virginia creeper *Parthenocissus quinquefolia*
Poison ivy *Toxicodendron radicans*

Ground Layer

Common ground nut *Apios americana*
Green dragon *Arisaema dracontium*
Jack-in-the-pulpit *Arisaema triphyllum*
False nettle *Boehmeria cylindrica*
Mist flower *Conoclinium coelistinum*
Dimpled trout lily *Erythronium umbilicatum*
Hollow-stem Joe-pye-weed *Eutrochium fistulatum*
Shuttleworth's ginger *Hexastylis shuttleworthii*
Orange jewelweed *Impatiens capensis*
Cardinal flower *Lobelia cardinalis*
Great blue lobelia *Lobelia siphilitica*
Climbing hempweed *Mikania scandens*
Monkey flower *Mimulus ringens*
Green arrow arum *Peltandra virginica*
May-apple *Podophyllum peltatum*
Rustweed *Polypremum procumbens*
Cutleaf coneflower *Rudbeckia laciniata*
Broadleaf arrowhead *Saggitaria latifolia*
Lizard's-tail *Saururus cernuus*
Sweet Betsy *Trillium cuneatum*
Common wingstem *Verbesina alternifolia*
Atamasco lily *Zephyranthes atamasca*
Bushy bluestem *Andropogon glomeratus*
River cane *Arundinaria gigantea*
Shallow sedge *Carex lurida*
River oats *Chasmanthium latifolium*
Common rush *Juncus effusis*
Sensitive fern *Onoclea sensibilis*
Royal fern *Osmunda spectabilis*
Cinnamon fern *Osmundastrum cinnamomeum*
Netted chain fern *Woodwardia areolata*

Figure 8: Bottomland Hardwood Forest Characteristics

Mesic Hardwood Forest

Priority Habitat

Soils: Moist Rich Soils
Fire Regime Necessary: No
Description: These forests occur in the non-wetland portions of floodplains, ravines, and north facing slopes. They have a canopy composed largely of beaches, oaks, and hickories, and a significant understory and shrub layer (Wildlife Action Plan).

Plant List

Canopy Trees

Southern sugar maple *Acer floridanum*
Musclewood *Carpinus caroliniana*
Bitternut hickory *Carya cordiformis*
American beech *Fagus grandifolia*
White ash *Fraxinus americana*
Common silverbell *Halesia tetraptera*
Tulip-tree *Liriodendron tulipifera*
Cucumber magnolia *Magnolia acuminata*
Fraser magnolia *Magnolia fraseri*
Bigleaf magnolia *Magnolia macrophylla*
Umbrella magnolia *Magnolia tripetala*
Red mulberry *Morus rubra*
Ironwood *Ostrya virginiana*
Northern red oak *Quercus rubra*
White basswood *Tilia americana*

Shrubs and Vines

Painted buckeye *Aesculus sylvatica*
Common pawpaw *Asimina triloba*
Strawberry bush *Euonymus americana*
Smooth hydrangea *Hydrangea arborescens*
Mountain laurel *Kalmia latifolia*
Doghobble *Leucothoe fontanesiana*
Northern spicebush *Lindera benzoin*
Piedmont azalea *Rhododendron canescens*

Ground Layer

Dolls'-eyes *Actaea pachypoda*
Black cohosh *Actaea racemosa*
Sharp lobed hepatica *Anemone acutiloba*
Round lobed hepatica *Anemone americana*
Jack-in-the-pulpit *Arisaema triphyllum*
Common wild ginger *Asarum canadense*
Cutleaf toothwort *Cardamine concatenata*
Broadleaf toothwort *Cardamine diphylla*
Blue cohosh *Caulophyllum thalictroides*
Devil's-bit *Chamaelirium luteum*
Northern horsebalm *Collinsonia canadensis*
Yellow lady's-slipper *Cypripedium parviflorum*
Harbinger-of-spring *Erigenia bulbosa*
Dimpled trout lily *Erythronium umbilicatum*
White avens *Geum canadense*
Wild geranium *Geranium maculatum*
Summer bluet *Houstonia purpurea*
Goldenseal *Hydrastis canadensis*
Crested iris *Iris cristata*
Hairy sweet cicely *Osmorhiza claytonii*
Smooth sweet cicely *Osmorhiza longistylis*
Ginseng Panax *quinquefolius*
Blue phlox *Phlox divaricata*
May-apple *Podophyllum peltatum*
Bloodroot *Sanguinaria canadensis*
Axillary goldenrod *Solidago caesia*
Star chickweed *Stellaria pubera*
Rue anemone *Thalictrum thalictroides*
Foamflower *Tiarella wherryi*
Catesby's trillium *Trillium catesbaei*
Sweet Betsy *Trillium cuneatum*
Nodding trillium *Trillium rugelii*
Halberd-leaf violet *Viola hastata*
Northern maidenhair fern *Adiantum pedatum*
Rattlesnake fern *Botrypus virginianus*
Silvery glade fern *Homalosorus pycnocarpon*
Broad beech fern *Phegopteris hexagonoptera*
Southern lady fern *Athyrium asplenioides*

Figure 9: Mesic Forest Characteristics

Oak-Hickory-Pine Forest

Priority Habitat

Soils: Dry to semi-dry Soils
Fire Regime Necessary: No
Description: These forests once covered 50% to 70% of the Georgia Piedmont. The canopy is composed of a variety of hardwood species, with a significant understory and shrub layer. (Wildlife Action Plan). These forests are occur in most areas not near stream or on north facing hills (Ambrose, Edwards, and Terrance 2013).

Plant List

Canopy Trees

Red Maple *Acer rubrum*
Pignut hickory *Carya glabra*
Pale/Sand hickory *Carya pallida*
Mockernut hickory *Carya tomentosa*
American chestnut (sprouts) *Castanea dentata*
Redbud *Cercis canadensis*
Flowering dogwood *Cornus florida*
Sweetgum *Liquidambar styraciflua*
Blackgum *Nyssa sylvatica*
Sourwood *Oxydendrum arboreum*
Shortleaf pine *Pinus echinata*
Loblolly pine *Pinus taeda*
White oak *Quercus alba*
Scarlet oak *Quercus coccinea*
Southern red oak *Quercus falcata*
Rock chestnut oak *Quercus montana*
Northern red oak *Quercus rubra*
Black oak *Quercus velutina*
Black locust *Robinia pseudoacacia*

Shrubs and Vines

Small-fruited pawpaw *Asimina parviflora*
Sweetshrub *Calycanthus floridus*
Coralbeads *Cocculus carolinus*
Strawberry bush *Euonymus americanus*
Mountain laurel *Kalmia latifolia*
Virginia creeper *Parthenocissus quinquefolia*
Oconee azalea *Rhododendron flammeum*
Great rhododendron *Rhododendron maximum*
Gorge rhododendron *Rhododendron minus*
Pinxter flower *Rhododendron periclymenoides*
Sparkleberry *Vaccinium arboreum*
Hillside blueberry *Vaccinium pallidum*
Deerberry *Vaccinium stamineum*
Mapleleaf viburnum *Viburnum acerifolium*
Muscadine *Vitis rotundifolia*

Ground Layer

Southern harebell *Campanula divaricata*
Pipsissewa *Chimaphila maculata*
Green-and-gold *Chrysogonum virginianum*
Pink lady's-slipper *Cypripedium acaule*
Whorled wild yam *Dioscorea quaternata*
Elephant's-foot *Elephantopus tomentosus*
Trailing arbutus *Epigaea repens (a sub-shrub)*
Eastern flowering spurge *Euphorbia corollata*
Galax *Galax urceolata*
Downy rattlesnake-orchid *Goodyera pubescens*
Little brown jugs *Hexastylis arifolia*
Veiny hawkweed *Hieracium venosum*
Quaker ladies *Houstonia caerulea*
Naked tick trefoil *Hylodesmum nudiflorum*
Common stargrass *Hypoxis hirsuta*
Carolina phlox *Phlox carolina*
Solomon's seal *Polygonatum biflorum*
Eastern Solomon's plume *Maianthemum racemosum*
Fire-pink *Silene virginica*
Cranefly orchid *Tipularia discolor*
Catesby's trillium *Trillium catesbaei*
Perfoliate bellwort *Uvularia perfoliata*
Christmas fern *Polystichum acrochoides*

Figure 10: Oak-Hickory-Pine Forest Characteristics

Montane Longleaf Pine-Hardwood Forest

Priority Habitat

Soils: Dry to Semi-dry Soils
Fire Regime Necessary: Yes
Description: These forests are largely composed of long leaf pine, and oaks. The understory and shrub layer are thin, but the ground layer has a diverse array of grasses and forbs. (Wildlife Action Plan).

Plant List

Canopy Trees

Shortleaf pine *Pinus echinata*
*Longleaf pine *Pinus palustris*
Scarlet oak *Quercus coccinea*
Southern red oak *Quercus falcata*
Blackjack oak *Quercus marilandica*
*Rock chestnut oak *Quercus montana*
Post oak *Quercus stellata*

Shrubs and Vines

*Sparkleberry *Vaccinium arboreum*
*Hillside blueberry *Vaccinium pallidum*
*Deerberry *Vaccinium stamineum*

Ground Layer

Purple gerardia *Agalinis purpurea*
Slender gerardia *Agalinis tenuifolia*
*Hemp dogbane *Apocynum cannabinum*
*Spurred butterfly pea *Centrosema virginianum*
*Maryland golden-aster *Chrysopsis mariana*
*Butterfly pea *Clitoria mariana*
Woodland coreopsis *Coreopsis major*
Hyssopleaf eupatorium *Eupatorium hyssopifolium*
Late flowering boneset *Eupatorium serotinum*
Eastern flowering spurge *Euphorbia corollata*
*Veiny hawkweed *Hieracium venosum*
Hairy lespedeza *Lespedeza hirta*
*Downy trailing lespedeza *Lespedeza procumbens*
Smooth trailing lespedeza *Lespedeza repens*
Dense blazing star *Liatris spicata*
Downy lobelia *Lobelia puberula*
Eastern sensitive briar *Mimosa microphylla*
Wild quinine *Parthenium integrifolium*
*Maypop *Passiflora incarnata*
*Silkgrass *Pityopsis graminifolia*
*Fragrant rabbit tobacco *Pseudognaphalium obtusifolium*
Black-eyed Susan *Rudbeckia hirta*
Rosinweed *Silphium compositum*
*Hedge nettle *Solanum carolinense*
*Eastern silvery aster *Symphyotrichum concolor*
*Long-stalked aster *Symphyotrichum dumosum*
*Georgia aster *Symphyotrichum georgianum*
*Common clasping aster *Symphyotrichum patens*
*Frost aster *Symphiotrichum pilosum*
Tall goldenrod *Solidago altissima*
Eastern gray goldenrod *Solidago nemoralus*
*Licorice goldenrod *Solidago odora*
*Pencil-flower *Stylosanthes biflora*
*Virginia goat's-rue *Tephrosia virginiana*
*Bird's-foot violet *Viola pedata*
*Splitbeard Bluestem *Andropogon ternarius*
Big bluestem *Andropogon gerardii*
Poverty oat-grass *Danthonia spicata*
Bigtop lovegrass *Eragrostis hirsuta*
Eastern beard grass *Gymnopogon ambiguus*
*Eastern needlegrass *Piptochaetium avenaceum*
Little bluestem *Schizachyrium scoparium*
Yellow Indiangrass *Sorghastrum nutans*
Purpletop *Tridens flavus*
*Bracken fern *Pteridium latiusculum*

Figure 11: Montane Longleaf-Pine Hardwood Forest Characteristics

Oak Woodland and Savanna

Priority Habitat

Soils: Dry to Semi-dry Soils
Fire Regime Necessary: Yes
Description: These forests are largely composed of long leaf pine, and oaks. The understory and shrub layer are thin, but the ground layer has a diverse array of grasses and forbs. (Wildlife Action Plan).

Plant List

Canopy Trees

Pignut Hickory *Carya Pignut Hickory*
Pale Hickory *Carya pallida*
Mockernut Hickory *Carya tomentosa*
Shortleaf Pine *Pinus echinata*
Loblolly Pine *Pinus taeda*
Virginia Pine *Pinus virginiana*
White Oak *Quercus alba*
Scarlet Oak *Quercus coccinea*
Southern Red Oak Quercus falcata
Blackjack Oak Quercus marilandica
Chinkapin Oak *Quercus muehlenbergii*
Chestnut Oak *Quercus prinus*
Post Oak *Quercus stellata*
Black Oak *Quercus velutina*
Northern Red Oak *Quercus rubra*

Ground Layer

Purple Gerardia *Agalinis purpurea*
Slender Gerardia *Agalinis tenuifolia*
Colicroot *Aletris farinosa*
False Garlic *Allium bivalve*
Fly Poison *Amianthium muscaetoxicum*
False Indigo *Amorpha herbacea*
Milkweed *Asclepias amplexicaulis*
Butterfly Weed *Asclepias tuberosa*
Aster *Aster concolor*
Bushy Aster *Aster dumosus*
Starred Aster *Aster lateriflorus*
Aster *Aster patens*
White-topped Aster *Aster pilosus*
Aster *Aster puniceus*
False Indigo *Baptisia alba*
Pale Indian Plantain *Cacalia atriphicifolia*
Partridge Pea *Cassia fasciculata*
Wild Sensitive Plant *Cassia nicitans*
Wild Chervil *Chaerophylhym tainturieri*
Woodland Coreopsis *Coreopsis major*
Croton glandulosus
Tick-trefoil *Desmodium dillenii*
Tick-trefoil *Desmodium laevigatum*
Desmodium marilandicum
Tick-trefoil *Desmodium paniculatum*
Buttonweed *Diodia teres*
Eclipta alba
Common Fleabane *Erigeron philadelphicus*
Daisy Fleabane *Erigeron strigosus*
Eryngium prostratum
Eupatorium album
Dog Fennel *Eupatorium capillifolium*
Hardy Ageratum *Eupatorium coelestinum*
Joe-Pye Weed *Eupatorium fistulosum*
Hyssopleaf Eupatorium *Eupatorium hysspifolium*
Boneset *Eupatorium perfoliatum*
Late Flowering Boneset *Eupatorium serotinum*
Flowering Spurge *Euphorbia corollata*
Geranium carolinianum
Gnaphalium helleri
Rabbit Tobacco *Gnaphalium obtusifolium*
Haplopappus divaricatus
Pennyroyal *Hedeoma pulegioides*
Sneeze Weed *Helenium autumnale*
Sneeze Weed *Helenium flexulosum*
Narrow-leaved Sunflower *Helianthus angustifolius*
Dark-eyed Sunflower *Helianthus atrorubens*
Helianthus hirsutus
Helianthus microcephalus
Woodland Sunflower *Helianthus strumosus*
Jerusalem Artichoke *Helianthus tuberosus*
Heterotheca mariana
Camphorweed *Heterotheca subaxillaris*

Figure 12: Oak Woodland and Savanna Characteristics

Hawkweed *Hieraceum gronovii*
Bluets *Houstonia caerulea*
Pine Weed *Hypericum gentianoides*
Dwarf St. John's-wort *Hypericum mutilum*
Yellow Star Grass *Hypoxis hirsuta*
Dwarf Dandelion *Krigia virginica*
Pine Weed *Lechea racemulosa*
Hairy Bush Clover *Lespedeza hirta*
Bush Clover *Lespedeza intermedia*
Creeping Bush Clover *Lespedeza repens*
Slender Bush Clover *Lespedeza virginica*
Grassleaf Blazing Star *Liatris graminifolia*
Button Snake Root *Liatris microcephala*
Dense Blazing Star *Liatris spicata*
Toad-flax *Linaria canadensis*
Cardinal Flower *Lobelia cardinalis*
Indian Tobacco *Lobelia inflata*
Downy Lobelia *Lobelia puberula*
Whorled Loosestrife *Lysimachia quadrifolia*
Wild Bergamot *Monarda fistulosa*
Dotted monarda *Monarda punctata*
Evening Primrose *Oenothera biennis*
Wild Quinine *Parthenium integrifolium*
Grey Beardtongue *Penstemon canescens*
Carolina Phlox *Phlox carolina*
Polygala *Polygala curtissii*
Bear's Foot *Polymnia uvedalia*
Herbwilliam *Ptilimnium capillaceum*
Hoary Mint *Pycnanthemum incanum*
Slender-leaved Mint *Pycnanthemum teniufolium*
Carolina Desert-Chicory *Pyrrohappus carolinianus*
Virginia Meadow Beauty *Rhexia virginica*
Beak Rush *Rhyncospora globularis*
Sunfacing coneflower *Rudbeckia heliopsidis*
Black-eyed Susan *Rudbeckia hirta*
Black-eyed Susan *Rudbeckia fulgida*
Cut-leaf Cone Flower *Rudbeckia laciniata*
Sorrel *Rumex hastatulus*
Rose Pink *Sabatia angularis*
Lyre-leaved Sage *Salvia lyrata*
Skullcap *Scutellaria integrifolia*
Sleepy Catchfly *Silene antirrhina*
Compass Plant *Silphium compositum*
Starry Rosinweed *Silphium dentatum*
Blue-eyed Grass *Sisyrinchium angustifolium*
Tall Goldenrod *Solidago altissima*
Showy Goldenrod *Solidago erecta*
Late Goldenrod *Solidago gigantea*
Common Goldenrod *Solidago nemoralis*
Rough-stemmed Goldenrod *Solidago rugosa*
Showy Goldenrod *Solidago speciosa*
Feather Bells *Stenanthium gramineum*
Wood Sage *Teucrium canadense*
Meadow Rue *Thalictrum revolutum*
Bastard Pennyroyal *Trichostema dichotomum*
White Vervain *Verbena urticifolia*
Crown Beard *Verbesina alternifolia*
Yellow Crownbeard *Verbesina occidentalis*
White Crownbeard *Verbesina virginica*
New York Ironweed *Vernonia novaboracensis*
Bentgrass *Agrostis hymenalis*
Bentgrass *Agrostis perennans*
Big Bluestem *Andropogon gerardii*
Broomsedge *Andropogon virginicus*
Hair Grass *Aira elegens*
Three Awn Grass *Aristida dichotoma*
Three Awn *Aristida oligantha*
River Cane *Arundinaria gigantea*
Poverty Oat Grass *Danthonia spicata*
Virginia Wild Rye *Elymus virginicus*
Love Grass *Eragrostis hirsuta*
Love Grass *Eragrostis refracta*
Purple Love Grass *Eragrostis spectabilis*
Woolly Plume Grass *Erianthus alopecuroides*
Plume Grass *Erianthus contortus*
Beard Grass *Gymnopogon ambiguus*
Beaked panicgrass *Panicum anceps*
Forked Panic Grass *Panicum dichotomum*
Roundseed Panicgrass *Panicum sphaerocarpon*
Bull Crowngrass *Paspalum boscianum*
Florida Paspalum *Paspalum floridanum*
Field Paspalum *Paspalum laeve*
Thin Paspalum *Paspalum setaceum*
Foxtail Grass *Setaria glauca*
Little Blue Stem *Schizachyrium scoparium*
Indian Grass *Sorghastrum nutans*
Wedge Grass *Sphenopholis obtusata*
Purple Top *Tridens flavus*
Six Weeks Grass *Vulpia octoflora*
Three-seeded Mercury *Acalphya rhomboidea*

Figure 12 cont.: Oak Woodland and Savanna Characteristics

Xeric Pine Woodlands

Priority Habitat

Soils: Dry Rocky Soils
Fire Regime Necessary: Yes
Description: These woodlands occur in the sandhills in the south of the piedmont. Dominated by a variety of pines (Wildlife Action Plan).

Plant List

Canopy Trees

Long leaf Pine *Pinus palustris*
Turkey Oak *Quercus laevis*
Sand Laurel Oak *Quercus hemisphaerica*
Persimmon *Diospyros virginiana*
Devilwood *Osmanthus americanus*
Loblolly pine *Pinus taeda*

Shrubs and Vines

Deerberry *Vaccinium stamineum*
Sparkleberry *Vaccinium arboreum*

Ground Layer

Woody Goldenroda *Chrysoma pauciflosculosa*
Prickly Pear *Opuntia humifusa*
Orange Grass *Hypericum gentianoides*
Arrowfeather Threeawn *Aristida purpurascens*
Capillary Hairsedge *Bulbostylis ciliatifolia*
Tapered Rosette Grass *Dichanthelium acuminatum*
Coastal Plain Dawnflower *Stylisma patens*

Figure 13: Xeric Pine Woodland Characteristics

Open Meadow

Nonpriority Ecoregion

Soils: Dry Rocky Soils
Fire Regime Necessary: Yes
Description: These woodlands occur in the sandhills in the south of the piedmont. Dominated by a variety of pines (Wildlife Action Plan).

Plant List

Wildflowers

Purple gerardia *Agalinis purpurea*
Slender gerardia *Agalinis tenuifolia*
Hemp dogbane *Apocynum cannabinum*
Spurred butterfly pea *Centrosema virginianum*
Maryland golden-aster *Chrysopsis mariana*
Butterfly pea *Clitoria mariana*
Woodland coreopsis *Coreopsis major*
Dog fennel *Eupatorium capillifolium*
Hyssopleaf eupatorium *Eupatorium hyssopifolium*
Late flowering boneset *Eupatorium serotinum*
False dandelion *Pyrrhopappus carolinanus*
Eastern flowering spurge *Euphorbia corollata*
Appalachiansunflower *Helianthus atrorubens*
Hairy sunflower *Helianthus hirsutus*
Roughleaf sunflower *Helianthus strumosus*
Veiny hawkweed *Hieracium venosum*
Hairy lespedeza *Lespedeza hirta*
Downy trailing lespedeza *Lespedeza procumbens*
Smooth trailing lespedeza *Lespedeza repens*
Dense blazing star *Liatris spicata*
Southern blazing star *Liatris squarrulosa*
Downy lobelia *Lobelia puberula*
Eastern sensitive briar *Mimosa microphylla*
Common wild quinine *Parthenium integrifolium*
Maypop *Passiflora incarnata*
Silkgrass *Pityopsis graminifolia*
Fragrant rabbit tobacco *Pseudognaphalium obtusifolium*
Black-eyed *Susan Rudbeckia hirta*
Rosinweed *Silphium compositum*
Hedge nettle *Solanum carolinense*
Eastern silvery aster *Symphyotrichum concolor*
Long-stalked aster *Symphyotrichum dumosum*
Georgia aster *Symphyotrichum georgianum*
Common clasping aster *Symphyotrichum patens*
Frost aster *Symphiotrichum pilosum*
Tall goldenrod *Solidago altissima*
Eastern gray goldenrod *Solidago nemoralus*
Licorice goldenrod *Solidago odora*
Pencil-flower *Stylosanthes biflora*
Virginia goat's-rue *Tephrosia virginiana*
Bird's-foot violet *Viola pedata*
Old field broomsedge *Andropogon virginicus*
Splitbeard bluestem *Andropogon ternarius*
Big bluestem *Andropogon gerardii*
Poverty oat-grass *Danthonia spicata*
Silky oat-grass *Danthonia sericea*
Bigtop lovegrass *Eragrostis hirsuta*
Eastern beard grass *Gymnopogon ambifuus*
Eastern needlegrass *Piptochaetium avenaceum*
Little bluestem *Schizachyrium scoparium*
Yellow Indiangrass *Sorghastrum nutans*
Purpletop/Greasy grass *Tridens flavus*
Bracken fern *Pteridium latiusculum*

Figure 14: Open Meadow Characteristics

The first step in this process is distilling the list of ecotypes into a handful of key ecosystem archetype, which provide similar ecosystem functions to each other. To do this, reference ecosystems were compared based on their species composition, community structures, and maintenance regimes. Those that were found to share all three were compiled into a single habitat archetype. The final archetypes were canebrake, bottomland forest / freshwater wetland, mesic forest, piedmont savanna, and oak-hickory-pine forest. Additionally, a pollinator meadow archetype was added to specifically target easement areas in which no trees can grow.

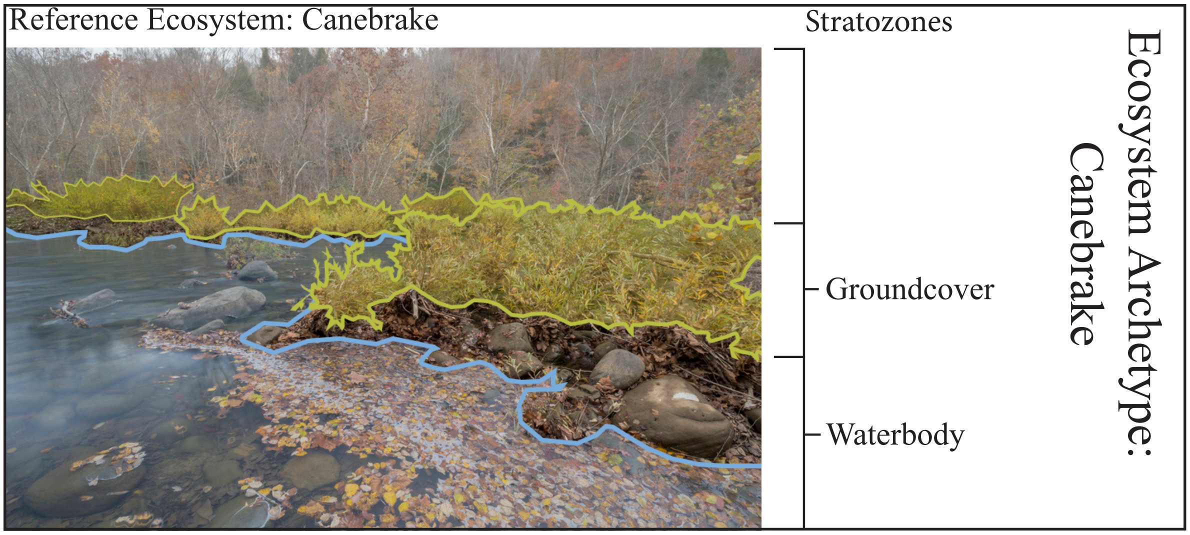


Figure 18: Stratozone Analysis-Canebrake

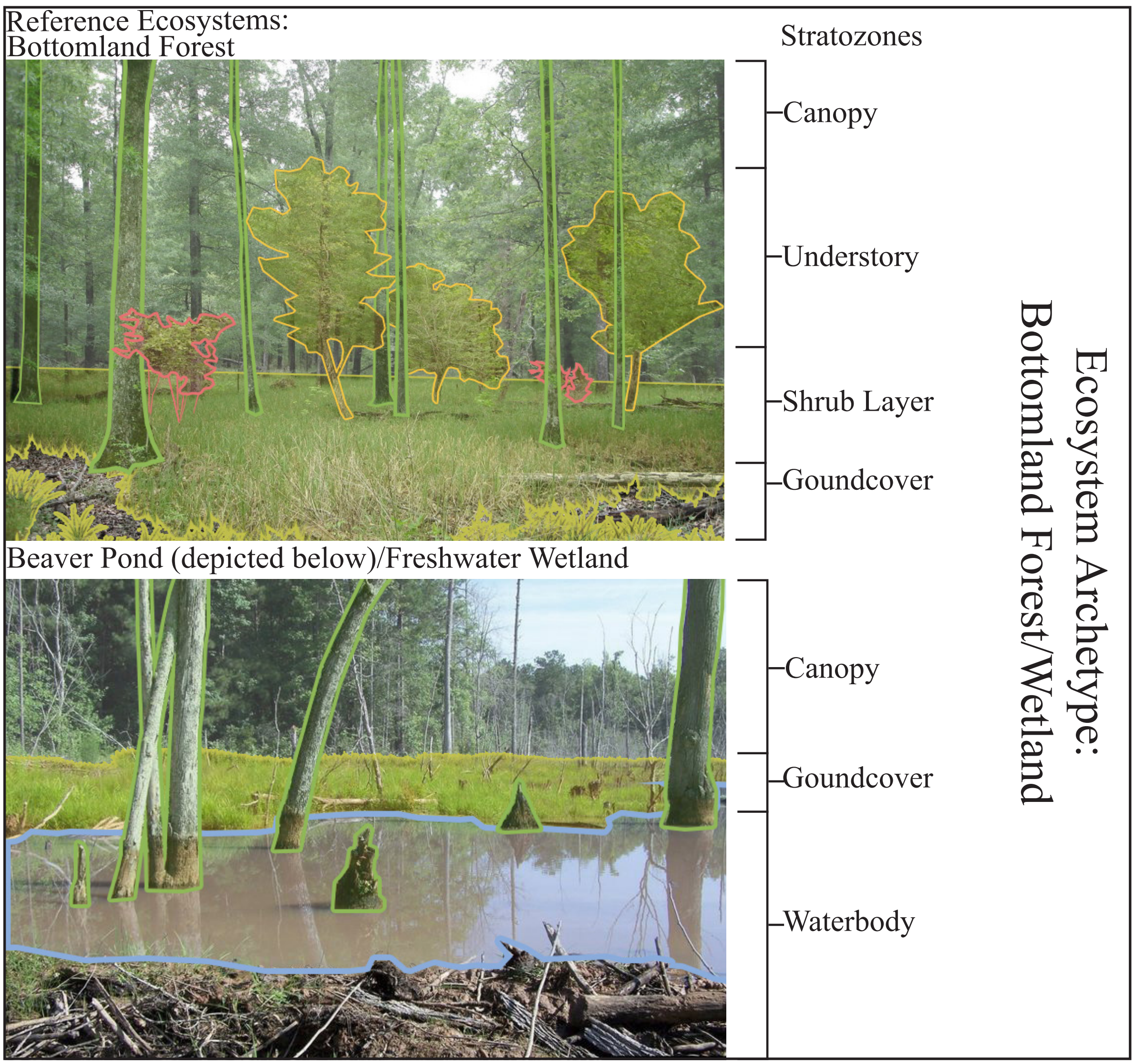


Figure 19: Stratozone Analysis-Bottomland Forest/Wetland

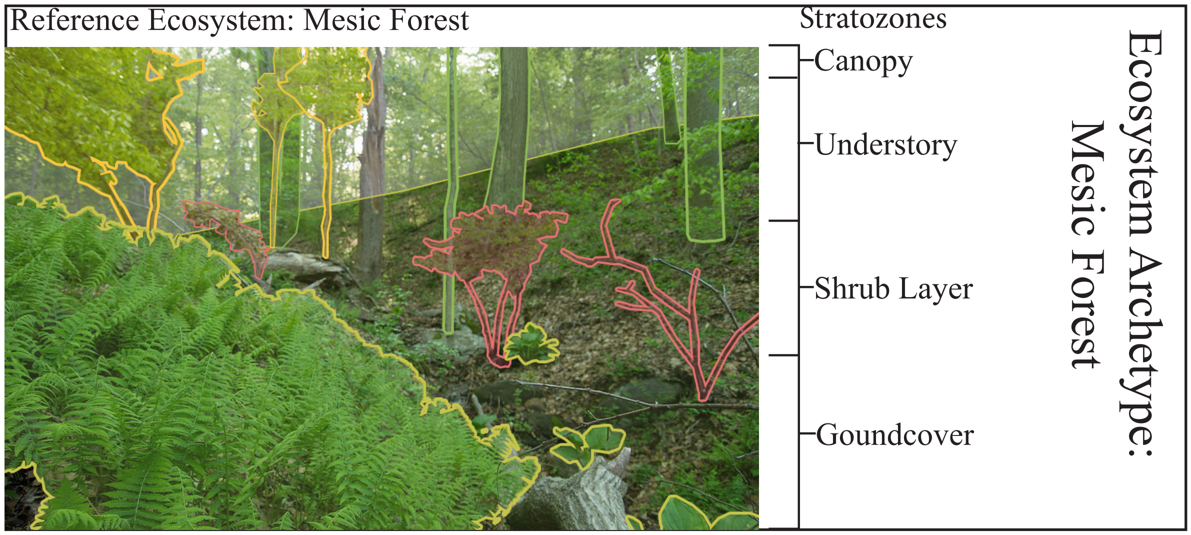


Figure 20: Stratozone Analysis-Mesic Forest

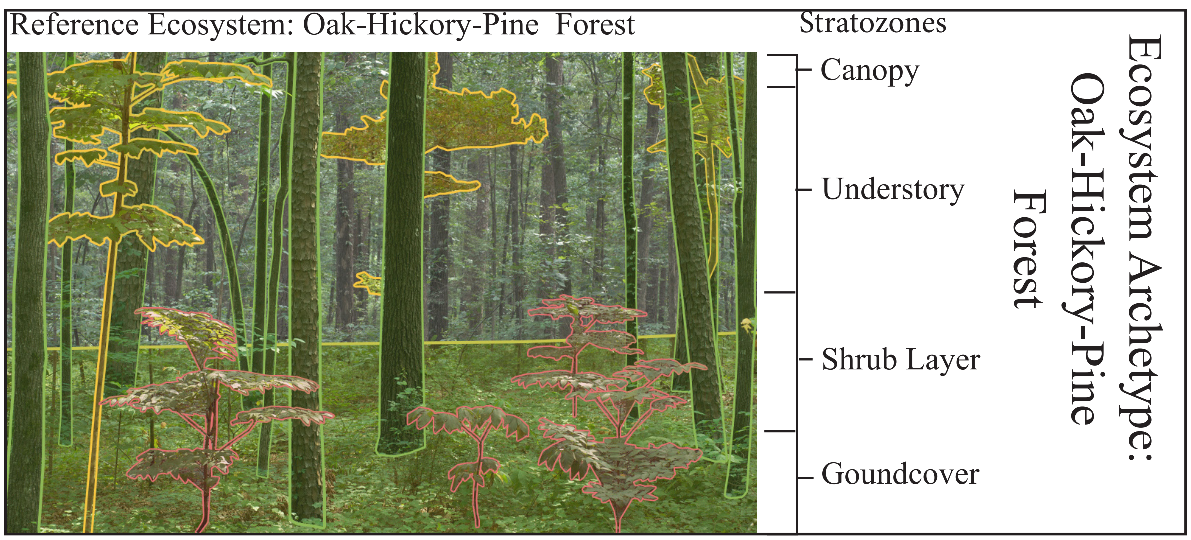


Figure 21: Stratozone Analysis-Oak-Hickory-Pine Forest

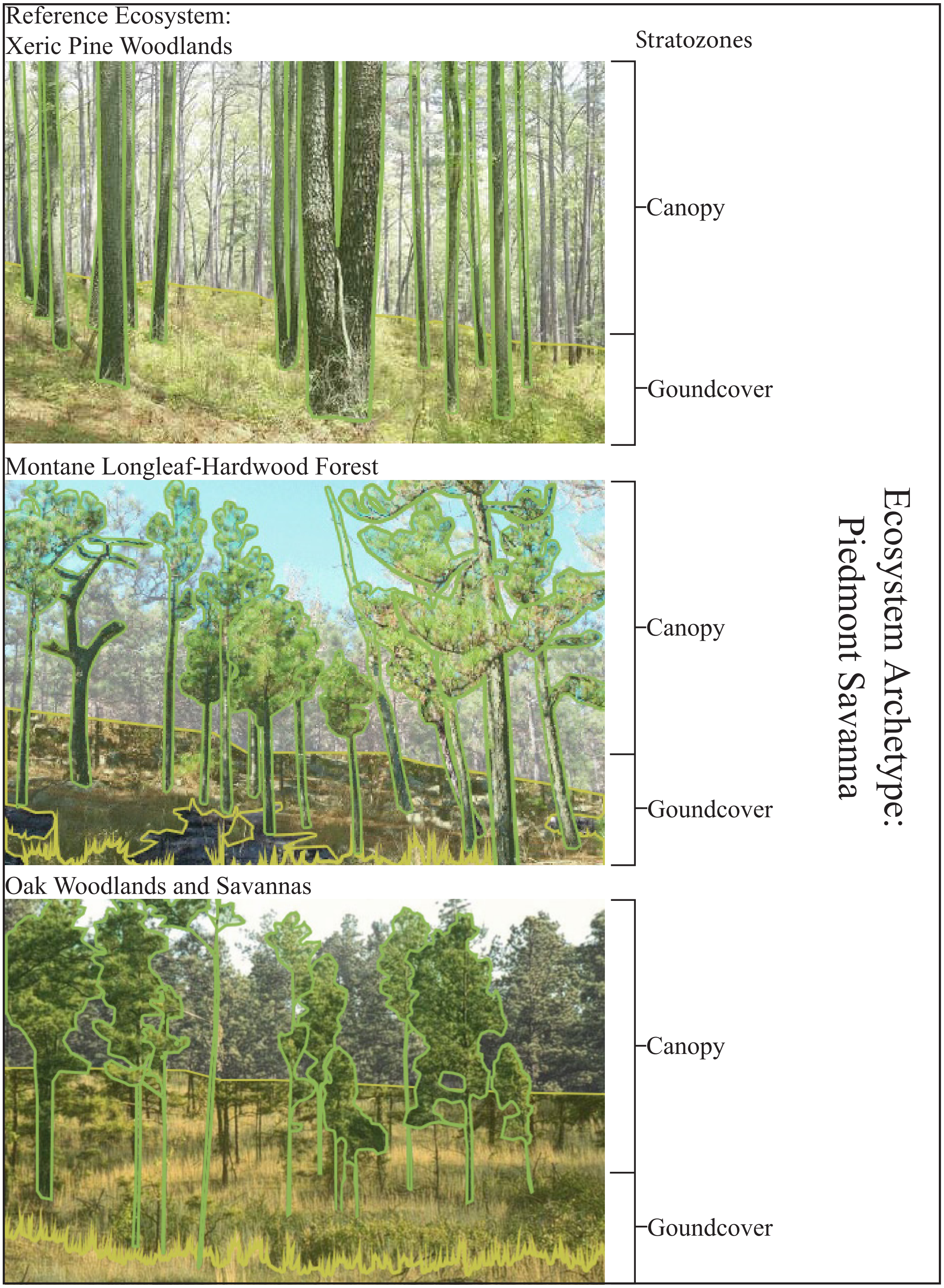


Figure 22: Stratozone Analysis-Piedmont Savanna

Because this research is focusing on the use of private land to create habitat, the priority species form the Georgia Wildlife Action Plan were researched. The species were listed along with their habitat requirements, associated plant species, migratory tendencies, and diet. Additionally, each species habitat requirements were cross referenced with each ecosystem archetype, and those archetypes with similar characteristics were listed alongside the species. The animal species' associated plant species were cross referenced with the plants from the ecosystem archetype and those plants not listed were added.

Table 1: Priority Species and Necessary Habitat

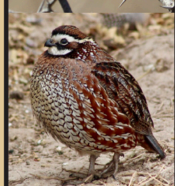
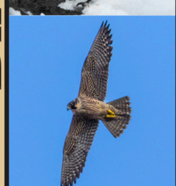
PRIORITIES SPECIES AND NECESSARY HABITAT							
Group	Photo	Species	Habitat	Associated Plants	Diet	Migratory	
Amphibians		Chamberlain's Dwarf *Eurycea chamberlaini*	**Habitat:** Seepage areas near ponds and streams	**Associated Plants:**	**Diet:**	**Migratory:** No	BL MF
Amphibians		Dwarf Waterdog *Necturus punctatus*	**Habitat:** slow streams, ditches, and swamps; favors bottom of leaf litter	**Associated Plants:**	**Diet:**	**Migratory:** No	BL MF
Amphibians		Patch-nosed Salamander *Urspelerpes brucei*	**Habitat:** slow streams, ditches, and swamps; favors bottom of leaf litter	**Associated Plants:**	**Diet:**	**Migratory:** No	BL MF
Birds		Grasshopper Sparrow *Ammodramus savannarum*	**Habitat:** Grasslands, dry fields, and prairies	**Associated Plants:** tall grasses	**Diet:** Insects; seeds	**Migratory:** Full migrant	
Birds		Northern Bobwhite *Colinus virginianus*	**Habitat:** Secondary vegetation after disturbance by fire or agriculture	**Associated Plants:**	**Diet:** Insects; seeds	**Migratory:** No	OM PS
Birds		Rusty Blackbird *Euphagus carolinus*	**Habitat:** Breeds around wetlands, ponds and streams in forests; Nests in dense ground-cover and conifers	**Associated Plants:**	**Diet:** Insects; seeds	**Migratory:** Full migrant	BL
Birds		Peregrine Falcon *Falco peregrinus*	**Habitat:** Inhabits a wide variety of habitats	**Associated Plants:**	**Diet:** Birds (Pigeons and Doves)		ALL
Birds		Whooping Crane *Grus americana*	**Habitat:** Breeds in prairie wetlands; winters in coastal brackish wetlands	**Associated Plants:** willow; sedge	**Diet:** Berries; nuts; insects; shrimp, crustaceans; frogs; fish	**Migratory:** Full Migrant	BL
Birds		Bald Eagle *Haliaeetus leucocephalus*	**Habitat:** Lives primarily on coasts, rivers, and lakesides; open land when migrating; Nests in tall forest trees	**Associated Plants:** Old growth trees	**Diet:** Fish; birds; small mammals	**Migratory:** Full Migrant	MF OHP PS BL OM

Table 1 cont.: Priority Species and Necessary Habitat

PRIORITIES SPECIES AND NECESSARY HABITAT

Birds

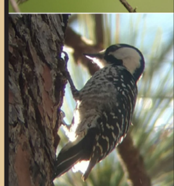
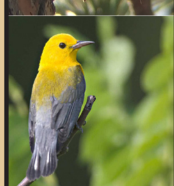
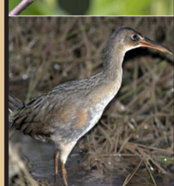
Photo	Species	Habitat	Associated Plants	Diet	Migratory	Habitat codes
	Least Bittern *Ixobrychus exilis*	**Habitat:** Freshwater marshes and reedy ponds; Nests in dense marsh vegetation	**Associated Plants:** Reeds; water obligate grasses, rushes and juncus	**Diet:** Fish; insects	**Migratory:** Some migration	BL MF CB
	Loggerhead Shrike *Lanius ludovicianus*	**Habitat:** semi-open country with trees and scrub; nests in a dense, potentially thorny tree or shrub	**Associated Plants:** trees; dense, possibly thorny shrubs; grasses	**Diet:** Insects; rodents; small birds	**Migratory:** Full Migrant	OHP PS BL MF
	Black Rail *Laterallus jamaicensis*	**Habitat:** fresh and saline marshes, and wet meadows and savannas; nests in marshes and impoundments	**Associated Plants:** needs tall vegetation to escape into and nest	**Diet:** Terrestrial and aquatic invertebrates	**Migratory:** Full Migrant	BL
	Swainson's Warbler *Limnothlypis swainsonii*	**Habitat:** swamps, river floodplains, and canebrakes; nests in cane, and rhododendron	**Associated Plants:** Rivercane; dwarf palmetto; rhododendron-laurel-hemlock; poplar-oak-maple; no groundcover	**Diet:** Larval Insects	**Migratory:** Full migrant	BL MF CB OHP
	Bachman's Sparrow *Peucaea aestivalis*	**Habitat:** Open pine or oak woods, palmetto scrub; common in under-story that has been limited by fire	**Associated Plants:** Pines, specifically long-leaf pine	**Diet:** Insects; seeds	**Migratory:** No	OM PS
	Red-cockaded Woodpecker *Picoides borealis*	**Habitat:** Mature pine woods maintained through burning; nests in mature pines with red heart fungus; needs 80 ha	**Associated Plants:** Pines, specifically long-leaf pine	**Diet:** Insects; wild fruit; seeds	**Migratory:** No	PS
	Prothonotary Warbler *Protonotaria citrea*	**Habitat:** Wooded swamps, river floodplains, and lake-shores	**Associated Plants:** Ash, black willow, buttonbush, sweetgum, red maple, hackberry, river birch, and elm	**Diet:** Insects; mollusks; some seeds	**Migratory:** Migrants in spring	BL
	King Rail *Rallus elegans*	**Habitat:** Brushy swamps and marshes; river margins	**Associated Plants:** Cattails, bulrushes, and spartina	**Diet:** Insects; crustaceans	**Migratory:** Migrates in winter	BL
	Kirtland's Warbler *Setophaga kirtlandii*	**Habitat:** Stands of fire managed young jack pines; winters in pine under-story	**Associated Plants:** Pine trees; jack pine	**Diet:** Insects; soft berries; pine sap	**Migratory:** Migrates south to the Bahamas for winter	PS

Table 1 cont.: Priority Species and Necessary Habitat

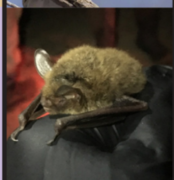
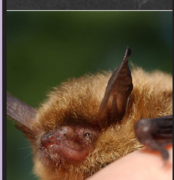
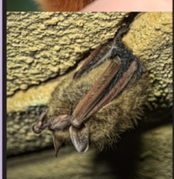
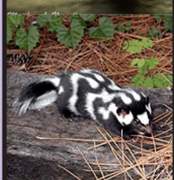
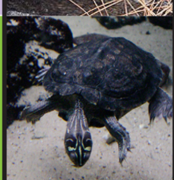
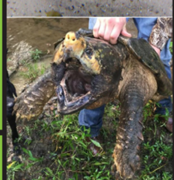
PRIORITIES SPECIES AND NECESSARY HABITAT							
Group	Photo	Species	Codes	Habitat	Associated Plants	Diet	Migratory
Birds		Barn Owl *Tyto alba*	OM PS	**Habitat:** Open woodland and farmland; nests in forests or cities near open land good for foraging like farmland	**Associated Plants:** Reeds; water obligate grasses, rushes and juncus	**Diet:** Mostly rodents	**Migratory:** Some winter migration
Mammals		Southeastern Myotis *Myotis austroriparius*	BL MF	**Habitat:** Riparian floodplains and wetlands; roosts in caves, hollow trees, and structures like bridges; forages over water	**Associated Plants:** hollow tees	**Diet:** Insects	**Migratory:** No
Mammals		Gray Myotis *Myotis grisescens*	BL MF	**Habitat:** Requires caves to nest; forages in riparian areas	**Associated Plants:**	**Diet:** Insects	**Migratory:** No
Mammals		Northern Myotis *Myotis septentrionalis*	OHP PS MF	**Habitat:** Boreal forests; roosts in buildings and tree cavities; hibernates in mines and caves	**Associated Plants:**	**Diet:** Insects	**Migratory:** No
Mammals		Tri-colored Bat *Perimyotis subflavus*	BL MF PS OHP	**Habitat:** Open woodland near water; hibernates in rock crevices and caves	**Associated Plants:**	**Diet:** Insects	**Migratory:** No
Mammals		Eastern Spotted Skunk *Spilogale putorius*	MF OHP PS OM	**Habitat:** Forests with dense under-story; tall grass prairies	**Associated Plants:** Dense under-story cover	**Diet:** Insects; rodents; birds & bird eggs; fruit	**Migratory:** No
Reptiles		Barbour's Map Turtle *Graptemys barbouri*	BL	**Habitat:** Free flowing rivers with limestone outcrops	**Associated Plants:**	**Diet:** Mollusks; insects	**Migratory:** No
Reptiles		Alligator Snapping Turtle *Macrochelys temminckii*	BL	**Habitat:** Rivers, lakes, and swamps	**Associated Plants:**	**Diet:** Fish; mollusks; rodents; smaller turtles; aquatic plants	**Migratory:** No
Reptiles		Northern Pine Snake *Pituophis melanoleucus*	OM PS	**Habitat:** Pine barrens; pine oak forests; old fields	**Associated Plants:**	**Diet:** Birds; rodents; reptiles; eggs	**Migratory:** No

Table 1 cont.: Priority Species and Necessary Habitat

PRIORITIES SPECIES AND NECESSARY HABITAT

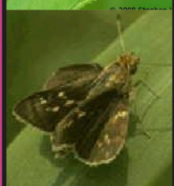
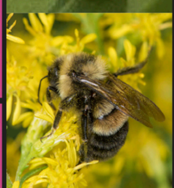
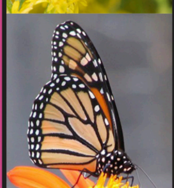
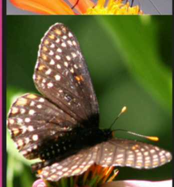
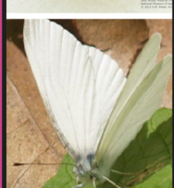
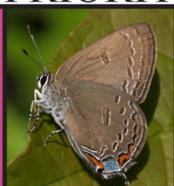
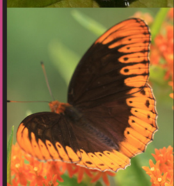
			Habitat	Associated Plants	Diet	Migratory	
Terrestrial Arthropods		Dusky Roadside-skipper *Amblyscirtes alternata*	**Habitat:** Open pine woods	**Associated Plants:** Bearded Skeleton Grass; nectar flowers	**Diet:** Adult: Nectar Host: Bearded Skeleton Grass	**Migratory:** No	OM PS
Terrestrial Arthropods		Bell's Roadside-skipper *Amblyscirtes belli*	**Habitat:** Grassy areas near creeks and forest openings	**Associated Plants:** Inland Sea Oats; nectar flowers	**Diet:** Adult: Nectar Host: Inland Sea Oats	**Migratory:** No	OM PS BL
Terrestrial Arthropods		Carolina Roadside-skipper *Amblyscirtes carolina*	**Habitat:** Bottomland forests near streams and swamps	**Associated Plants:** Sweet pepperbush, swamp milkweed, cinquefoil, wild strawberry, blackberry, ironweed, and switch cane	**Diet:** Adult: Nectar Host: Switch cane	**Migratory:** No	BL MF CB
Terrestrial Arthropods		Rusty-patched Bumblebee *Bombus affinis*	**Habitat:** Woodlands; meadows; old fields	**Associated Plants:**	**Diet:** Nectar	**Migratory:** No	OM PS BL
Terrestrial Arthropods		Monarch Butterfly *Danaus plexippus*	**Habitat:** Open country with milkweed	**Associated Plants:** Native milkweeds	**Diet:** Adult food: Milkweed Nectar; Host: Milkweed	**Migratory:** Yes	BL OM PS
Terrestrial Arthropods		Baltimore Checkerspot *Euphydryas phaeton*	**Habitat:** Wet meadows, bogs, and marshes	**Associated Plants:** turtlehead, hairy beardtongue, false foxglove, native milkweeds, viburnum, and wild rose	**Diet:** Adult: Nectar Host: Plant material	**Migratory:** No	BL OM
Terrestrial Arthropods		A spur-throat grasshopper *Melanoplus longicornis*	**Habitat:** Hardwood forests	**Associated Plants:**	**Diet:** Plant Foliage	**Migratory:** No	OHP MF
Terrestrial Arthropods		Helicta satyr *Neonympha helicta*	**Habitat:** Grassy wetlands; grassy pine forests	**Associated Plants:** sedges	**Diet:** Host: various sedges	**Migratory:** No	BL OM PS
Terrestrial Arthropods		West Virginia White *Pieris virginiensis*	**Habitat:** Moist deciduous woodlands, or mixed woods	**Associated Plants:** Toothwort, plants from the mustard family, spring beauty, and violets	**Diet:** Adult: Toothwort nectar Host: Toothworts and mustard	**Migratory:** No	BL MF OHP

Table 1 cont.: Priority Species and Necessary Habitat

PRIORITIES SPECIES AND NECESSARY HABITAT				
Terrestrial A.		Edwards hairstreak *Satyrium edwardsii*		OHP PS
		Habitat: Oak thickets in rocky open habitats	**Associated Plants:** Scrub oak, black oak, dogbane, goldenrod, meadowsweet, milkweeds, New Jersey tea, staghorn sumac, and white sweet clover	**Diet:** Adult: Nectar Host: Scrub oak and black oak **Migratory:** No
		Diana fritillary *Speyeria diana*		OM PS
		Habitat: Fields; forest edges and openings	**Associated Plants:** violets, common and swamp milkweeds, ironweed, and red clover	**Diet:** Adult: Dung, flower nectar; Host: Violets **Migratory:** No
		Carolina Roadside-skipper *Amblyscirtes carolina*		OHP PS MF
		Habitat: On bare rocks in forests	**Associated Plants:**	**Diet:** Lichen **Migratory:** No

CB Canebrake

BL Bottomland Forest / Freshwater Wetland

MF Mesic Forest

OHP Oak-Hickory-Pine Forest

PS Piedmont Savanna

OM Open Meadow

Table 2: Bottomland Forest/Wetland Merged with Priority Species Plant List

Bottomland - Wetland Plants

Merged Plant Lists

Canopy Trees

Box elder *Acer negundo*
Red maple *Acer rubrum*
River birch *Betula nigra*
Southern hackberry *Celtis laevigata*
Musclewood *Carpinus caroliniana*
Bitternut hickory *Carya cordiformis*
Green ash *Fraxinus pennsylvanica*
Common silverbell *Halesia tetraptera*
Sweet gum *Liquidambar styraciflua*
Tulip-tree *Liriodendron tulipifera*
Sycamore *Platanus occidentalis*
Overcup oak *Quercus lyrata*
Swamp chestnut oak *Quercus michauxii*
Water oak *Quercus nigra*
Cherrybark oak *Quercus pagoda*
Willow oak *Quercus phellos*
Shumard oak *Quercus shumardii*
Black willow *Salix nigra*
*Winged Elm *Ulmus alata*

Shrubs and Vines

Tag alder *Alnus serrulata*
Beautyberry *Callicarpa americana*
Sweet shrub *Calycanthus floridus*
Buttonbush *Cephalanthus occidentalis*
*Sweet Pepperbush *Clethra alnifolia*
Swamp dogwood *Cornus amomum*
Stiff dogwood *Cornus stricta*
Strawberry bush *Euonymus americanus*
Witch-hazel *Hamamelis virginia*
Virginia sweetspire *Itea virginica*
Mountain laurel *Kalmia latifolia*
Hairy northern spicebush *Lindera benzoin*
Swamp azalea *Rhododendron viscosum*
*Black Rasberry (Blackberry) *Rubus occidentalis*
Elderberry *Sambucus canadensis*
*Witherod Viburnum *Viburnum cassinoides*
*Possum-haw Vibernum *Viburnum nudum*
Yellowroot *Xanthorhiza simplicissima*
Crossvine *Bignonia capreolata*
Trumpet vine *Campsis radicans*
Climbing hydrangea *Decumaria barbara*
Virginia creeper *Parthenocissus quinquefolia*
Poison ivy *Toxicodendron radicans*

Ground Layer

Common ground nut *Apios americana*
Green dragon *Arisaema dracontium*
Jack-in-the-pulpit *Arisaema triphyllum*
*Swamp Milkweed *Asclepias incarnata*
False nettle *Boehmeria cylindrica*
*Cutleaf Toothwort *Cardamine concatenata*
*Turtlehead *Chelone lyonii*
*Spring Beauty *Claytonia virginica*
Mist flower *Conoclinium coelistinum*
*Tansy Mustard *Descurainia pinnata*
Dimpled trout lily *Erythronium umbilicatum*
Hollow-stem Joe-pye-weed *Eupitorium fistulatum*
*Wild Strawberry *Fragaria virginiana*
Shuttleworth's ginger *Hexastylis shuttleworthii*
Orange jewelweed *Impatiens capensis*
Cardinal flower *Lobelia cardinalis*
Great blue lobelia *Lobelia siphilitica*
Alternate leaf seedbox *Ludwigia alternifolia*
Climbing hempweed *Mikania scandens*
Monkey flower *Mimulus ringens*
Green arrow arum *Peltandra virginica*
Arrowleaf tearthumb *Persicaria sagittata*
May-apple *Podophyllum peltatum*
Rustweed *Polypremum procumbens*
*Common Cinquefoil *Potentilla simplex*
*Swamp Rose *Rosa palustris*
Cutleaf coneflower *Rudbeckia laciniata*
*Dwarf Palmetto *Sabal minor*
Broadleaf arrowhead *Saggitaria latifolia*
Lizard's-tail *Saururus cernuus*
Sweet Betsy *Trillium cuneatum*
*Ironweed *Vernonia gigantea*
Common wingstem *Verbesina alternifolia*
*Halberd-leaf violet *Viola hastata*
*Bird's-foot violet *Viola pedata*
*Common Violet *Viola soraria*
Atamasco lily *Zephyranthes atamasca*
Bushy bluestem *Andropogon glomeratus*
River cane *Arundinaria gigantea*
*Switch Cane *Arundinaria tectata*
Shallow sedge *Carex lurida*
River oats *Chasmanthium latifolium*
Common rush *Juncus effusis*
*Cattail *Typha latifolia*
Sensitive fern *Onoclea sensibilis*
Royal fern *Osmunda spectabilis*
Cinnamon fern *Osmundastrum cinnamomeum*
Netted chain fern *Woodwardia areolata*

* =Additions from Animal Species Needs

Table 3: Mesic Forest Merged with Priority Species Plant List

Mesic Forest Plants

Merged Plant Lists

Plant List

Canopy Trees

Southern sugar maple *Acer floridanum*
Musclewood *Carpinus caroliniana*
Bitternut hickory *Carya cordiformis*
American beech *Fagus grandifolia*
White ash *Fraxinus americana*
Common silverbell *Halesia tetraptera*
Tulip-tree *Liriodendron tulipifera*
Cucumber magnolia *Magnolia acuminata*
Fraser magnolia *Magnolia fraseri*
Bigleaf magnolia *Magnolia macrophylla*
Umbrella magnolia *Magnolia tripetala*
Red mulberry *Morus rubra*
Ironwood *Ostrya virginiana*
Northern red oak *Quercus rubra*
White basswood *Tilia americana*

Shrubs and Vines

Painted buckeye *Aesculus sylvatica*
Common pawpaw *Asimina triloba*
*Sweet Pepperbush *Clethra alnifolia*
Strawberry bush *Euonymus americana*
Smooth hydrangea *Hydrangea arborescens*
Mountain laurel *Kalmia latifolia*
Doghobble *Leucothoe fontanesiana*
Northern spicebush *Lindera benzoin*
Piedmont azalea *Rhododendron canescens*
*Black Rasberry (Blackberry) *Rubus occidentalis*

Ground Layer

Dolls'-eyes *Actaea pachypoda*
Black cohosh *Actaea racemosa*
Sharp lobed hepatica *Anemone acutiloba*
Round lobed hepatica *Anemone americana*
Jack-in-the-pulpit *Arisaema triphyllum*
Common wild ginger *Asarum canadense*
*Swamp Milkweed *Asclepias incarnata*
Cutleaf toothwort *Cardamine concatenata*
Broadleaf toothwort *Cardamine diphylla*
Blue cohosh *Caulophyllum thalictroides*
Devil's-bit *Chamaelirium luteum*
*Spring Beauty *Claytonia virginica*
Northern horsebalm *Collinsonia canadensis*
Yellow lady's-slipper *Cypripedium parviflorum*
*Tansy Mustard *Descurainia pinnata*
Harbinger-of-spring *Erigenia bulbosa*
Dimpled trout lily *Erythronium umbilicatum*
*Wild Strawberry *Fragaria virginiana*
White avens *Geum canadense*
Wild geranium *Geranium maculatum*
Summer bluet *Houstonia purpurea*
Goldenseal *Hydrastis canadensis*
Crested iris *Iris cristata*
Hairy sweet cicely *Osmorhiza claytonii*
Smooth sweet cicely *Osmorhiza longistylis*
Ginseng *Panax quinquefolius*
Blue phlox *Phlox divaricata*
May-apple *Podophyllum peltatum*
*Common Cinquefoil *Potentilla simplex*
*Dwarf Palmetto *Sabal minor*
Bloodroot *Sanguinaria canadensis*
Axillary goldenrod *Solidago caesia*
Star chickweed *Stellaria pubera*
Rue anemone *Thalictrum thalictroides*
Foamflower *Tiarella wherryi*
Catesby's trillium *Trillium catesbaei*
Sweet Betsy *Trillium cuneatum*
Nodding trillium *Trillium rugelii*
Halberd-leaf violet *Viola hastata*
*Bird's-foot violet *Viola pedata*
*Common Violet *Viola soraria*
*Ironweed *Vernonia gigantea*
*Switch Cane *Arundinaria tectata*
*Shallow sedge *Carex lurida*
*River oats *Chasmanthium latifolium*
*Common rush *Juncus effusis*
Northern maidenhair fern *Adiantum pedatum*
Rattlesnake fern *Botrypus virginianus*
Silvery glade fern *Homalosorus pycnocarpon*
Broad beech fern *Phegopteris hexagonoptera*
Southern lady fern *Athyrium asplenioides*

*= Additions from Animal Species Needs

Table 4: Oak-Hickory-Pine Forest Merged with Priority Species Plant List

Oak-Hickory-Pine Plants

Merged Plant Lists

Canopy Trees

Red Maple *Acer rubrum*
Pignut hickory *Carya glabra*
Pale/Sand hickory *Carya pallida*
Mockernut hickory *Carya tomentosa*
American chestnut (sprouts) *Castanea dentata*
Redbud *Cercis canadensis*
Flowering dogwood *Cornus florida*
*Tulip-tree *Liriodendron tulipifera*
Sweetgum *Liquidambar styraciflua*
Blackgum *Nyssa sylvatica*
Sourwood *Oxydendrum arboreum*
Shortleaf pine *Pinus echinata*
Loblolly pine *Pinus taeda*
White oak *Quercus alba*
Scarlet oak *Quercus coccinea*
Southern red oak *Quercus falcata*
*Blackjack Oak Quercus marilandica
Rock chestnut oak *Quercus montana*
Northern red oak *Quercus rubra*
Black oak *Quercus velutina*
Black locust *Robinia pseudoacacia*

Shrubs and Vines

Small-fruited pawpaw *Asimina parviflora*
Sweetshrub *Calycanthus floridus*
*New Jersey Tea *Ceanothus americanus*
Coralbeads *Cocculus carolinus*
Strawberry bush *Euonymus americanus*
Mountain laurel *Kalmia latifolia*
Virginia creeper *Parthenocissus quinquefolia*
Oconee azalea *Rhododendron flammeum*
Great rhododendron *Rhododendron maximum*
Gorge rhododendron *Rhododendron minus*
Pinxter flower *Rhododendron periclymenoides*
*Staghorn Sumac *Rhus typhina*
Sparkleberry *Vaccinium arboreum*
Hillside blueberry *Vaccinium pallidum*
Deerberry *Vaccinium stamineum*
Mapleleaf viburnum *Viburnum acerifolium*
Muscadine *Vitis rotundifolia*

Ground Layer

*Dogbane *Apocynum cannabinum*
Southern harebell *Campanula divaricata*
*Cutleaf Toothwort *Cardamine concatenata*
Pipsissewa *Chimaphila maculata*
Green-and-gold *Chrysogonum virginianum*
*Spring Beauty *Claytonia virginica*
Pink lady's-slipper *Cypripedium acaule*
*Tansy Mustard *Descurainia pinnata*
Whorled wild yam *Dioscorea quaternata*
Elephant's-foot *Elephantopus tomentosus*
Trailing arbutus *Epigaea repens (a sub-shrub)*
Eastern flowering spurge *Euphorbia corollata*
Galax *Galax urceolata*
Downy rattlesnake-orchid *Goodyera pubescens*
Little brown jugs *Hexastylis arifolia*
Veiny hawkweed *Hieracium venosum*
Quaker ladies *Houstonia caerulea*
Naked tick trefoil *Hylodesmum nudiflorum*
Common stargrass *Hypoxis hirsuta*
Carolina phlox *Phlox carolina*
Solomon's seal *Polygonatum biflorum*
*Dwarf Palmetto *Sabal minor*
**Solidago spp.*
Eastern Solomon's plume *Maianthemum racemosum*
Fire-pink *Silene virginica*
Cranefly orchid *Tipularia discolor*
Catesby's trillium *Trillium catesbaei*
Perfoliate bellwort *Uvularia perfoliata*
*Halberd-leaf violet *Viola hastata*
*Bird's-foot violet *Viola pedata*
*Common Violet *Viola sororia*
Christmas fern *Polystichum acrosticoides*

*= Additions from Animal Species Needs

Table 5: Piedmont Savanna Merged with Priority Species Plant List

Piedmont Savannah Plants

Merged Plant Lists

Plant List

Canopy Trees

Pignut Hickory *Carya glabra*
Pale Hickory *Carya pallida*
Mockernut Hickory *Carya tomentosa*
Shortleaf Pine *Pinus echinata*
Loblolly Pine *Pinus taeda*
Longleaf pine *Pinus palustris*
Virginia Pine *Pinus virginiana*
White Oak *Quercus alba*
Scarlet Oak *Quercus coccinea*
Southern Red Oak Quercus falcata
Blackjack Oak Quercus marilandica
Rock Chestnut Oak *Quercus montana*
Chinkapin Oak *Quercus muehlenbergii*
Chestnut Oak *Quercus prinus*
Post Oak *Quercus stellata*
Black Oak *Quercus velutina*
Northern Red Oak *Quercus rubra*

Shrubs and Vines

*New Jersey Tea *Ceanothus americanus*
*Staghorn Sumac *Rhus typhina*
Sparkleberry *Vaccinium arboreum*
Hillside blueberry *Vaccinium pallidum*
Deerberry *Vaccinium stamineum*

Ground Layer

Purple Gerardia *Agalinis purpurea*
Slender Gerardia *Agalinis tenuifolia*
Colicroot *Aletris farinosa*
False Garlic *Allium bivalve*
Fly Poison *Amianthium muscaetoxicum*
False Indigo *Amorpha herbacea*
Hemp dogbane *Apocynum cannabinum*
Milkweed *Asclepias amplexicaulis*
Butterfly Weed *Asclepias tuberosa*
Aster *Aster concolor*
Bushy Aster *Aster dumosus*
Starred Aster *Aster lateriflorus*
Aster *Aster patens*
White-topped Aster *Aster pilosus*
Aster *Aster puniceus*
False Indigo *Baptisia alba*
Pale Indian Plantain *Cacalia atriphicifolia*
*Cutleaf Toothwort *Cardamine concatenata*
Partridge Pea *Cassia fasciculata*
Wild Sensitive Plant *Cassia nicitans*
Spurred butterfly pea *Centrosema virginianum*
Wild Chervil *Chaerophylhym tainturieri*
Maryland golden-aster *Chrysopsis mariana*
*Spring Beauty *Claytonia virginica*
Butterfly pea *Clitoria mariana*
Greater Tickseed *Coreopsis major*
Croton glandulosus
*Tansy Mustard *Descurainia pinnata*
Tick-trefoil *Desmodium dillenii*
Tick-trefoil *Desmodium laevigatum*
Desmodium marilandicum
Tick-trefoil *Desmodium paniculatum*
Buttonweed *Diodia teres*
Eclipta alba
Common Fleabane *Erigeron philadelphicus*
Daisy Fleabane *Erigeron strigosus*
Eryngium prostratum
Eupatorium album
Dog Fennel *Eupatorium capillifolium*
Hardy Ageratum *Eupatorium coelestinum*
Joe-Pye Weed *Eupatorium fistulosum*
Hyssopleaf Eupatorium *Eupatorium hysspifolium*
Boneset *Eupatorium perfoliatum*
Late Flowering Boneset *Eupatorium serotinum*
Flowering Spurge *Euphorbia corollata*
Geranium carolinianum
Gnaphalium helleri
Veiny hawkweed *Hieracium venosum*
Rabbit Tobacco *Gnaphalium obtusifolium*
Haplopappus divaricatus
Pennyroyal *Hedeoma pulegioides*
Sneeze Weed *Helenium autumnale*
Sneeze Weed *Helenium flexulosum*
Narrow-leaved Sunflower *Helianthus angustifolius*
Dark-eyed Sunflower *Helianthus atrorubens*
Helianthus hirsutus
Helianthus microcephalus
Woodland Sunflower *Helianthus strumosus*
Jerusalem Artichoke *Helianthus tuberosus*
Heterotheca mariana
Camphorweed *Heterotheca subaxillaris*
Hawkweed *Hieraceum gronovii*
Bluets *Houstonia caerulea*
Pine Weed *Hypericum gentianoides*
Dwarf St. John's-wort *Hypericum mutilum*
Yellow Star Grass *Hypoxis hirsuta*
Dwarf Dandelion *Krigia virginica*
Pine Weed *Lechea racemulosa*
Hairy Bush Clover *Lespedeza hirta*

Table 5 cont.: Piedmont Savanna Merged with Priority Species Plant List

Bush Clover *Lespedeza intermedia*	Feather Bells *Stenanthium gramineum*
Downy trailing lespedeza *Lespedeza procumbens*	Pencil-flower *Stylosanthes biflora*
Creeping Bush Clover *Lespedeza repens*	Eastern silvery aster *Symphyotrichum concolor*
Slender Bush Clover *Lespedeza virginica*	Long-stalked aster *Symphyotrichum dumosum*
Grassleaf Blazing Star *Liatris gramnifolia*	Georgia aster *Symphyotrichum georgianum*
Liatris microcephela	Common clasping aster *Symphyotrichum patens*
Dense Blazing Star *Liatris spicata*	Frost aster *Symphiotrichum pilosum*
Toad-flax *Linaria canadensis*	Virginia goat's-rue *Tephrosia virginiana*
Cardinal Flower *Lobelia cardinalis*	Wood Sage *Teucrium canadense*
Indian Tobacco *Lobelia inflata*	Meadow Rue *Thalictrum revolutum*
Downy Lobelia *Lobelia puberula*	Bastard Pennyroyal *Trichostema dichotomum*
Whorled Loosestrife *Lysimachia quadrifolia*	*Verbena urticifolia*
Wild Bergamot *Monarda fistulosa*	Crown Beard *Verbesina alternifolia*
Dotted monarda *Monarda punctata*	*Verbesina occidentalis*
Evening Primrose *Oenothera biennis*	*Verbesina virginica*
Wild Quinine *Parthenium integrifolium*	New York Ironweed *Vernonia novaboracensis*
Maypop *Passiflora incarnata*	Bird's-foot violet *Viola pedata*
Grey Beardtongue *Penstemon canescens*	Bentgrass *Agrostis hymenalis*
Phlox carolina	Bentgrass *Agrostis perennans*
Silkgrass *Pityopsis graminifolia*	Big Bluestem *Andropogon gerardii*
Polygala *Polygala curtissii*	Splitbeard *bluestem Andropogon ternarius*
Bear's Foot *Polymnia uvedalia*	Broomsedge *Andropogon virginicus*
Fragrant rabbit tobacco *Pseudognaphalium obtusifolium*	Hair Grass *Aira elegens*
	Wire Grass Aristida beyrichiana
Ptilimnium capillaceum	Three Awn Grass *Aristida dichotoma*
Hoary Mint *Pycnanthemum incanum*	Three Awn *Aristida oligantha*
Slender-leaved Mint *Pycnanthemum teniufolium*	River Cane *Arundinaria gigantea*
Pyrrohappus carolinianus	Switch Cane *Arundinaria tectata*
Virginia Meadow Beauty *Rhexia virginica*	*River oats *Chasmanthium latifolium*
Beak Rush *Rhyncospora globularis*	Poverty Oat Grass *Danthonia spicata*
Rudbeckia heliopsidis	Virginia Wild Rye *Elymus virginicus*
Black-eyed Susan *Rudbeckia hirta*	Love Grass *Eragrostis hirsuta*
Black-eyed Susan *Rudbeckia fulgida*	Love Grass *Eragrostis refracta*
Cut-leaf Cone Flower *Rudbeckia laciniata*	Purple Love Grass *Eragrostis spectabilis*
Sorrel *Rumex hastatulus*	Woolly Plume Grass *Erianthus alopecuroides*
Rose Pink *Sabatia angularis*	Plume Grass *Erianthus contortus*
Lyre-leaved Sage *Salvia lyrata*	Bearded Skeleton Grass *Gymnopogon ambiguus*
Skullcap *Scutellaria integrifolia*	*Panicum anceps*
Sleepy Catchfly *Silene antirrhina*	*Panicum dichotomum*
Compass Plant *Silphium compositum*	*Panicum sphaerocarpon*
Silphium dentatum	*Paspalum boscianum*
Blue-eyed Grass *Sisyrinchium angustifolium*	*Paspalum floridanum*
Hedge nettle *Solanum carolinense*	*Paspalum laeve*
Tall Goldenrod *Solidago altissima*	*Paspalum setaceum*
Solidago erecta	Eastern needlegrass *Piptochaetium avenaceum*
Late Goldenrod *Solidago gigantea*	Foxtail Grass *Setaria glauca*
Licorice goldenrod *Solidago odora*	Little Blue Stem *Schizachyrium scoparium*
Common Goldenrod *Solidago nemoralis*	Indian Grass *Sorghastrum nutans*
Rough-stemmed Goldenrod *Solidago rugosa*	Wedge Grass *Sphenopholis obtusata*
Showy Goldenrod *Solidago speciosa*	Purple Top *Tridens flavus*

Table 5 cont.: Piedmont Savanna Merged with Priority Species Plant List

Six Weeks Grass *Vulpia octoflora* Three-seeded Mercury *Acalphya rhomboidea* Bracken fern *Pteridium latiusculum* *= Additions from Animal Species Needs

To assure that the framework is implementable for laymen, each archetypes plant list was cross referenced with all nurseries within a 25-mile radius, as well as the State Botanical Garden of Georgia Native Plant Sale, the Trees Atlanta Plant Sale, and six regional leaders in native plants: Woodlanders, Baker Environmental Nursery, Nearly Native, South Eastern Growers, Plant Delights, Goodness Grows, and Garden Delights. Plants that could be not found at any of these resources were considered too difficult to attain and were therefore removed from the list.

Table 6: Bottomland Forest/Wetland Master Plant List

Bottomland - Wetland Plants

Canopy Trees

Box elder *Acer negundo*
Red maple *Acer rubrum*
River birch *Betula nigra*
Musclewood *Carpinus caroliniana*
Bitternut hickory *Carya cordiformis*
Green ash *Fraxinus pennsylvanica*
Sweet gum *Liquidambar styraciflua*
Tulip-tree *Liriodendron tulipifera*
Sycamore *Platanus occidentalis*
Overcup oak *Quercus lyrata*
Swamp chestnut oak *Quercus michauxii*
Cherrybark oak *Quercus pagoda*
Willow oak *Quercus phellos*
Shumard oak *Quercus shumardii*
Black willow *Salix nigra*
*Winged Elm *Ulmus alata*

Shrubs and Vines

Beautyberry *Callicarpa americana*
Sweet shrub *Calycanthus floridus*
Buttonbush *Cephalanthus occidentalis*
*Sweet Pepperbush *Clethra alnifolia*
Swamp dogwood *Cornus amomum*
Strawberry bush *Euonymus americanus*
Witch-hazel *Hamamelis virginia*
Virginia sweetspire *Itea virginica*
Mountain laurel *Kalmia latifolia*
Hairy northern spicebush *Lindera benzoin*
Swamp azalea *Rhododendron viscosum*
Elderberry *Sambucus canadensis*
*Possum-haw Vibernum *Viburnum nudum*
Yellowroot *Xanthorhiza simplicissima*
Crossvine *Bignonia capreolata*
Trumpet vine *Campsis radicans*
Climbing hydrangea *Decumaria barbara*
Virginia creeper *Parthenocissus quinquefolia*

Ground Layer

*Swamp Milkweed *Asclepias incarnata*
*Turtlehead *Chelone lyonii*
Hollow-stem Joe-pye-weed *Eupitorium fistulatum*
*Wild Strawberry *Fragaria virginiana*
Shuttleworth's ginger *Hexastylis shuttleworthii*
Cardinal flower *Lobelia cardinalis*
Great blue lobelia *Lobelia siphilitica*
Green arrow arum *Peltandra virginica*
May-apple *Podophyllum peltatum*
*Dwarf Palmetto *Sabal minor*
Lizard's-tail *Saururus cernuus*
Sweet Betsy *Trillium cuneatum*
*Ironweed *Vernonia gigantea*
*Bird's-foot violet *Viola pedata*
Atamasco lily *Zephyranthes atamasca*
Bushy bluestem *Andropogon glomeratus*
River cane *Arundinaria gigantea*
Shallow sedge *Carex lurida*
River oats *Chasmanthium latifolium*
Common rush *Juncus effusis*
*Cattail *Typha latifolia*
Sensitive fern *Onoclea sensibilis*
Royal fern *Osmunda spectabilis*
Cinnamon fern *Osmundastrum cinnamomeum*
Netted chain fern *Woodwardia areolata*

* =Additions from Animal Species Needs

Table 7: Mesic Forest Master Plant List

Mesic Forest Plants

Plant List

*= Additions from Animal Species Needs

Canopy Trees

Musclewood *Carpinus caroliniana*
Bitternut hickory *Carya cordiformis*
American beech *Fagus grandifolia*
White ash *Fraxinus americana*
Tulip-tree *Liriodendron tulipifera*
Cucumber magnolia *Magnolia acuminata*
Bigleaf magnolia *Magnolia macrophylla*
Umbrella magnolia *Magnolia tripetala*
Red mulberry *Morus rubra*
Ironwood *Ostrya virginiana*
Northern red oak *Quercus rubra*
White basswood *Tilia americana*

Shrubs and Vines

Painted buckeye *Aesculus sylvatica*
Common pawpaw *Asimina triloba*
*Sweet Pepperbush *Clethra alnifolia*
Strawberry bush *Euonymus americana*
Smooth hydrangea *Hydrangea arborescens*
Mountain laurel *Kalmia latifolia*
Northern spicebush *Lindera benzoin*
Piedmont azalea *Rhododendron canescens*

Ground Layer

Black cohosh *Actaea racemosa*
Round lobed hepatica *Anemone americana*
*Swamp Milkweed *Asclepias incarnata*
Blue cohosh *Caulophyllum thalictroides*
Yellow lady's-slipper *Cypripedium parviflorum*
*Wild Strawberry *Fragaria virginiana*
Crested iris *Iris cristata*
Blue phlox *Phlox divaricata*
May-apple *Podophyllum peltatum*
*Dwarf Palmetto *Sabal minor*
Bloodroot *Sanguinaria canadensis*
Rue anemone *Thalictrum thalictroides*
Foamflower *Tiarella wherryi*
Catesby's trillium *Trillium catesbaei*
Sweet Betsy *Trillium cuneatum*
*Bird's-foot violet *Viola pedata*
*Ironweed *Vernonia gigantea*
*Shallow sedge *Carex lurida*
*River oats *Chasmanthium latifolium*
*Common rush *Juncus effusis*
Northern maidenhair fern *Adiantum pedatum*
Broad beech fern *Phegopteris hexagonoptera*
Southern lady fern *Athyrium asplenioides*

Table 8: Oak-Hickory-Pine Forest Master Plant List

Oak-Hickory-Pine Plants

Canopy Trees

Red Maple *Acer rubrum*
Pignut hickory *Carya glabra*
Pale/Sand hickory *Carya pallida*
Mockernut hickory *Carya tomentosa*
Redbud *Cercis canadensis*
Flowering dogwood *Cornus florida*
*Tulip-tree *Liriodendron tulipifera*
Sweetgum *Liquidambar styraciflua*
Blackgum *Nyssa sylvatica*
Sourwood *Oxydendrum arboreum*
White oak *Quercus alba*
Scarlet oak *Quercus coccinea*
Southern red oak *Quercus falcata*
*Blackjack Oak Quercus marilandica
Northern red oak *Quercus rubra*
Black oak *Quercus velutina*

Shrubs and Vines

Sweetshrub *Calycanthus floridus*
*New Jersey Tea *Ceanothus americanus*
Strawberry bush *Euonymus americanus*
Mountain laurel *Kalmia latifolia*
Virginia creeper *Parthenocissus quinquefolia*
Oconee azalea *Rhododendron flammeum*
Great rhododendron *Rhododendron maximum*
Gorge rhododendron *Rhododendron minus*
Pinxter flower *Rhododendron periclymenoides*
*Staghorn Sumac *Rhus typhina*
Sparkleberry *Vaccinium arboreum*
Deerberry *Vaccinium stamineum*
Mapleleaf viburnum *Viburnum acerifolium*

Ground Layer

Green-and-gold *Chrysogonum virginianum*
Solomon's seal *Polygonatum biflorum*
*Dwarf Palmetto *Sabal minor*
**Solidago spp.*
Fire-pink *Silene virginica*
Catesby's trillium *Trillium catesbaei*
*Bird's-foot violet *Viola pedata*
Christmas fern *Polystichum acrosticoides*

*= Additions from Animal Species Needs

Table 9: Piedmont Savanna Master Plant List

Piedmont Savannah Plants

Master Plant Lists

Plant List

Canopy Trees

Pignut Hickory *Carya glabra*
Pale Hickory *Carya pallida*
Mockernut Hickory *Carya tomentosa*
Longleaf pine *Pinus palustris*
Virginia Pine *Pinus virginiana*
White Oak *Quercus alba*
Scarlet Oak *Quercus coccinea*
Southern Red Oak Quercus falcata
Blackjack Oak *Quercus marilandica*
Chinkapin Oak *Quercus muehlenbergii*
Chestnut Oak *Quercus prinus*
Post Oak *Quercus stellata*
Black Oak *Quercus velutina*
Northern Red Oak *Quercus rubra*

Shrubs and Vines

*New Jersey Tea *Ceanothus americanus*
*Staghorn Sumac *Rhus typhina*
Sparkleberry *Vaccinium arboreum*
Deerberry *Vaccinium stamineum*

Ground Layer

Butterfly Weed *Asclepias tuberosa*
False Indigo *Baptisia alba*
Spurred butterfly pea *Centrosema virginianum*
Maryland golden-aster *Chrysopsis mariana*
Greater Tickseed *Coreopsis major*
Hardy Ageratum *Eupatorium coelestinum*
Joe-Pye Weed *Eupatorium fistulosum*
Narrow-leaved Sunflower *Helianthus angustifolius*
Woodland Sunflower *Helianthus strumosus*
Jerusalem Artichoke *Helianthus tuberosus*
Bluets *Houstonia caerulea*
Hairy Bush Clover *Lespedeza hirta*
Liatris microcephela
Dense Blazing Star *Liatris spicata*
Cardinal Flower *Lobelia cardinalis*
Wild Bergamot *Monarda fistulosa*
Dotted monarda *Monarda punctata*
Maypop *Passiflora incarnata*
Hoary Mint *Pycnanthemum incanum*
Rudbeckia heliopsidis
Black-eyed Susan *Rudbeckia hirta*
Black-eyed Susan *Rudbeckia fulgida*
Skullcap *Scutellaria integrifolia*
Compass Plant *Silphium compositum*
Blue-eyed Grass *Sisyrinchium angustifolium*
Licorice goldenrod *Solidago odora*
Common Goldenrod *Solidago nemoralis*
Rough-stemmed Goldenrod *Solidago rugosa*
Eastern silvery aster *Symphyotrichum concolor*
Georgia aster *Symphyotrichum georgianum*
New York Ironweed *Vernonia novaboracensis*
Bird's-foot violet *Viola pedata*
Big Bluestem *Andropogon gerardii*
Splitbeard *bluestem Andropogon ternarius*
Broomsedge *Andropogon virginicus*
Wire Grass *Aristida beyrichiana*
River Cane *Arundinaria gigantea*
*River oats *Chasmanthium latifolium*
Purple Love Grass *Eragrostis spectabilis*
Little Blue Stem *Schizachyrium scoparium*
Indian Grass *Sorghastrum nutans*
Purple Top *Tridens flavus*
Bracken fern *Pteridium latiusculum*

*= Additions from Animal Species Needs

Table 10: Open Meadow Master Plant List

Open Meadow

Ground Layer

*Swamp Milkweed *Asclepias incarnata*
*Butterfly Weed *Asclepias tuberosa*
Spurred butterfly pea *Centrosema virginianum*
*Turtlehead *Chelone lyonii*
Maryland golden-aster *Chrysopsis mariana*
Woodland coreopsis *Coreopsis major*
*Wild Strawberry *Fragaria virginiana*
Appalachian sunflower *Helianthus atrorubens*
Roughleaf sunflower *Helianthus strumosus*
Hairy lespedeza *Lespedeza hirta*
Dense blazing star *Liatris spicata*
Maypop *Passiflora incarnata*
Black-eyed *Susan Rudbeckia hirta*
Rosinweed *Silphium compositum*
Eastern silvery aster *Symphyotrichum concolor*
Georgia aster *Symphyotrichum georgianum*
Eastern gray goldenrod *Solidago nemoralus*
Licorice goldenrod *Solidago odora*
Bird's-foot violet *Viola pedata*
Broomsedge *Andropogon virginicus*
Splitbeard bluestem *Andropogon ternarius*
Big bluestem *Andropogon gerardii*
*River oats *Chasmanthium latifolium*
Little bluestem *Schizachyrium scoparium*
Indiangrass *Sorghastrum nutans*
Purpletop *Tridens flavus*

CHAPTER 5

SUITABILITY ANALYSIS FOR ECOSYTEM ARCHETYPES

In order to conduct a suitability analysis parameters were generated based off of characteristic needs and limitations gathered in the research of the ecoregions that comprise each habitat archetype. These parameters included: These parameters included: soil type, geological aspect, water obligation, previous and current land-use, necessary management regimes, and relationships to other ecosystems. Once suitability areas for each archetype were generated, they were then overlaid and selected based on a priority based weighting to create a suitability map for all of Athens-Clarke County.

Athens Hydrology Map

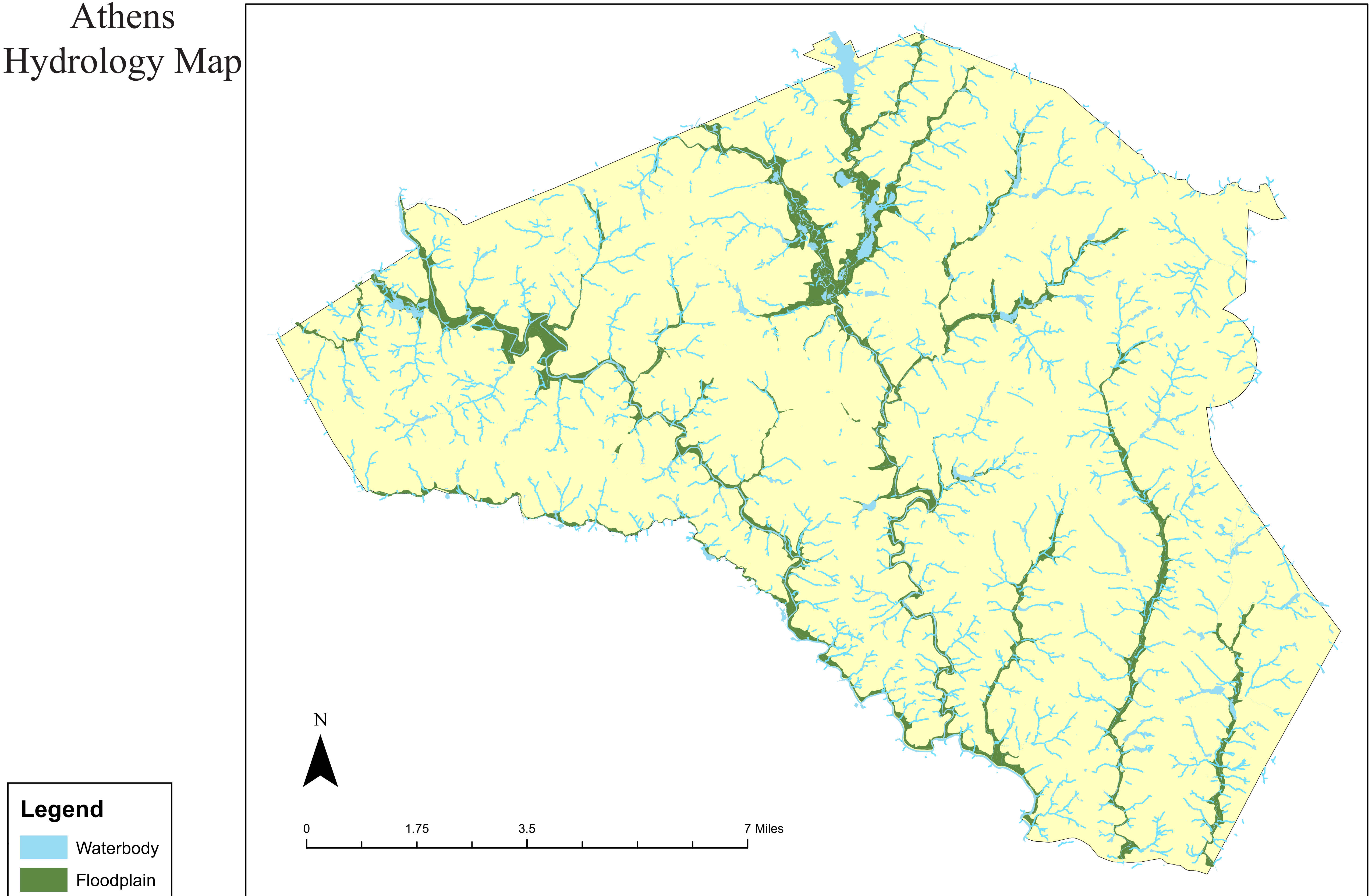


Figure 20: Athens Hydrology Map

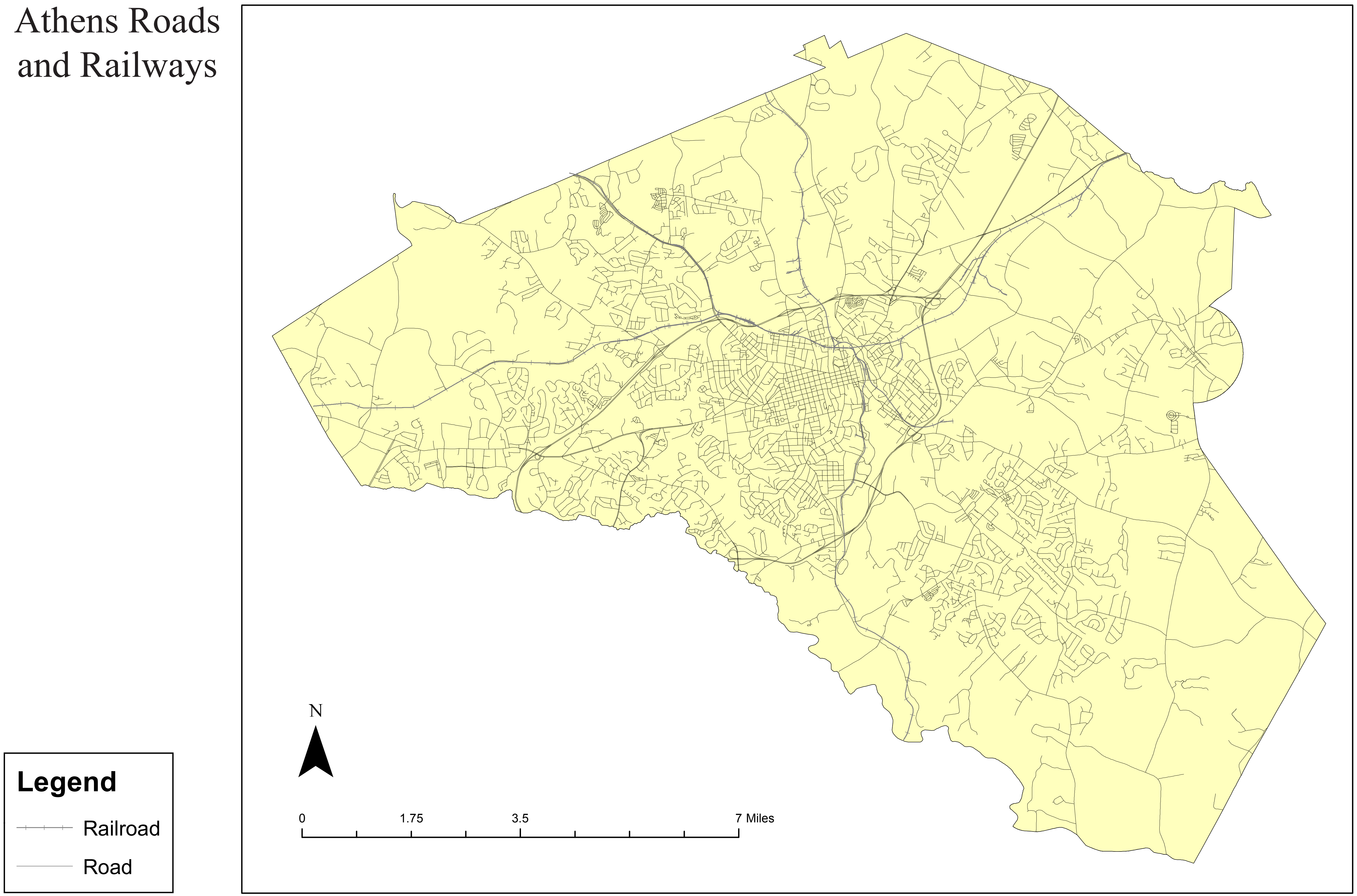


Figure 21: Athens Roads and Railways Map

Athens Soil Map

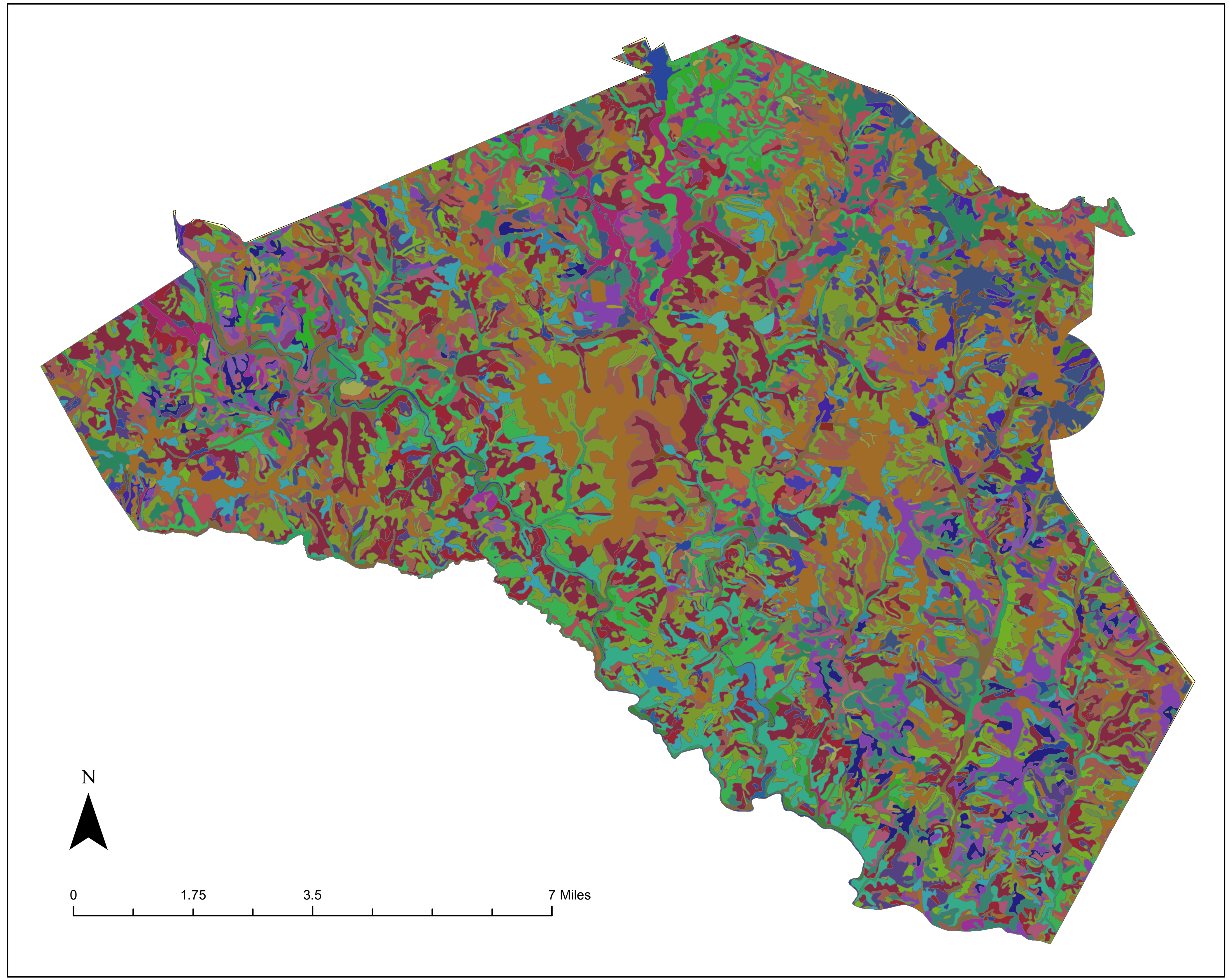


Figure 22: Athens Soil Map

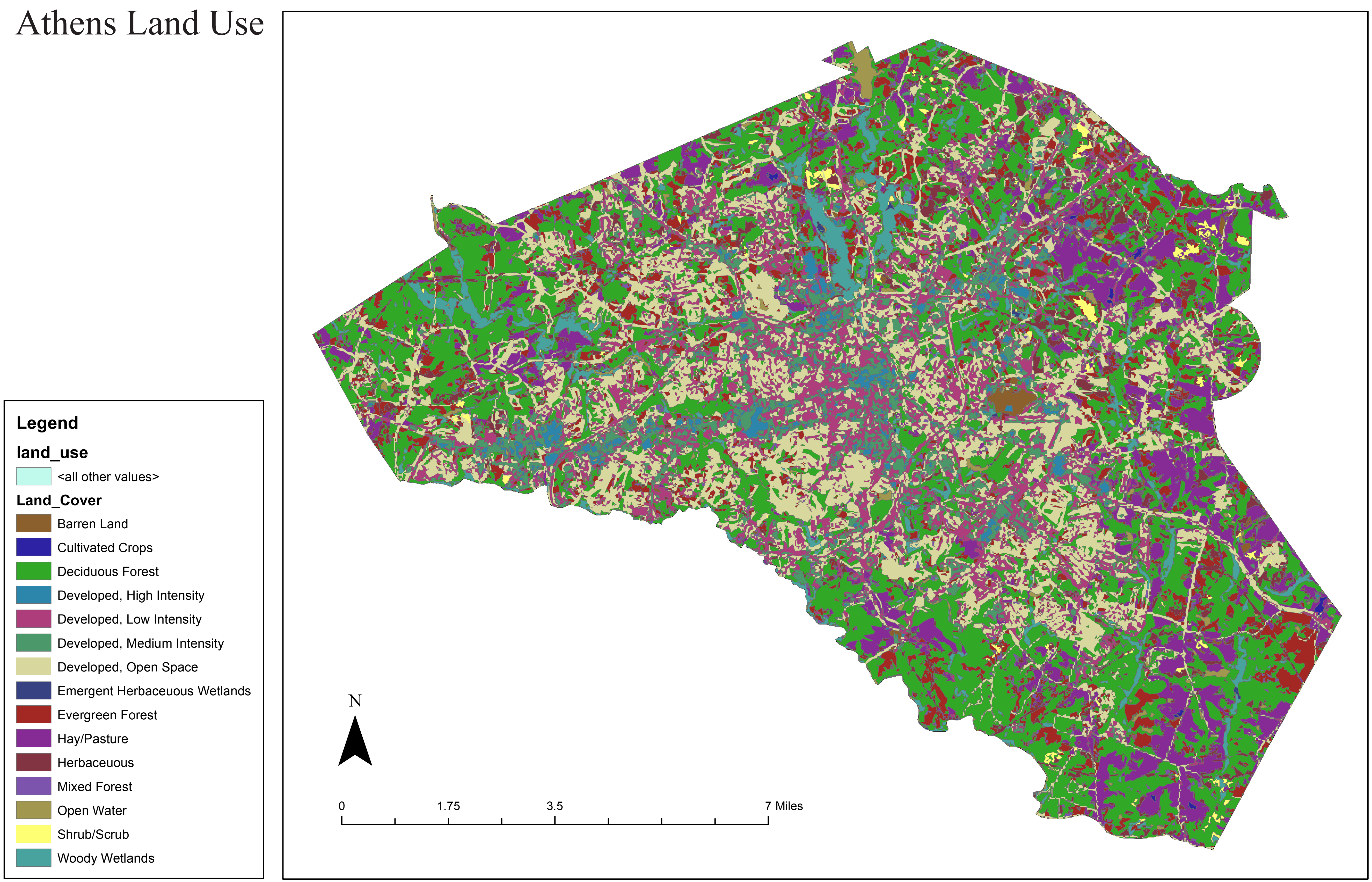


Figure 23: Athens Land Use Map

Athens North Aspects Map

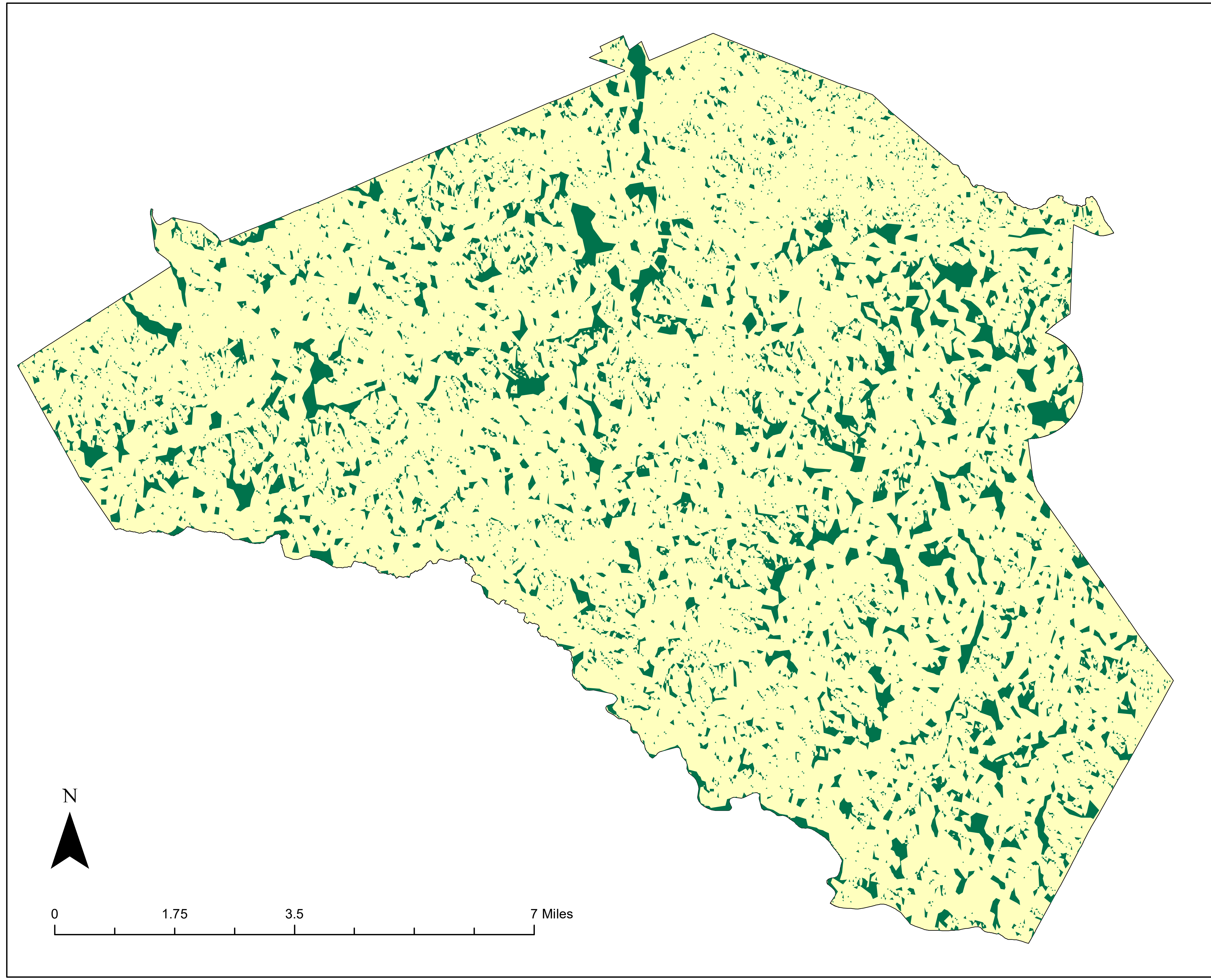


Figure 23: Athens North Aspects Map

Open Meadow

The open meadow habitat archetype is derived from savannah and prairies habitats, which are large swaths of grasses and forbs with minimal shrub layer and almost no trees (Edwards, Ambrose, and Kirkman 2013). Because of its lack of trees this archetype is ideal for roadside and utility easements, which have height restrictions on plantings, or in the case of roadsides, visibility and clear zone safety requirements. Open meadows are ideal for application at the residential site scale, where they can provide legibility to a forest edge, and act as a canopy gap for forest species like butterflies and ground nesting birds (Tallamy 2007; Darke and Tallamy 2014; McClure et al. 2013). Additionally, because of its showy flowers and lack of woody plants it is ideal for squeezing into urban setting in grass strips and planters.

Based on this information, for this study open meadow suitability will be defined by 2 metrics: location on heavy and medium development, and on utility easements.

Open Meadow

Ecoregion Influences:
Piedmont Prairie

Habitat Provided:
Northern Bobwhite *Colinus virginianus*
Bald Eagle *Haliaeetus lecocephalus*
Bachman's Sparrow *Peucaea aestivalis*
Barn Owl *Tyto alba*
Eastern Spotted Skunk *Spilogale putorius*
Northern Pine snake *Pituophis melanoleucus*
Dusky Roadside Skipper *Amblyscirtes alternata*
Bell's Roadside-skipper *Amblyscirtes belli*
Rusty Patch Bumblebee *Bombus affinis*
Monarch Butterfly *Danaus plexippus*
Baltimore Checkerspot *Euphydras phaeton*
Helicta Satyr *Neonympha helicta*
Diana Fritillary *Speyeria diana*

Required Maintenance: Periodic Burning; manual removal of invasives and native propagation if necessary

Plant Species Needs

^=Out Hardiness Zone
#=Nonnative
$=Inappropriate for ecoregion

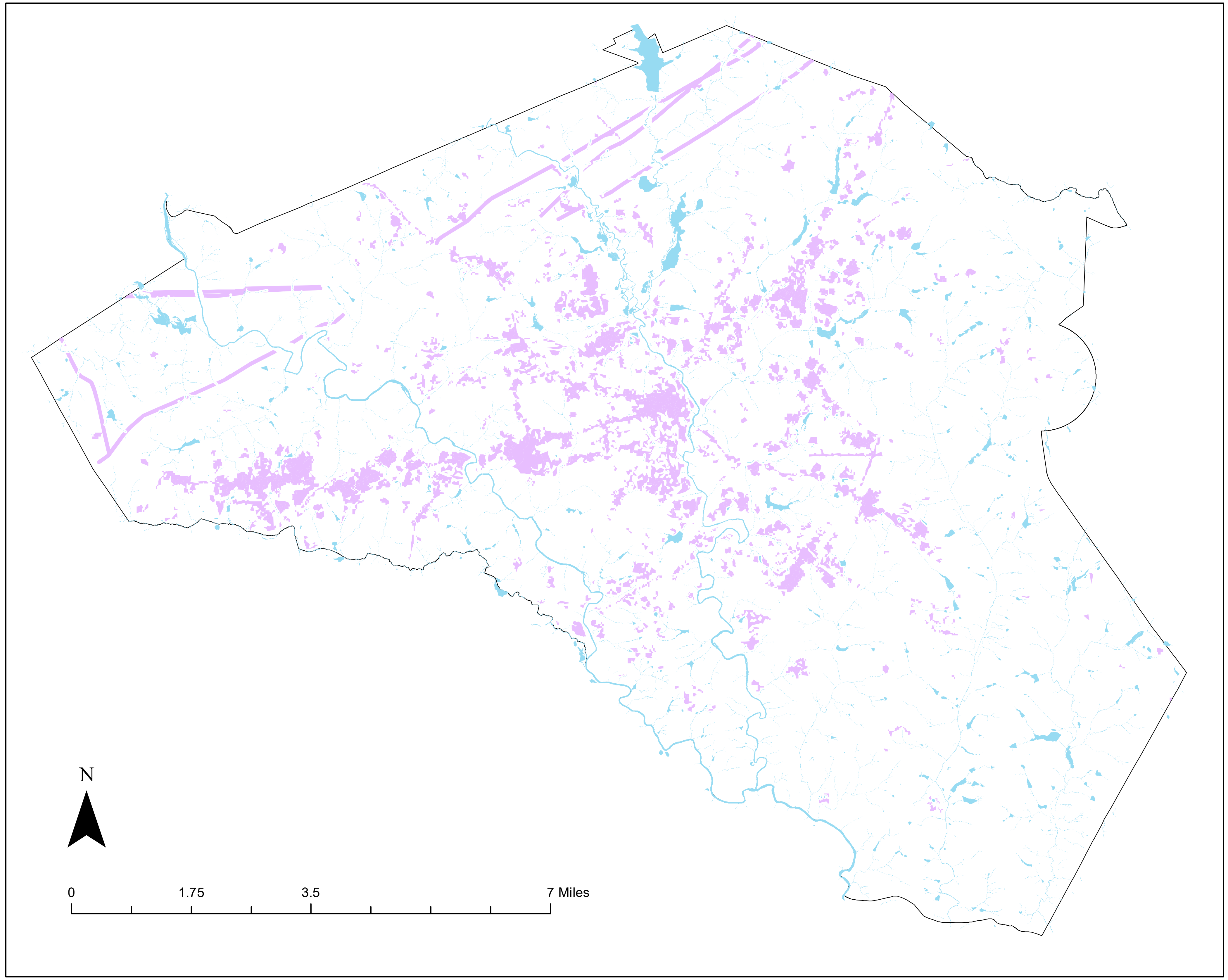
Seed and Berry Producers
Reeds
Sedges
Bearded Skeleton Grass
Inland Sea Oats
Rushes
Juncuses
Common Milkweeds
Swamp Milkweeds
Turtlehead
^Hairy beardtongue
#Foxglove
$Viburnum
Wild Rose
Toothwort
Mustard Family
Spring Beauty
Violets
Ironweed
#Red Clover

Plant Structure Needs

Tall Vegetation for Nesting

Figure 24: Piedmont Savanna Habitat Archetype

Open Meadow Archetype



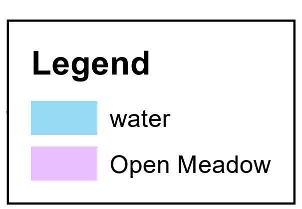


Figure 25: Open Meadow Suitability Map

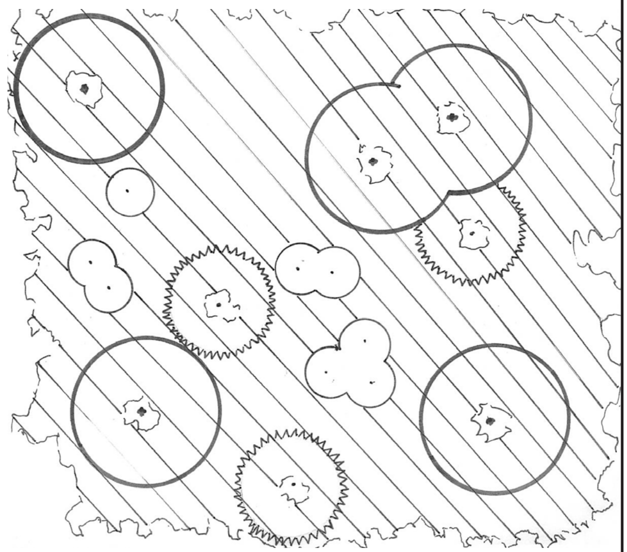
Piedmont Savanna

The Piedmont Savanna archetype is derived from the montane longleaf pine – hardwood forest, oak woodland and savanna, and xeric pine woodland habitats. These habitats were combined because of their similar plant composition, similar stratozone structure lacking much shrub layer, and necessity for periodic disturbance from anthropogenic fire regimes (Edwards, Ambrose, and Kirkman 2013; Juras 1997).

While now almost non-existent the piedmont savanna's once spread across the southeastern piedmont. These landscapes were characterized by generally open tree canopies of varying densities and large swaths of forb studded grasses. The plant species were largely composed of fire tolerant oaks and pine tree canopy, a minimal shrub layer, and a diverse array of forbs and grasses. This ecotype required frequent anthropogenic disturbance by fire regime to created canopy gaps, restore nutrients to the soil, and eliminate woody competition for the ground layer (Juras 2013).

Based on these habitat requirements, this study will define suitability for the Piedmont Savanna Archetype by two characteristics. Because of the intensity of disturbance created by the required burn regime, and the fact that site design will be implemented by non-professionals, piedmont savannas will be limited to land-use areas which are either cleared or in an early successional stage. This decreases the risk of damaging forest fragments that are further along in succession low population density, and isolates piedmont savannas to the more rural fields outside of loop-10. Piedmont Savannas typically exist on dry soils, so suitability will be limited to non-alluvial soils. Finally, because piedmont grasslands smaller than 20 acres are best converted back to forest, (Wolter et al. 2008) fragments must be 20 acres or larger.

Piedmont Savannah



Ecoregion Influences:
Montane Longleaf - Hardwood Forest
Oak Woodland and Savannah
Xeric Pine Woodland

Habitat Provided:
Northern Bobwhite *Colinus virginianus*
Bald Eagle *Haliaeetus lecocephalus*
Loggerhead Shrike *Lanius ludovicianus*
Bachman's Sparrow *Peucaea aestivalis*
Red-cockaded Woodpecker *Picodes borealis*
Kirtland's Warbler *Setophaga kirtlandii*
Barn Owl *Tyto alba*
Northern Myotis *Myotis septentrionalis*
Tri-colored Bat *Perimvotis subflavus*
Eastern Spotted Skunk *Spilogale putorius*
Northern Pine snake *Pituophis melanoleucus*
Dusky Roadside Skipper *Amblyscirtes alternata*
Bell's Roadside-skipper *Amblyscirtes belli*
Monarch Butterfly *Danaus plexippus*
Rusty Patch Bumblebee *Bombus affinis*
Helicta Satyr *Neonympha helicta*
Edwards Hairstreak *Satyrium edwardsii*
Diana Fritillary *Speyeria diana*

Requierd Maintenance: Periodic Bruning; manual removal of invasives and cane propogation if necissary

Plant Species Needs
Seed and Berry Producers
Longleaf Pine
^Jack Pine
Reeds
Sedges
Bearded Skeleton Grass
Inland Sea Oats
Rushes
Juncuses
Common Milkweeds
Swamp Milkweeds
Scrub Oak
Blackjack Oak
Dogbane
Goldenrod
New Jersey Tea
Staghorn Sumac
#White Sweet Clover
Violets
Ironweed
#Red Clover
Toothwort
Mustard Family
Spring Beauty

^=Out Hardiness Zone
#=Nonnative
$=Inaoppropriate for ecoregion

Plant Structure Needs
Old Growth Trees
Dense, possibly thorny shrubs
Tall Vegetation for Nesting
Needs Areas without Groundcover

Figure 26: Piedmont Savanna Habitat Archetype

Piedmont Savanna Archetype

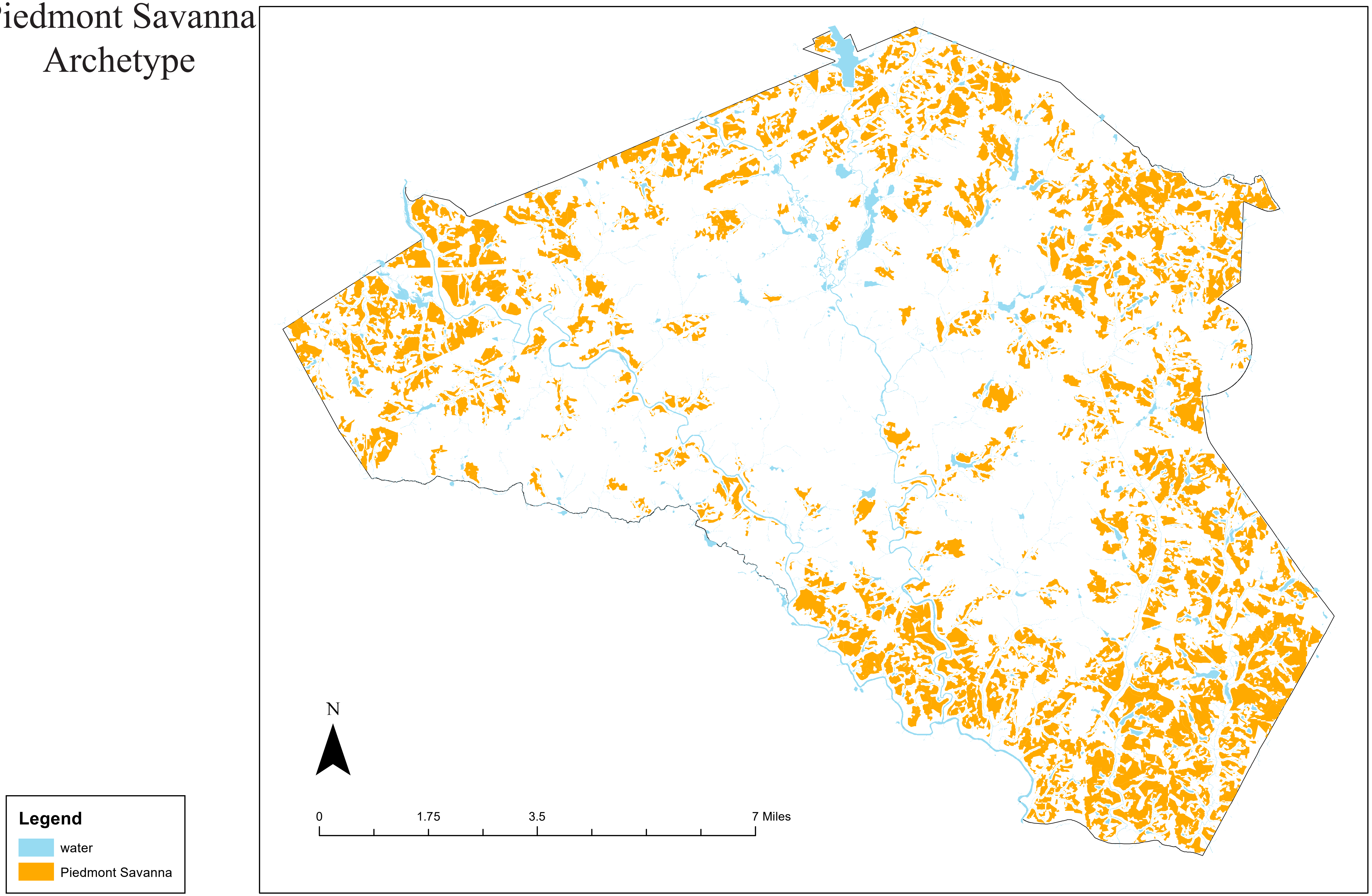


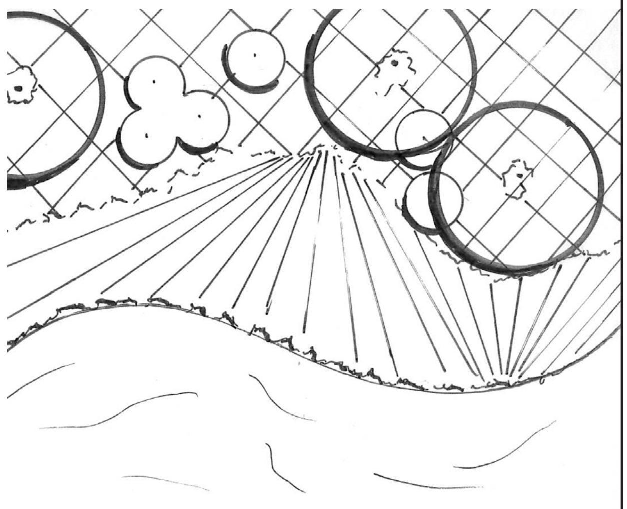
Figure 27: Piedmont Savanna Suitability Map

Canebrakes

Canebrakes are large stands of North American native bamboos Arundinaria gigantea and Arundinaria tecta. These occur in alluvial floodplains across the southeastern United States. They prefer full sun, rich soils, and low competition, but their rhizomatous root system allows them to allocate nutrients to parts of the brake located further into the forest understory (Peters 2013). Because of their preference for full light, healthy canebrakes are dependent on disturbance from periodic burning to create canopy gaps and eliminate woody plant competition (Gagnon and Platt 2008).

Based off of these habitat requirements, for this study suitability for the canebrake archetype will be defined by three parameters: location within a floodplain or within 100 ft. of a stream, which is the NRCS's suggested riparian buffer (efotg.sc.egov.usda.gov), and overlap with piedmont savanna suitability. Because canebrakes require a periodic burning regime, and one cannot begin such a practice outside of the context of the surrounding forest matrix, canebrakes are being limited solely to those floodplains adjacent to forests which will be undergoing periodic burning themselves.

Canebrake



Ecoregion Influences:
Canebrake

Habitat Provided:
Bald Eagle *Haliaeetus lecocephalus*
Least Bittern* *Ixobrychus exilis*
Black Rail *Laterallus jamaicensis*
Swainson's Warbler* *Limnothlypis swainsonii*
King Rail *Rallus elegans*
Helicta satyr *Neonympha helicta*

Required Maintenance: Periodic Burning; manual removal of invasives and cane propagation if necessary

Plant Species Needs

River Cane *Arundinaria gigantea*
Switch Cane *Arundinaria tectata*

Plant Structure Needs

Dense Cane Thickets

Figure 28: Canebrake Habitat Archetype

Canebrake
Archetype

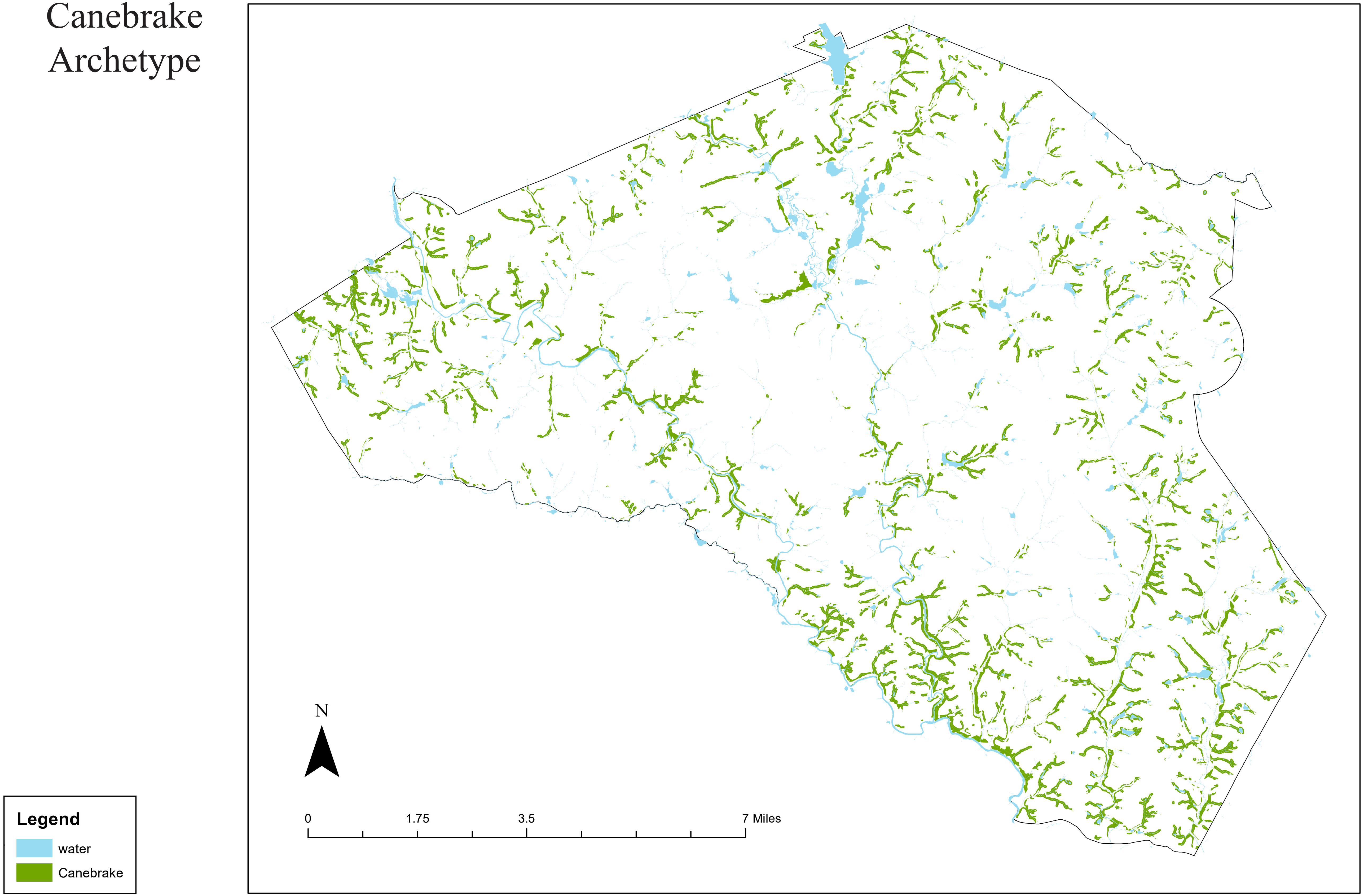


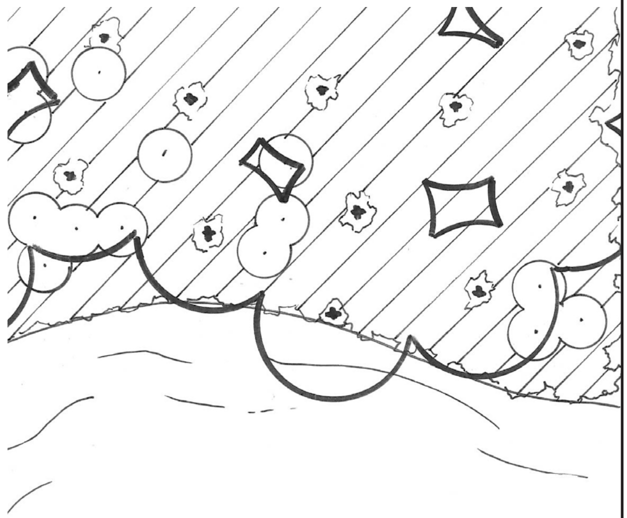
Figure 29: Canebrake Suitability Map

Bottomland Forest/Freshwater Wetland

This archetype is based off of bottomland forests and freshwater wetlands. These habitats occur in frequently flooded alluvial soils, often in river floodplains. They are composed of trees that can handle low oxygen soils, like river birch and water oak, as well as numerous water tolerant or water obligate shrubs, sedges, grasses and perennials (Edwards, Ambrose, and Kirkman 2013). These habitats are essential for numerous reasons including: the diversity of life, their function as a corridor linking fragmented habitats (Hilty and Lidicker 2006), and their importance filtering pollution from water run-off before it enters aquatic habitat (Zhang et al 2017).

Based off these habitat requirements, for this study suitability for the Bottomland Forest – Freshwater Wetland archetype will be defined by a two parameters, location within a river, stream, or wetland floodplain, and location on areas not suitable for canebrakes.

Bottomland - Wetland



Ecoregion Influences:
Bottomland Forest
Beaver Pond/Freshwater Marsh

Habitat Provided:
Chamberlian's Dwarf Salamander *Eurycea chamberlaini*
Dwarf Waterdog *Necturus punctatus*
Patch-nosed Salamander *Urspelerpes brucei*
Rusty Blackbird *Euphagus carolinus*
Peregrine Falcon *Falco peregrinus*
Bald Eagle *Haliaeetus lecocephalus*
Least Bittern *Ixobrychus exilis*
Loggerhead Shrike *Lanius ludovicianus*
Black Rail *Laterallus jamaicensis*
Swainson's Warbler *Limnothlypis swainsonii*
Prothonotary Warbler *Protonotaria citrea*
King Rail *Rallus elegans*
Southeastern Myotis *Myotis austroriparius*
Gray Myotis *Myotis grisescens*
Tri-colored bat *Perimyotis subflavus*
Barbour's Map Turtle *Graptemys barbouri*
Alligator Snapping Turtle *Macrochelys temminckii*
Bell's Roadside-skipper *Amblyscirtes belli*
Carolina Roadside-skipper *Amblyscirtes carolina*
Rusty-patched Bumblebee *Bombus Affinis*
Monarch Butterfly *Danaus plexippus*
Helicta Satyr *Neonympha helicta*
West Virginia White *Pieris virginiensis*

Required Maintenance: Manual removal of invasives and native propagation if necessary

Animal Species Needs

Seed and Berry Producers
Black Willow
Sedges
Reeds
River Oats
Dwarf Palmetto
Rhododendron
Mountain Laurel
Hemlock
Poplars
Oaks
Red Maple
Ash
Buttonbush
Sweetgum
Hackberry
River birch
Elm
Cattails
^Spartina
Sweet Pepperbush
Native Milkweeds
Swamp Milkweed
Cinquefoil
Wild Strawberry
Blackberry
Ironweed
Switchcane
Turtlehead
^Hairy beardtongue
#Foxglove
Viburnum
Wild Rose
Toothwort
Mustard Family
Spring Beauty
Violets

^=Out of Hardiness Zone
#=Nonnative
$=Inappropriate for ecoregion

Plant Structure Needs

Old Growth Trees
Dense, possibly thorny shrubs
Tall Vegetation for Nesting
Needs Areas without Groundcover

Figure 30: Bottomland Forest/Wetland Habitat Archetype

Bottomland Forest/ Wetland Archetype

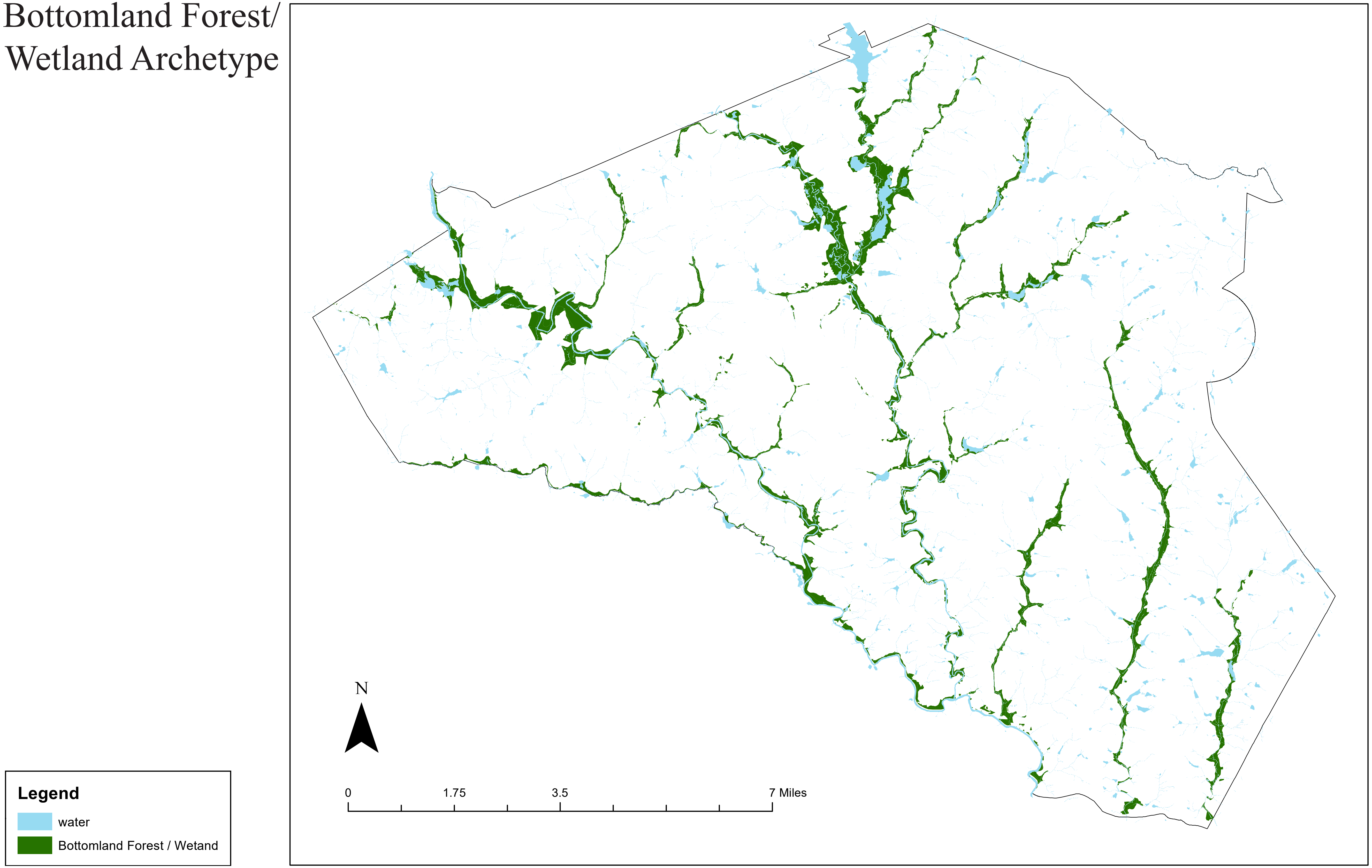


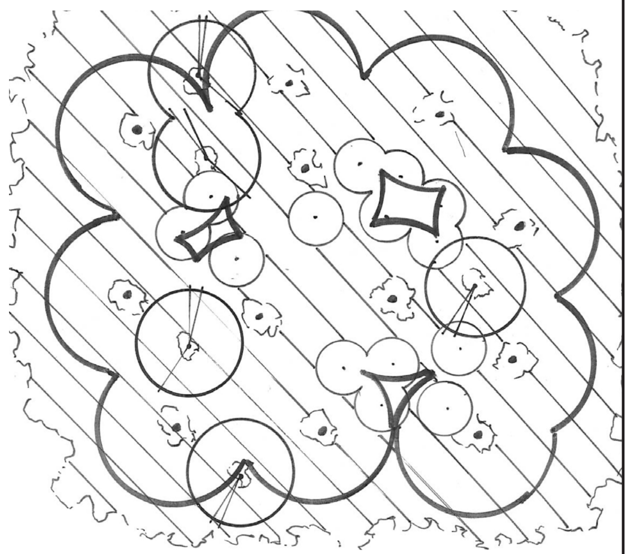
Figure 31: Bottomland Forest/Wetland Suitability Map

Mesic Forests

Mesic forests are lush forests growing in moist, cooler, shaded sites on north facing aspects and in close proximity to streams and rivers (Edwards, Ambrose, and Kirkman 2013).

Based on these habitat requirements, for this study suitability for the Mesic Forest archetype will be defined by three parameters: aspect, proximity to stream and river courses, and canebrake suitability. Suitability for mesic forest is set to 100 ft. from a river course, which is the NRCS's suggested riparian buffer (efotg.sc.egov.usda.gov), sites on north facing aspects, and areas not suitable for canebrakes.

Mesic Forest



Ecoregion Influences:
Mesic Hardwood Forest

Habitat Provided:
Chamberlian's Dwarf Salamander *Eurycea chamberlaini*
Dwarf Waterdog *Necturus punctatus*
Patch-nosed Salamander *Urspelerpes brucei*
Bald Eagle *Haliaeetus lecocephalus*
Least Bittern *Ixobrychus exilis*
Loggerhead Shrike *Lanius ludovicianus*
Swainson's Warbler *Limnothlypis swainsonii*
Southeastern Myotis *Myotis austroriparius*
Gray Myotis *Myotis grisescens*
Northern Myotis *Myotis septentrionalis*
Tri-colored bat *Perimyotis subflavus*
Eastern Spotted Skunk *Spilogale putorius*
Carolina Roadside-skipper *Amblyscirtes carolina*

Required Maintenance: Manual removal of invasives and native propagation if necessary

Plant Species Needs

Reeds
Grasses
Rushes
Juncuses
Dwarf Palmetto
Rhododendron
Mountain Laurel
Hemlock
Poplar
Oaks
Maple
Sweet Pepperbush
Swamp Milkweed
Common Milkweed
Cinquefoil
Wild Strawberry
Blackberry
Ironweed
Switchcane
Toothwart
Mustard Family
Spring Beauty
Violets

^=Out of Hardiness Zone
#=Nonnative
$=Inappropriate for ecoregion

Plant Structure Needs

Old Growth Trees
Dense, possibly thorny shrubs
Tall Vegetation for Nesting
Needs Areas without Groundcover

Figure 32: Mesic Forest Habitat Archetype

Mesic Forest Archetype

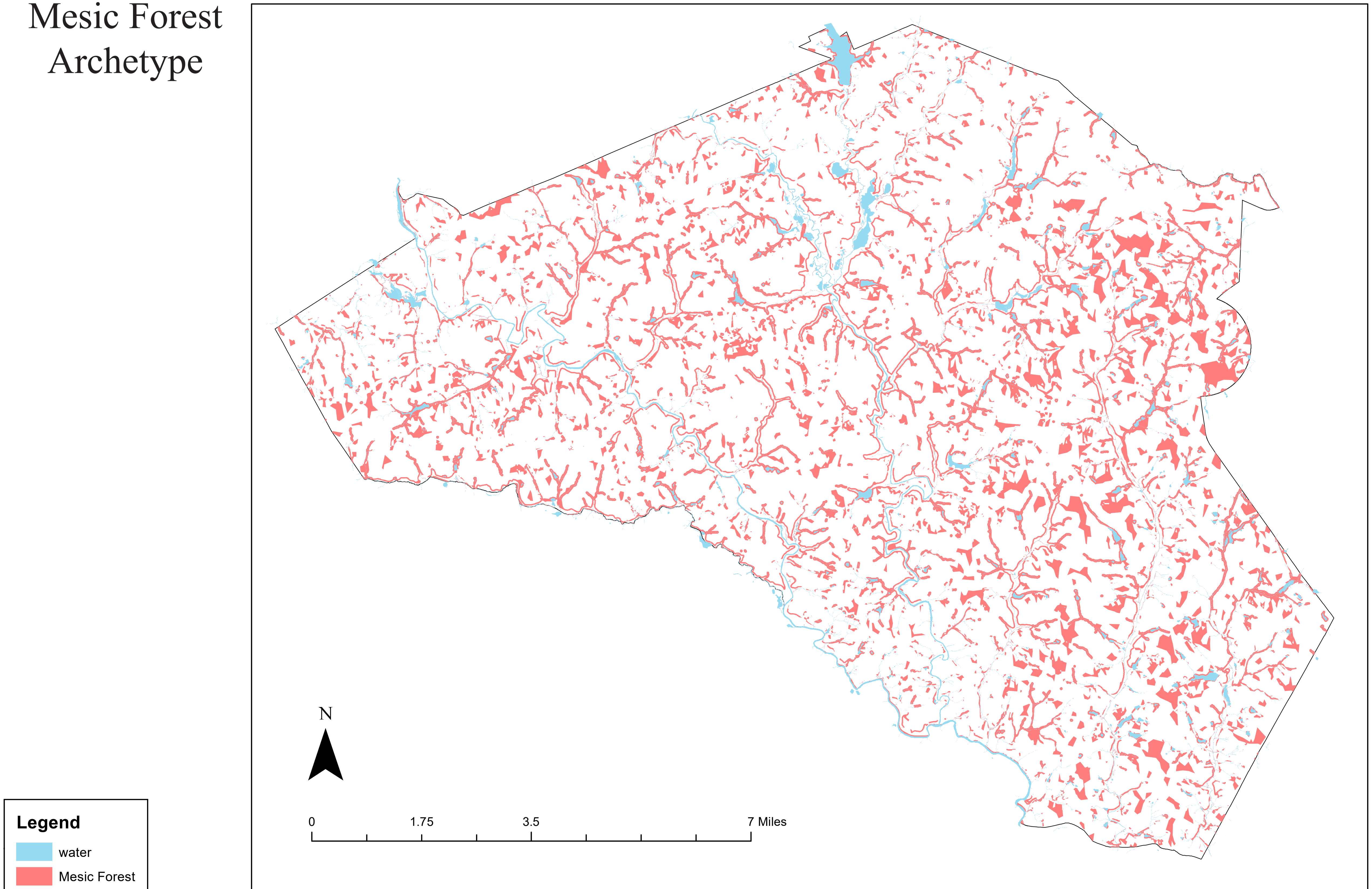


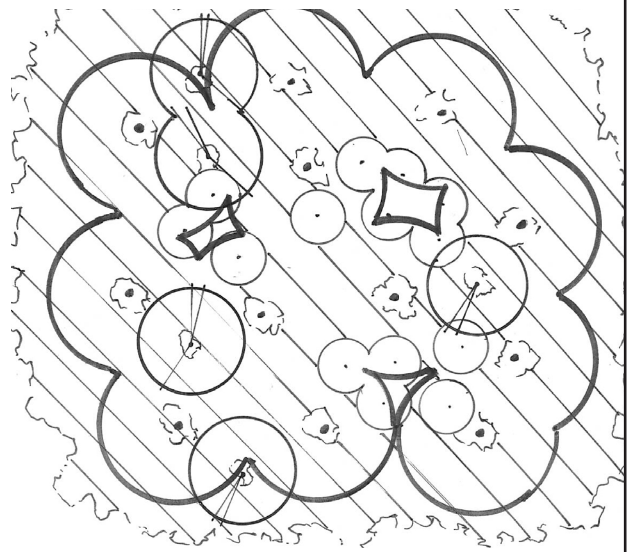
Figure 33: Mesic Forest Suitability Map

Oak-Hickory-Pine Forests

Oak-Hickory-Pine forests are closed canopy hardwood forests common in the southeastern United States and making up the “matrix” forest in the piedmont (Edwards, Ambrose, and Kirkman 2013).

Because it is the matrix forest, the suitability analysis assumes the Oak-Hickory-Pine forest to be the backdrop forest, thus filling all areas not found to be more suitable for another archetype.

Oak-Hickory-Pine Forest



Ecoregion Influences:
Oak-Hickory-Pine Forest

Habitat Provided:
Bald Eagle *Haliaeetus lecocephalus*
Loggerhead Shrike *Lanius ludovicianus*
Swainson's Warbler *Limnothlypis swainsonii*
Northern Myotis *Myotis septentrionalis*
Tri-colored bat *Perimyotis subflavus*
Eastern Spotted Skunk *Spilogale putorius*
Spur-throat Grasshopper *Melanoplus longicornis*
West Virginia White *Pieris virginiensis*
Edwards hairstreak *Satyrium edwardsii*
Carolina Roadside-skipper *Amblyscirtes carolina*

Required Maintenance: Manual removal of invasives and native propagation if necessary

Plant Species Needs
Dwarf Palmetto
Rhododendron
Mountain Laurel
Hemlock
Poplar
Maple
Toothwart
Mustard Family
Spring Beauty
Violets
Blackjack Oak
Black Oak
Dogbane
Goldenrod
Newjersey Tea
Staghorn Sumac
#White Sweet clover

^=Out Hardiness Zone
#=Nonnative
$=Inappropriate for ecoregion

Plant Structure Needs
Old Growth Trees
Dense, possibly thorny shrubs
Tall Vegetation for Nesting
Needs Areas without Groundcover

Figure 34: Oak-Hickory-Pine Forest Habitat Archetype

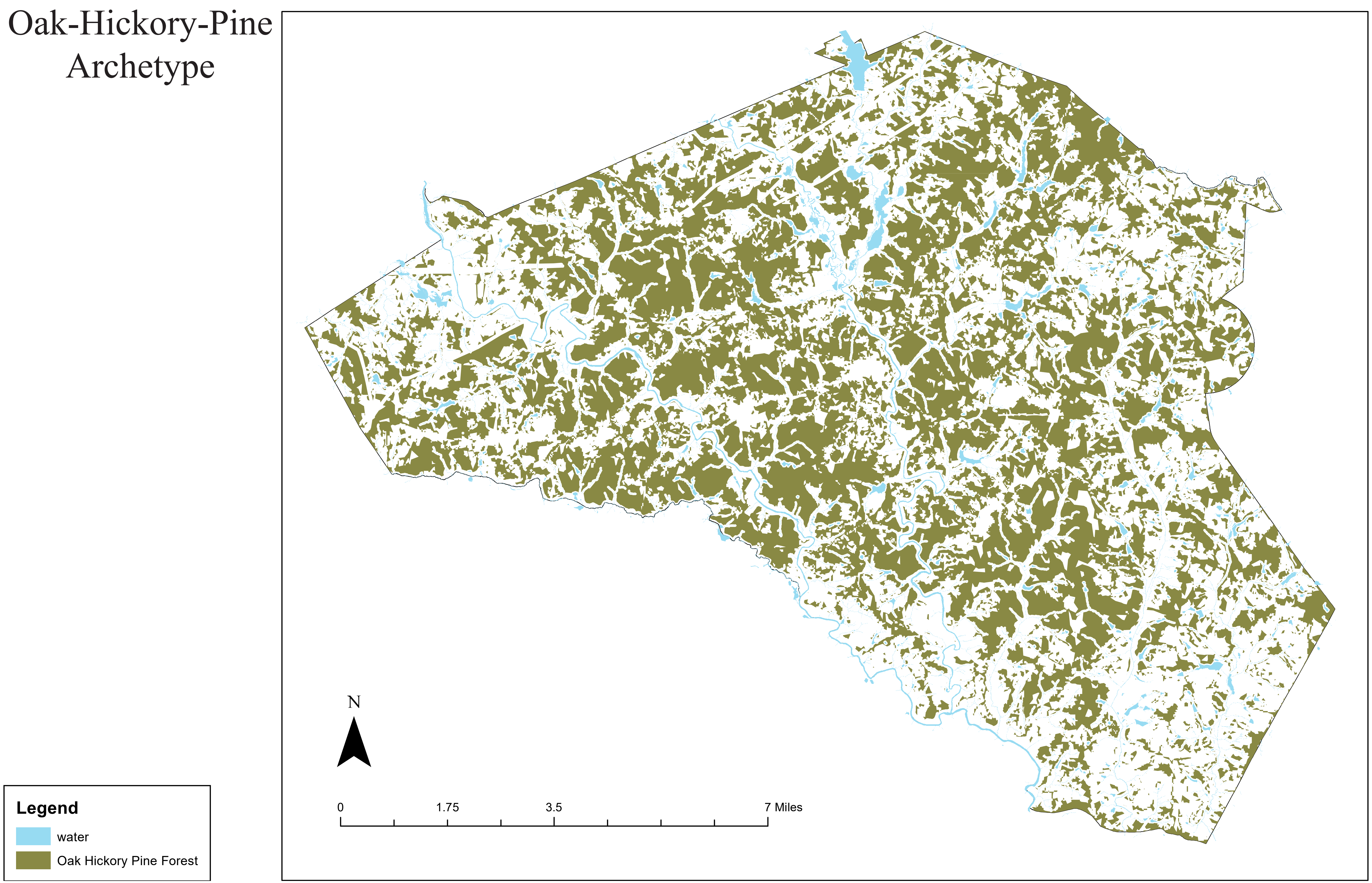


Figure 35: Oak-Hickory-Pine Forest Suitability Map

Habitat Archetype Suitability Map

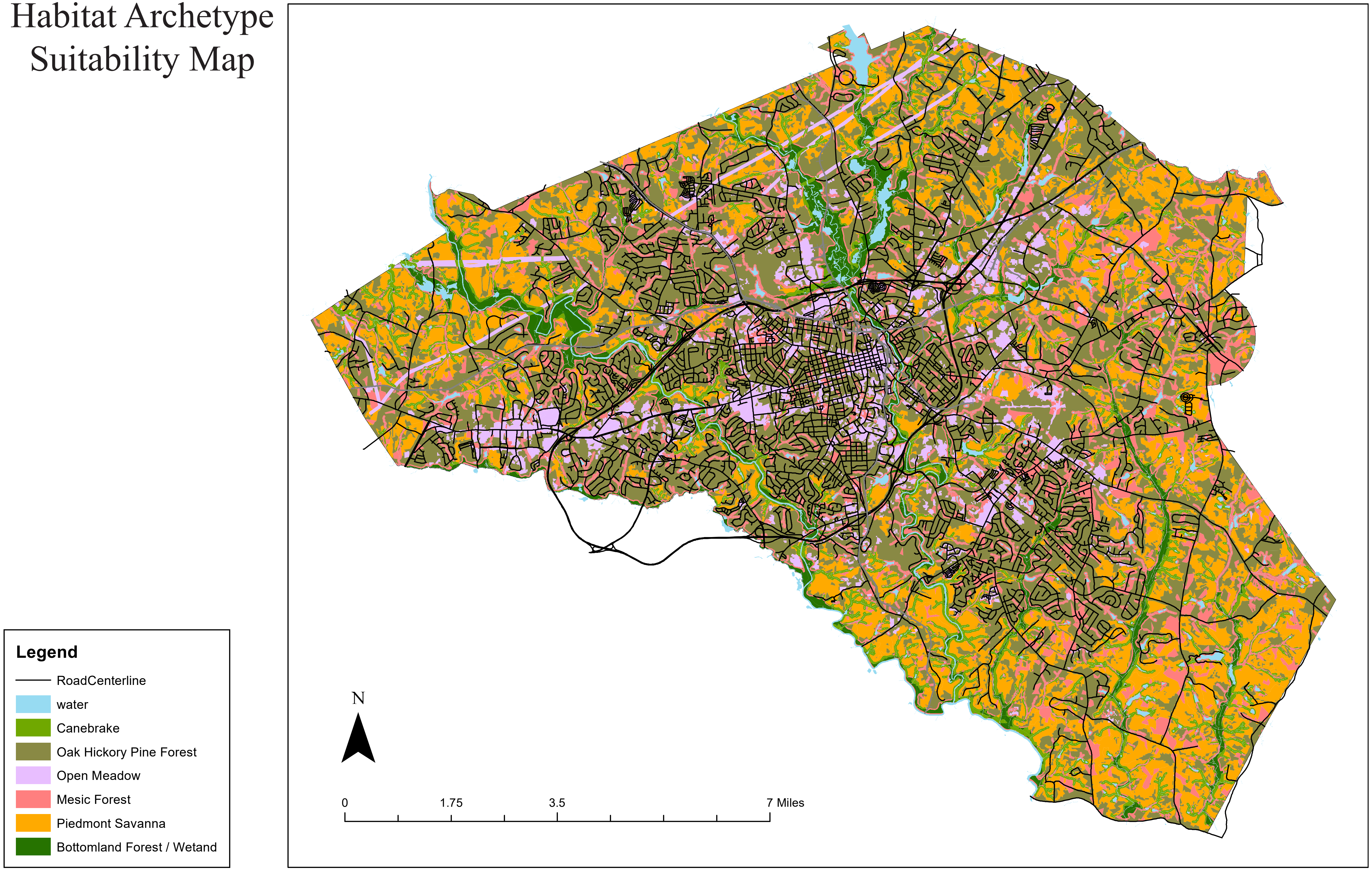


Figure 36: Athens Habitat Archetype Suitability Map

Archetype Suitability (Northwest)

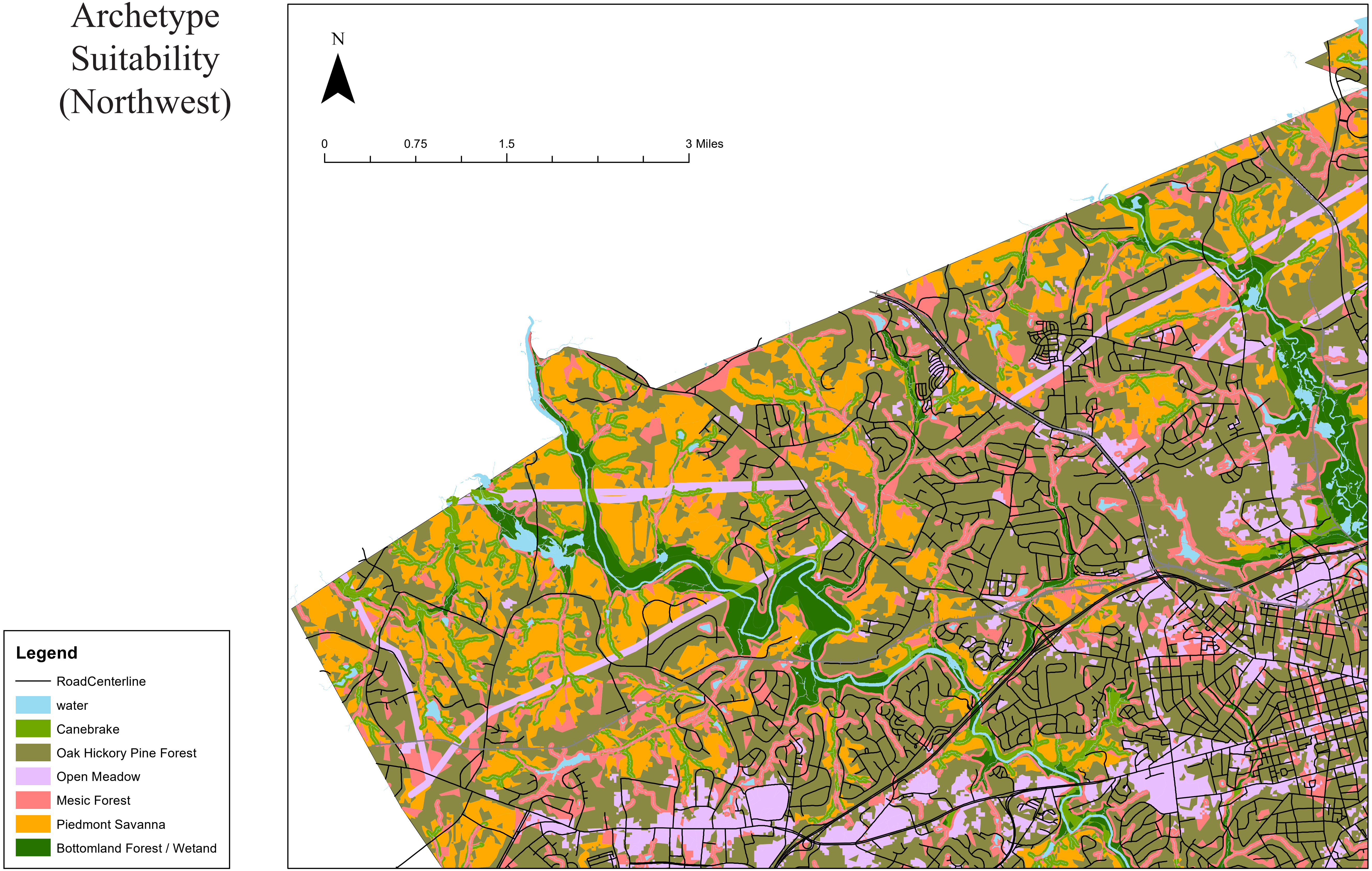


Figure 37: Athens Habitat Archetype Suitability Map (Northwest)

Archetype Suitability (Northeast)

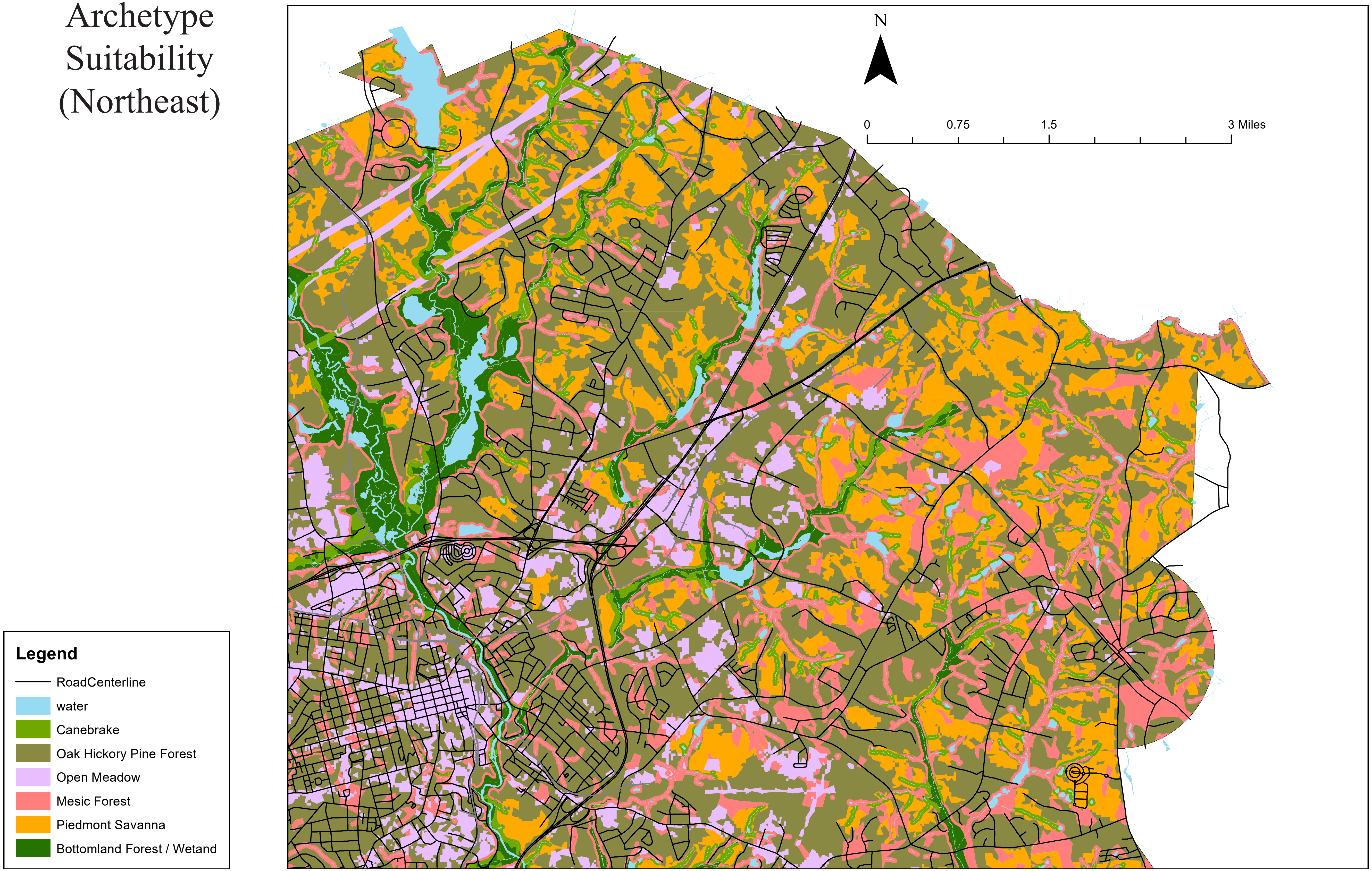
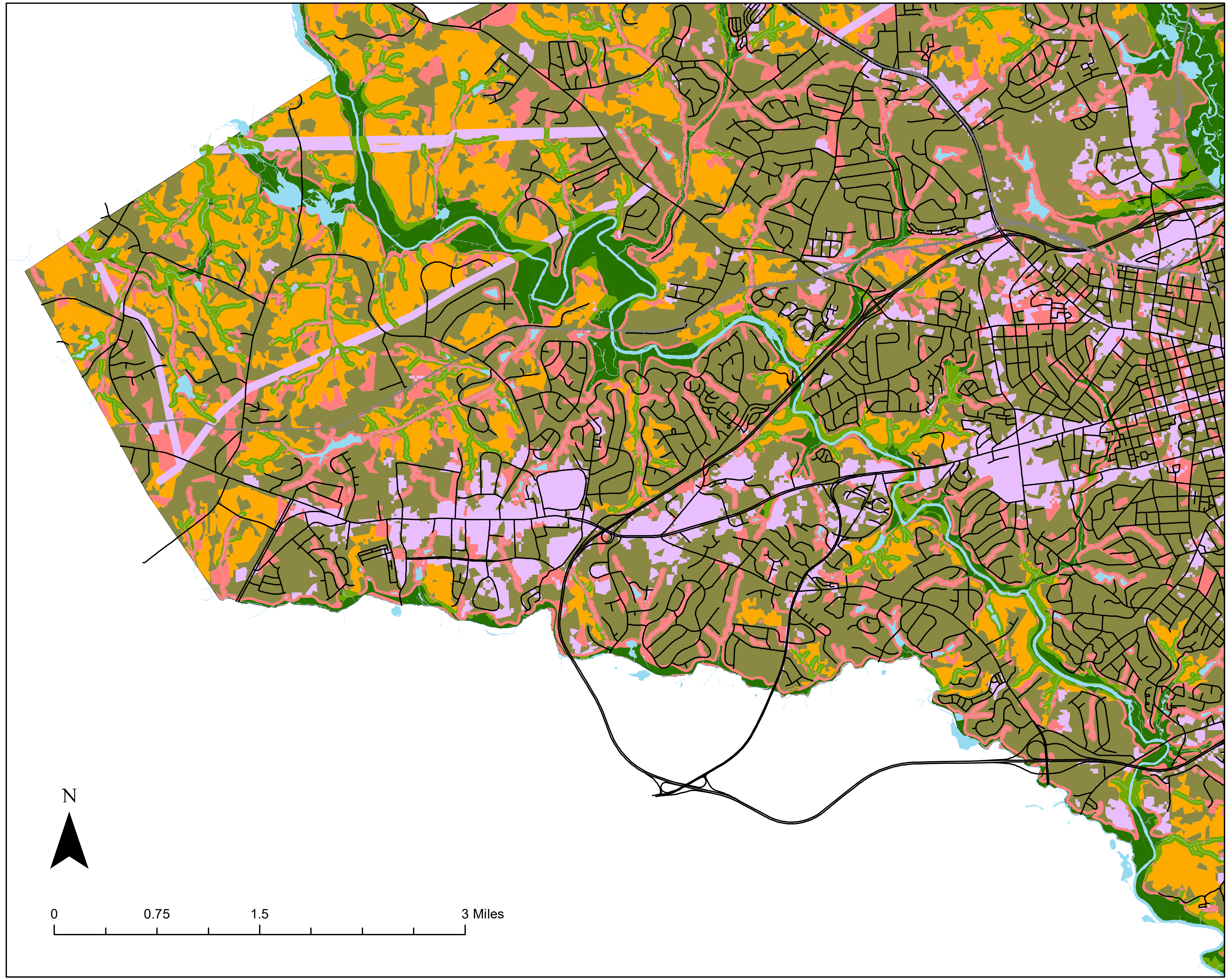


Figure 38: Athens Habitat Archetype Suitability Map (Northeast)

Archetype
Suitability
Southwest)



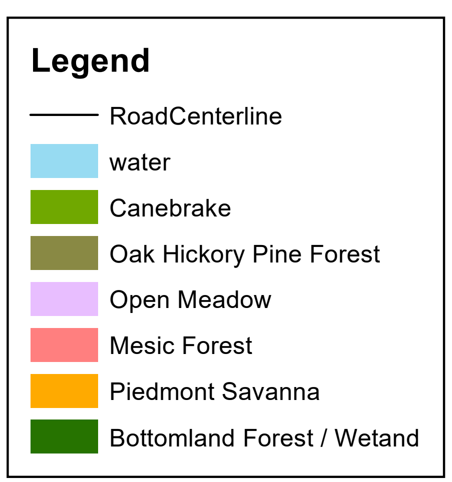


Figure 39: Athens Habitat Archetype Suitability Map (Southeast)

Archetype Suitability (Southeast)

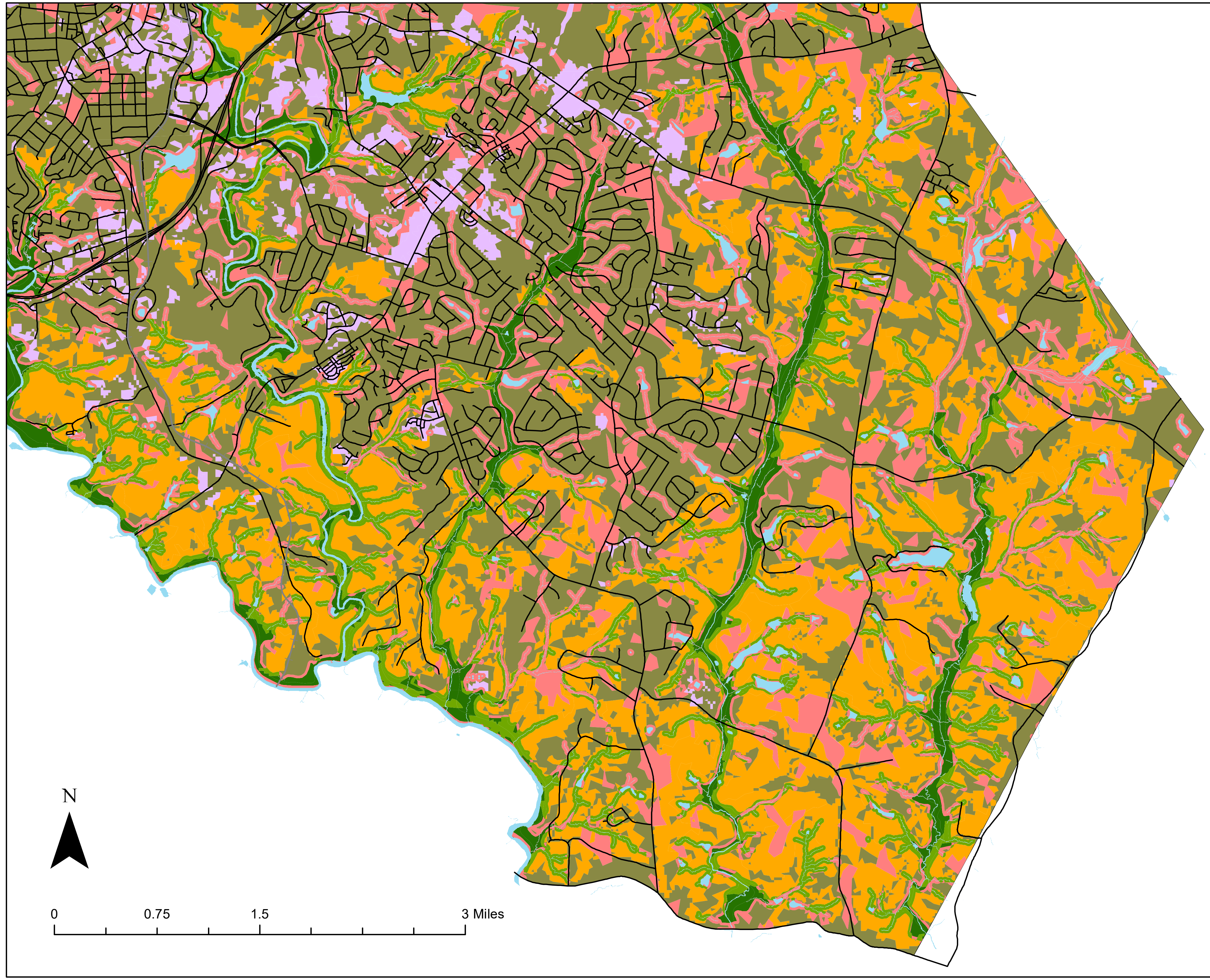


Figure 40: Athens Habitat Archetype Suitability Map (Southwest)

CHAPTER 6

DESIGN

The design component of this research focuses on developing a set of general forms private landowners can implement on their own properties. The variety across the Athens landscape presents a different set of opportunities and limitation at each site. In order to provide guidance across the Athens landscape designs were generated in three common contexts: urban, suburban, and rural.

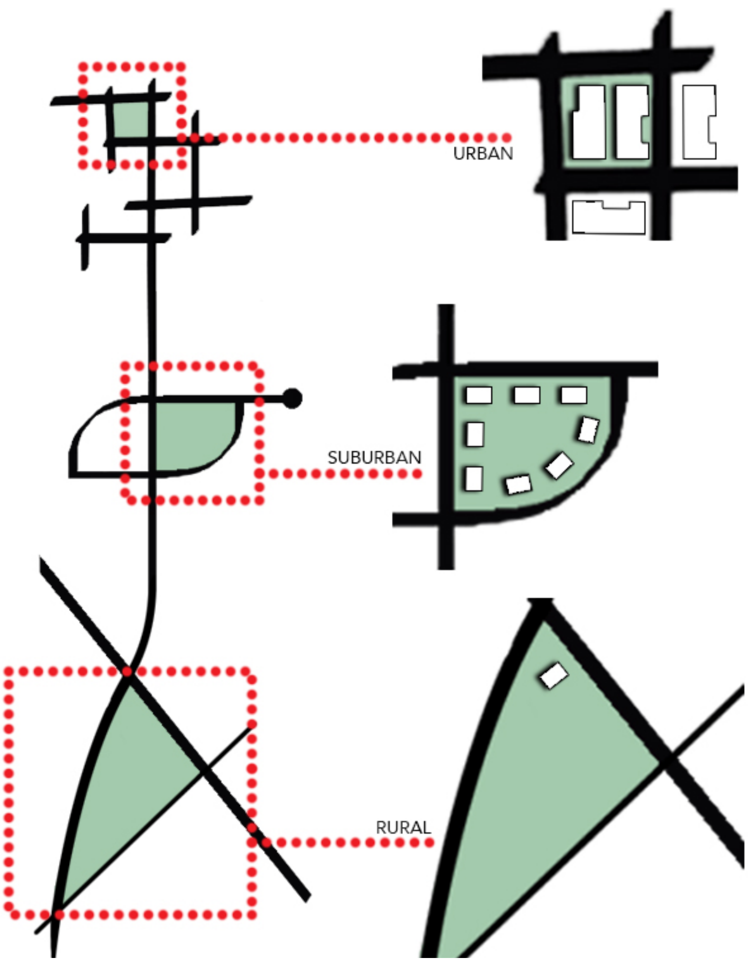


Figure 41: Transect of Athens-Clarke County's Land-Use Contexts

Form Based Design

Urban Context: Streetscaping

The urban context presents a unique opportunity for design. While the area is too heavily impacted by human development to provide much ecological function, it is ideally placed for promoting interest in native species and habitat restoration. Downtowns bustling streets and heavy pedestrian traffic offer the possibilities of high exposure. A thoughtfully and beautifully designed streetscape has tremendous potential to educate average citizens about the importance of native species.

While large fauna may not be able to utilize spaces in the heavily fragmented urban context, there are several charismatic mega-fauna, that can be found. Encouraging butterflies, bees, and birds with flower heavy open meadow planting will help provide respites of life in eve the most densely developed spaces.

Establishing native species in downtown Athens does not require a full renovation. Instead existing lawn strips and tree planters can simply be planted with native forbs and grasses. Similar techniques have already been implemented at the intersection of Washington Street and College Avenue. Additionally, the invasive nandina and Chinese holly, currently featured heavily in the downtown's foundation plantings, should be replaced with native species.

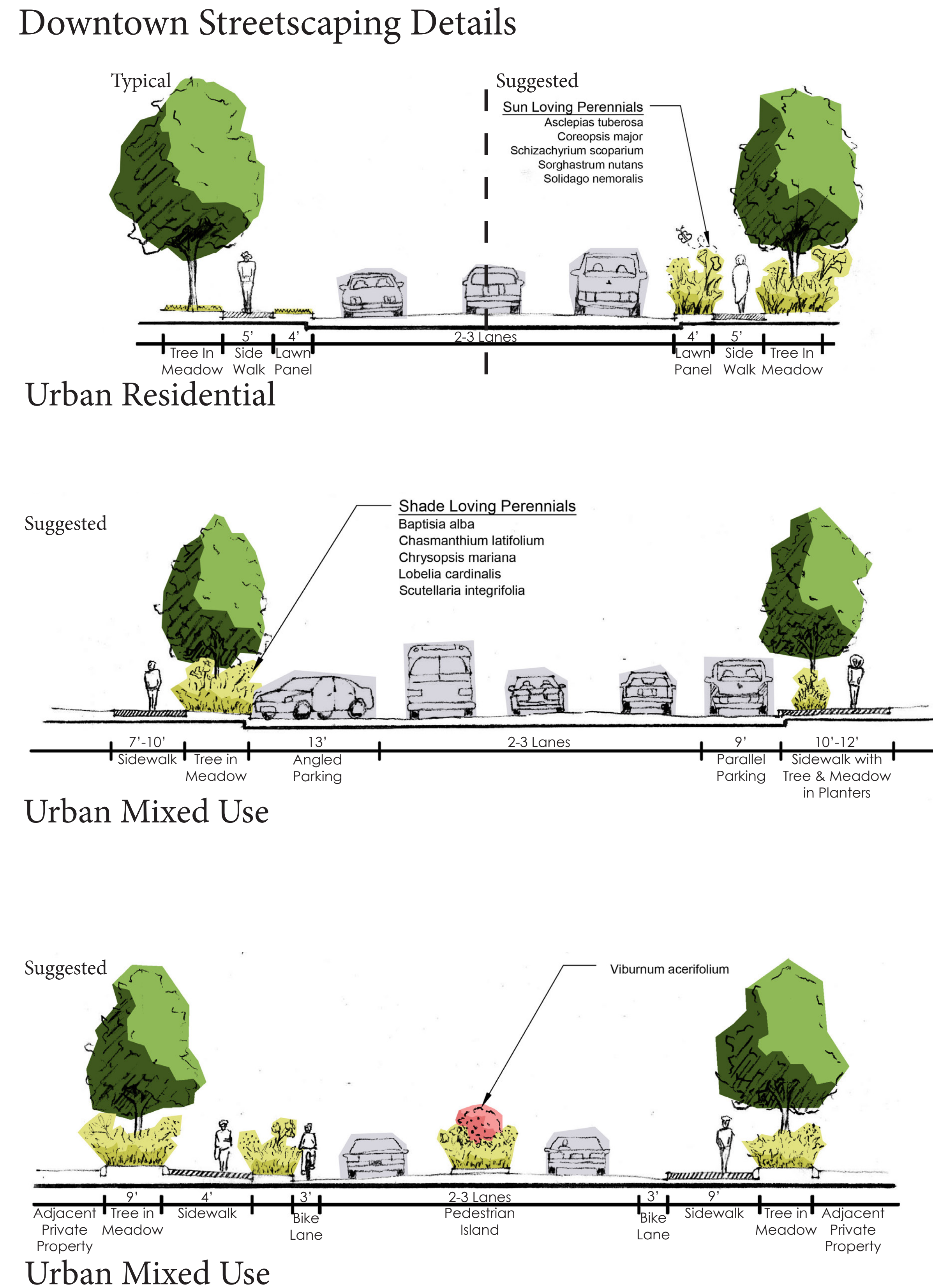


Figure 42: Urban Context-Streetscaping

Figure 43: Suburban Context-Neighborhood Scale Suggested Forms

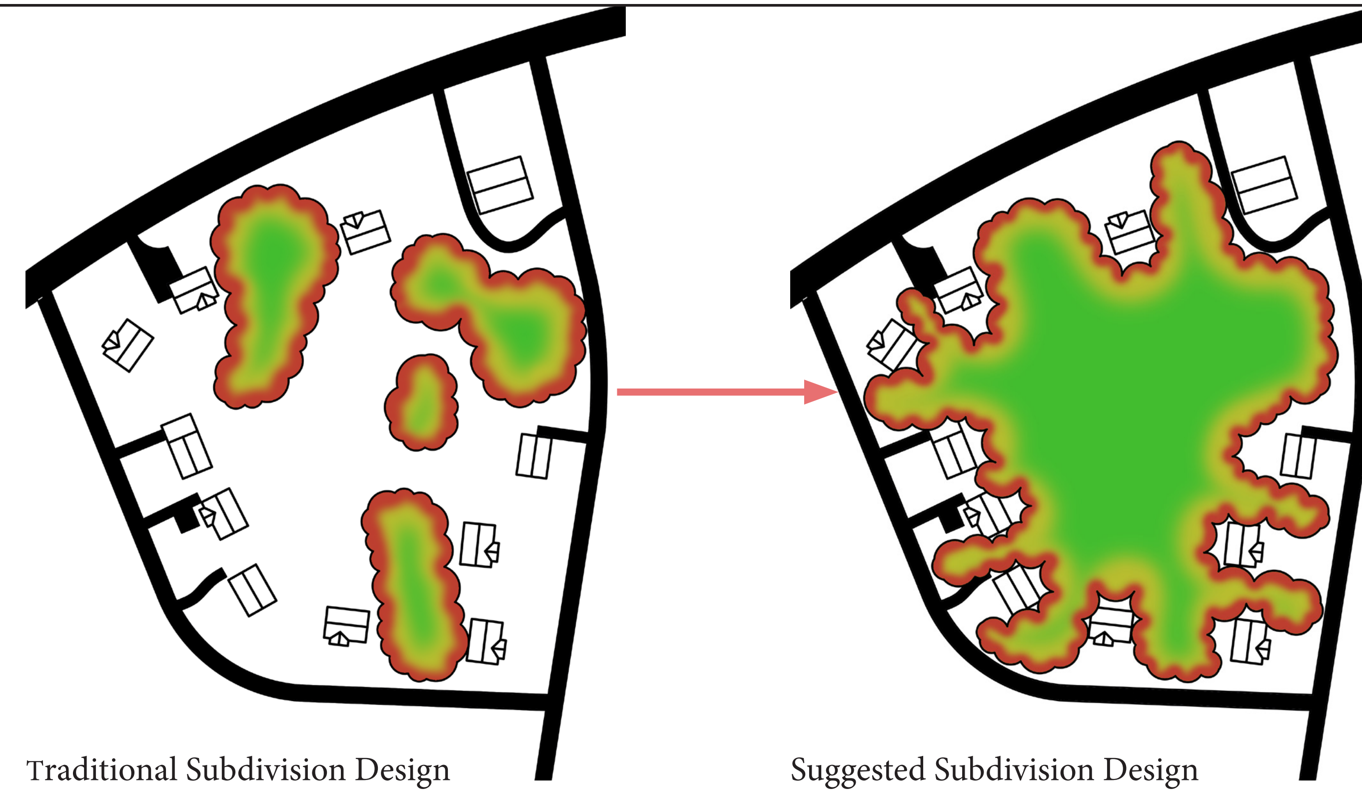
Form Based Design

Suburban Context: Neighborhood Scale

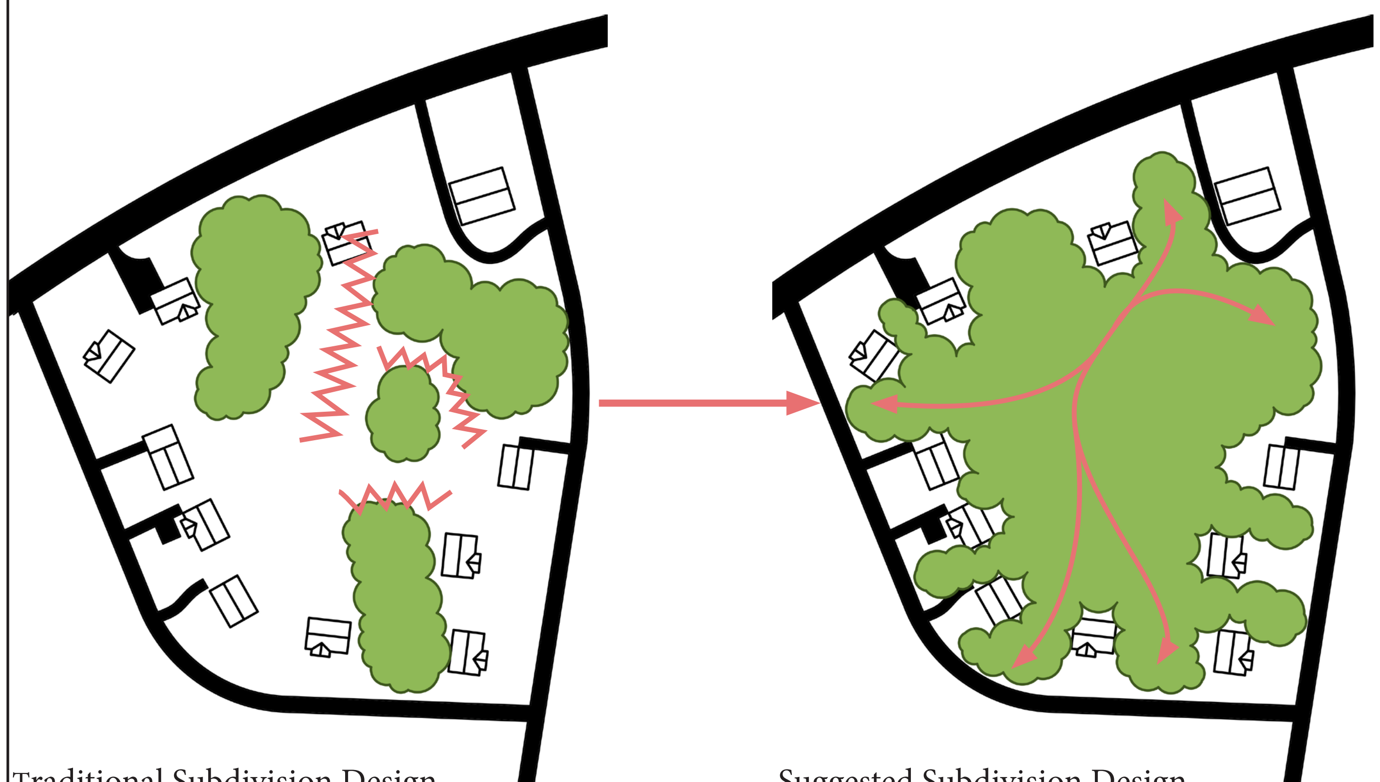
At the subdivision and neighborhood scale the design should seek to maximize habitat connectivity and core habitat, and eliminate ecologically barren, and labor intensive lawn. Traditional suburban subdivision design incorporates large swathes of lawn, with occasional specimen trees, foundation plantings, and ornamental shrubs. This creates a design that is sterile and devoid of life both aesthetically and ecologically.

Instead of leaving lawn as the primary ground cover, this design replaces it with an appropriate groundcover providing visual interest and ecological function. The ground cover around the house would be selected from the open meadow archetype, while the ground cover under the tree canopy would be selected from whichever habitat archetype covers the subdivision appears on the suitability map.

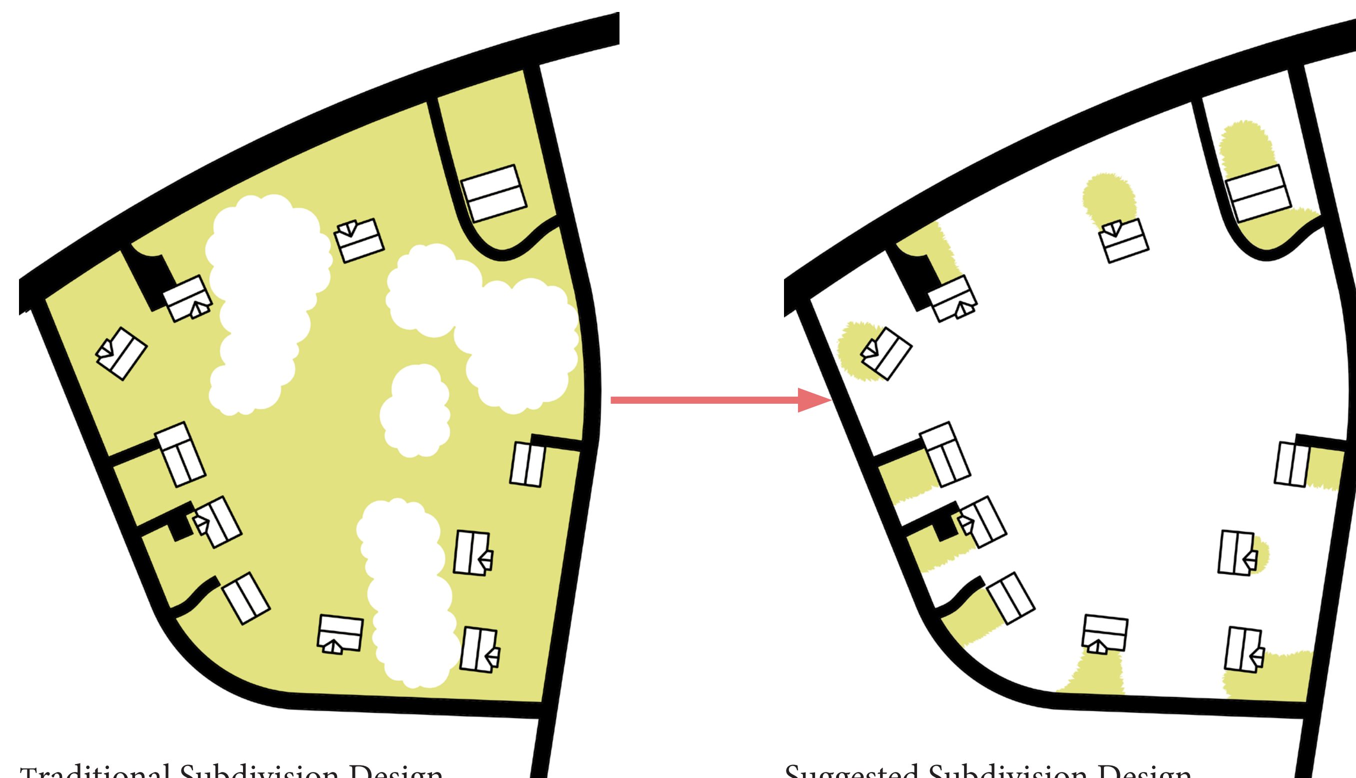
To minimize habitat fragmentation neighbors should organize to connect their designs across yard. Trees should be planted to connect wooded patches, and understory plantings and appropriate groundcover should be established to create a suitable vegetative vertical structure.



Maximizes core habitat for the appropriate habitat archetype



Maximizes connectivity for the appropriate habitat archetype



Minimizes mowed lawn requiring intensive management

Figure 44: Suburban Context-Benefits of Suggested Forms

Form Based Design
Suburban Context: Site Analysis

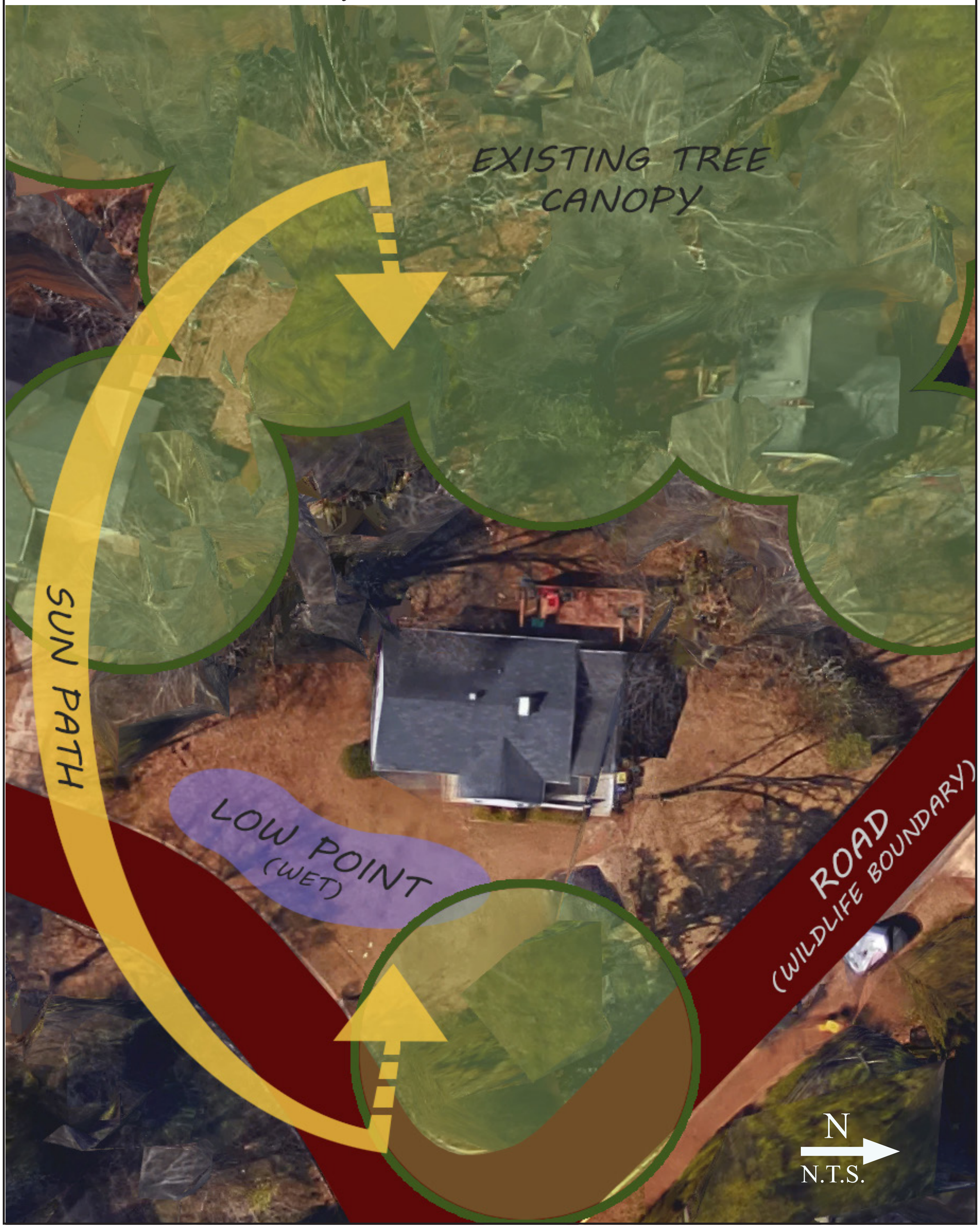


Figure 45: Suburban Context-Site Analysis

Form Based Design

Suburban Context: Site Scale

It is important to understand that the habitat archetype suitability map is a course analysis of Athens-Clarke County in general. The information on that map is intended to give homeowners an understanding of their surrounding ecological context, and suggestions on how it can fit into it.

When designing a property, the homeowner will almost certainly encounter anomalies to the conditions suggested in the suitability framework. Individual sites have various conditions, like low wet points, which cannot be picked up through course the GIS analysis of the suitability analysis. For these anomalies, the property owner must use their own judgment. For example low area with seasonally ponding water provides a potential space to use plants from the bottom land/wetland archetype which are resilient to flooding.

Additionally, a private land owner may have their own aesthetic preferences which they wish to impart on their landscape. For example, many people are off put by the perceived messiness of tall meadow grasses. For issues like this, it often helps to contextualize the "messy wilderness" with an orderly frame, like a mowed area around the house and a mow strip along the road. This creates a perception of order, and creates a space for lawn activities near the house (Nassauer 1995).

Figure 46: Suburban Context-Site Scale Design

Figure 47: Suburban Context-Site View from the Street

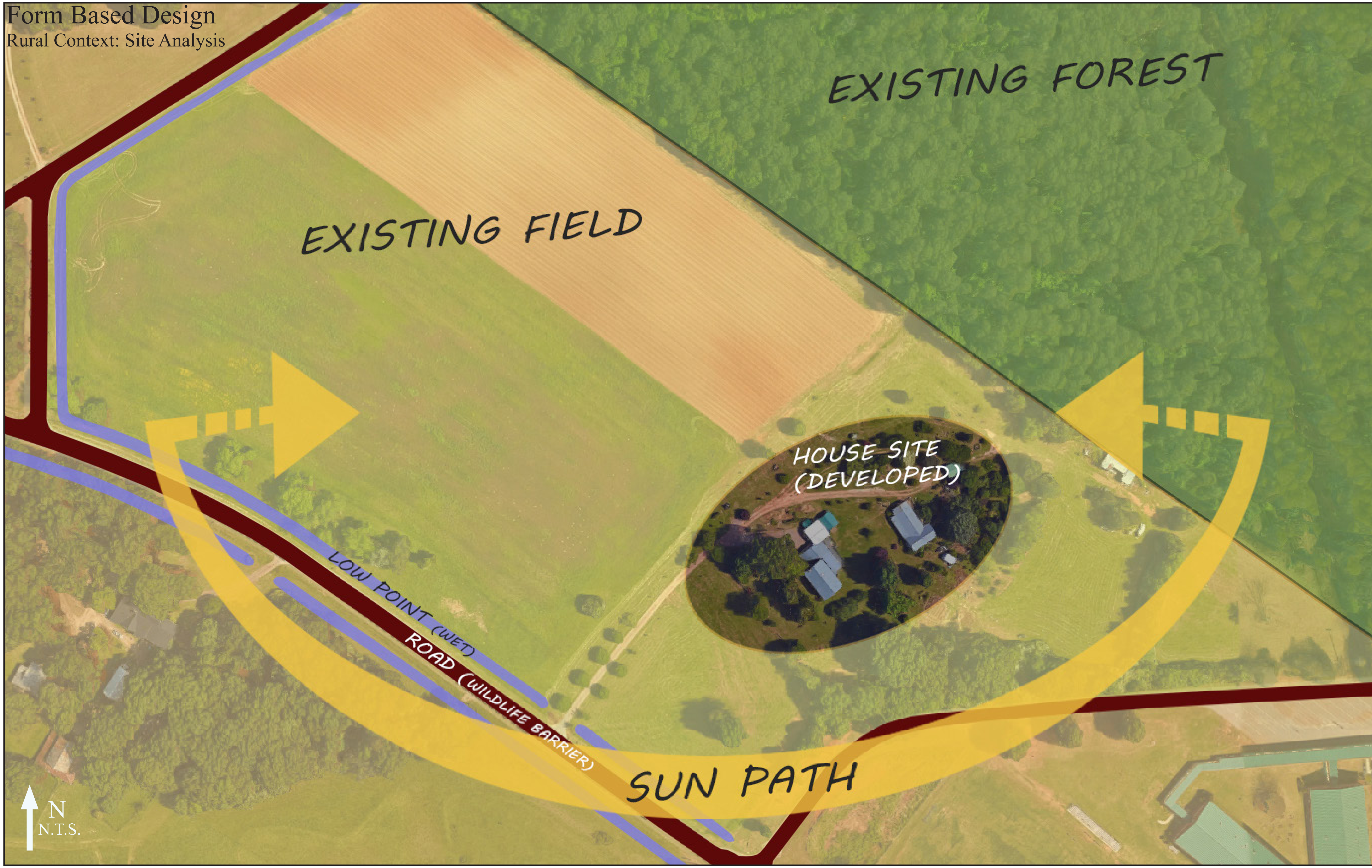


Figure 48: Rural Context-Site Analysis

Form Based Design

Rural Context: Site Scale

Many of the same suggestions from the suburban context apply here: analyze the sites specific conditions, amend the suggested framework appropriately, and incorporate personal preferences into the design. Additionally, because the piedmont savanna archetype will be implemented in the rural context, be sure to leave a cleared space between 30 and 100 feet between any residential structures and grasses that will be burned (www.nfpa.org).

Property is large enough to be split into multiple habitat suitabilities. In this case maintain existing canopy and establish oak-hickory-pine forest

Sparkleberry *Vaccinium arboreum*

Blackjack Oak *Quercus marilandica*

A mix of perennials and grasses from the piedmont savanna groundcover list

Southern Red Oak *Quercus falcata*

Mowed lawn around house to prevent risk of fire damage during periodic burns

Shortleaf Pine *Pinus echinata*

Figure 49: Rural Context-Site Scale Design Suggestions

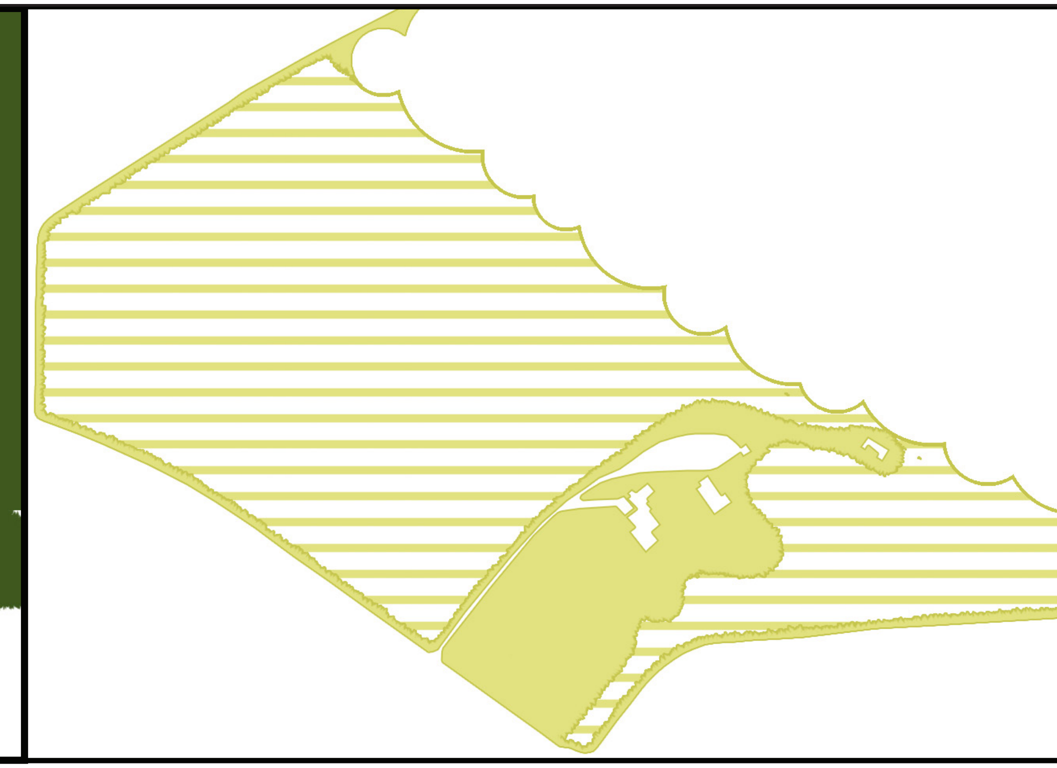
Figure 50: Rural Context-Site View from the Street

Form Based Design

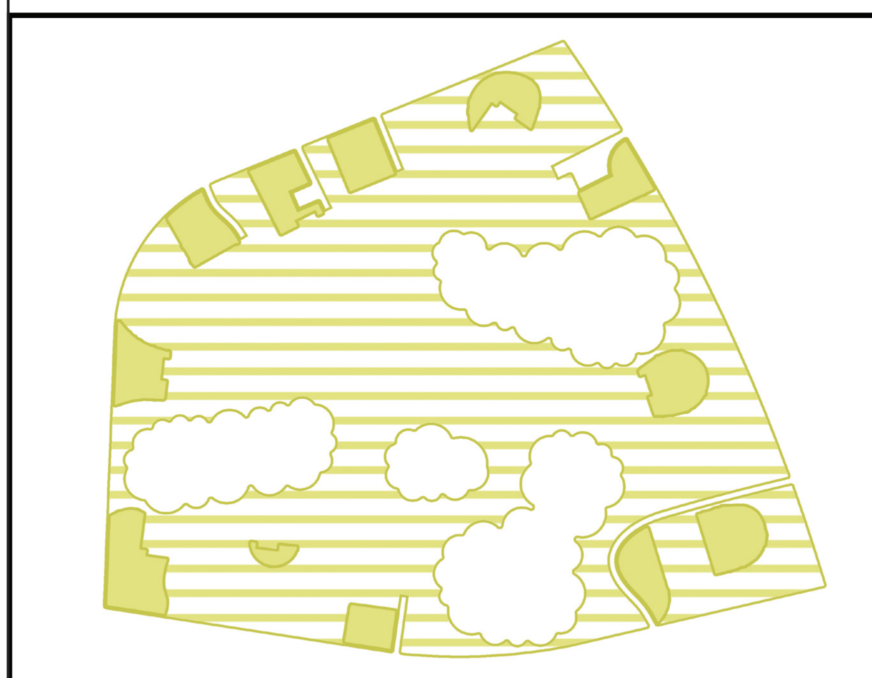
Ecological benefits

The goals in these design suggestions is to minimize ecologically sterile landscapes like lawn and promote the construction of functional habitat. Because these are just form based general designs results may vary depending on site specific circumstances; however based on these general design principals the results can be expected to provide a rough approximation for the ecological benefits.

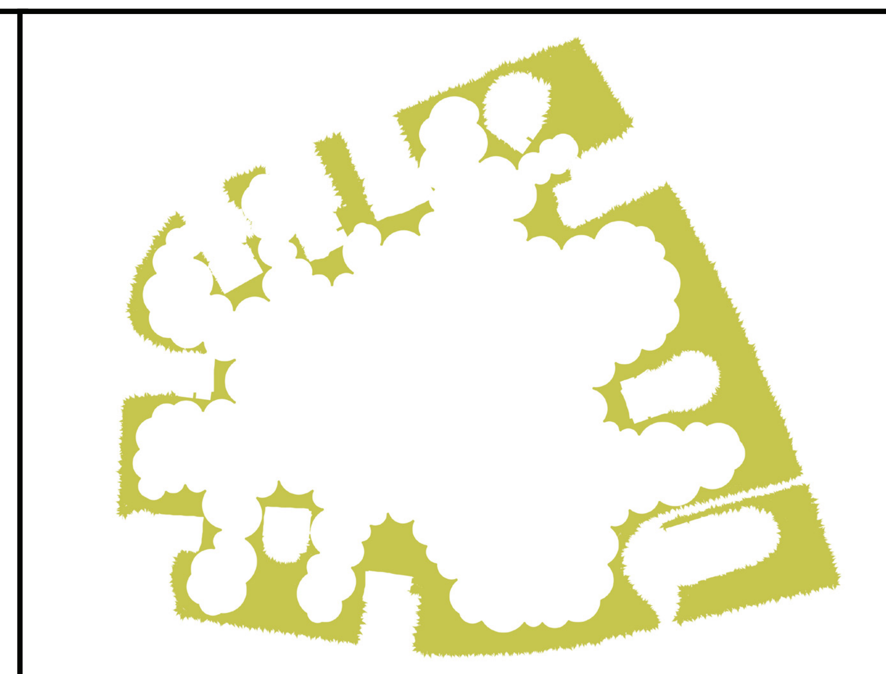
Converts 89% of rural property to habitat for priority species



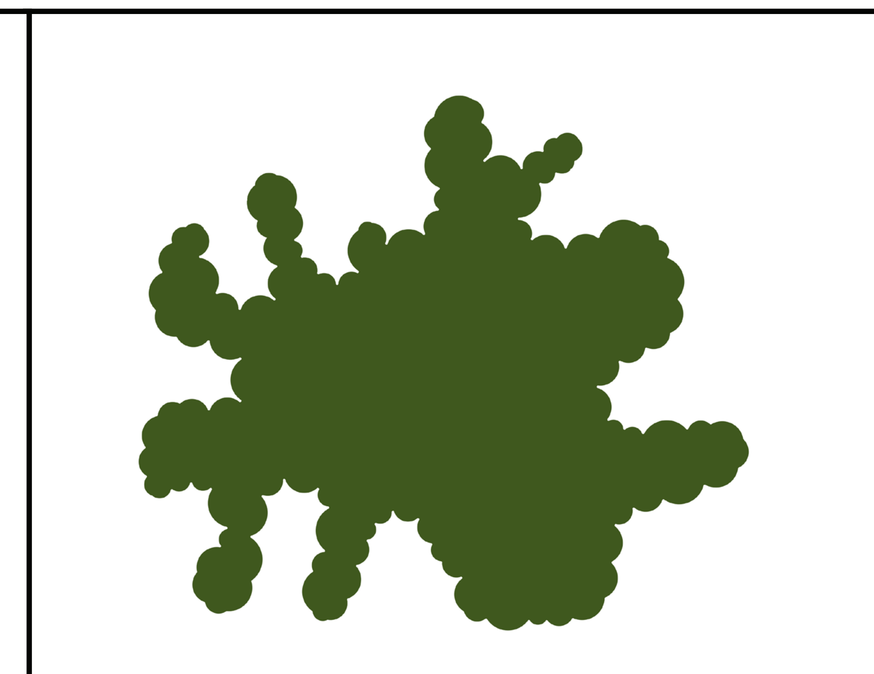
Eliminates 80% of lawn on rural properties



Eliminates 88% of total lawn on suburban properties



Converts 25% of suburban property to open meadow conducive for charismatic fauna like butterflies and bees



Converts 60% of suburban property to habitat for priority species

Figure 51: Form Based Design-Ecological Benefits

Similar to differences in land-use contexts, landowners will have to deal with different habitat suitabilities, and thus different planting pallets, in their design. Below is an example of a possible ecosystem continuum across a landscape.

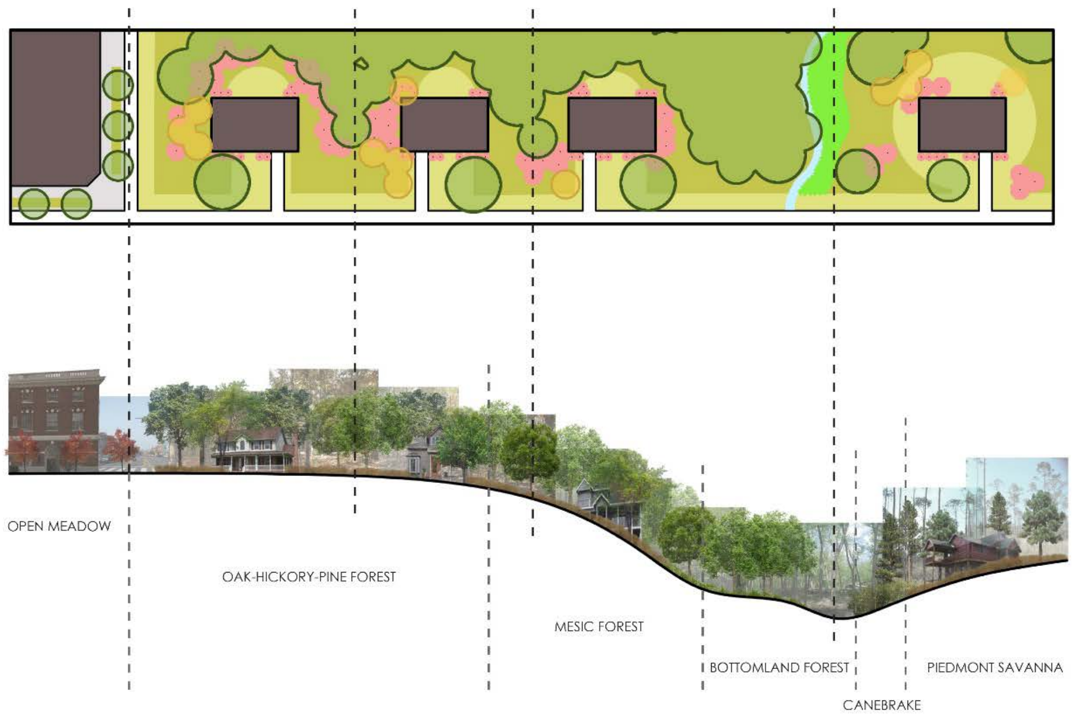


Figure 56: Plan and section of landscape across multiple ecosystem suitabilities

These different suitabilities require unique plant selection and design. The following are examples of appropriate planting plans in each context.

Urban

Here it is suggested that existing infrastructure be infilled with native street trees and plants from the open meadow framework to promote pollinator and avian connectivity across the dense urban core.

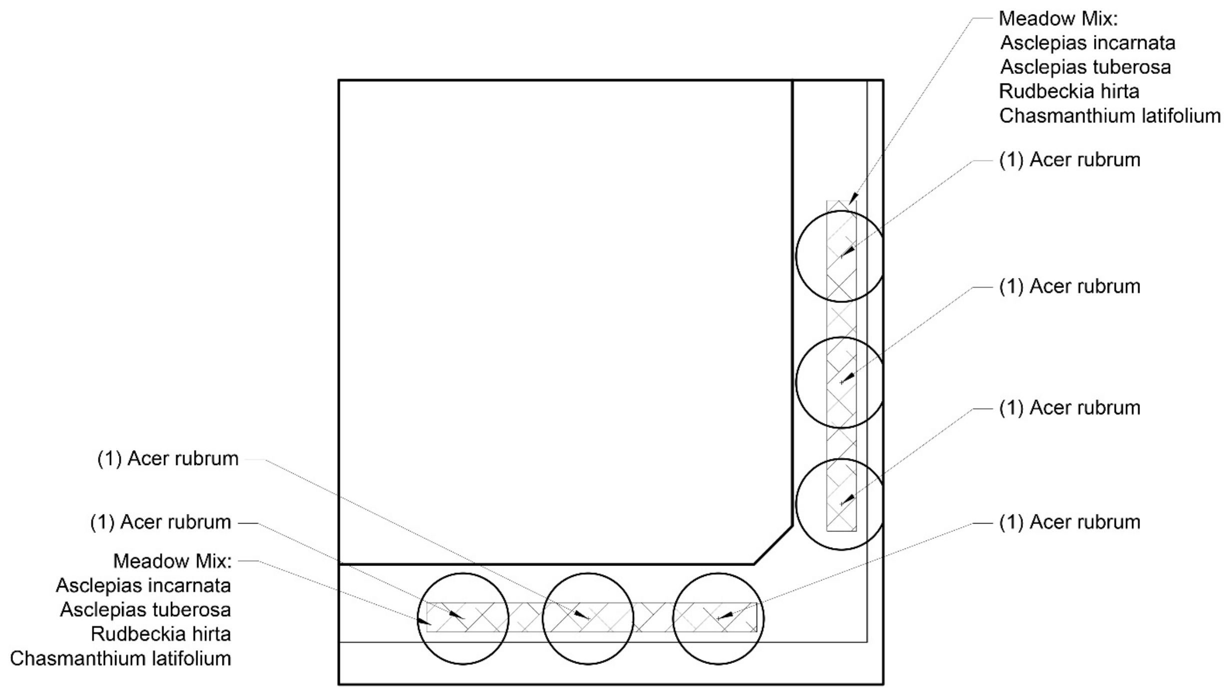


Figure 57: Planting plan for urban context

Oak-Hickory-Pine Forest Suitability

The planting plan featured below is designed for a hill top property entirely within the oak-hickory-pine forest suitability. Design includes a dense canopy behind the house, which potentially links to other neighborhood properties, foundation and privacy screening shrubs close to the house, and unmowed ground covers in front of the house to provide visibility, and legibility to the public facing side of the property. All plants were selected from the Oak-Hickory-Pine Forest Archetype plant list.

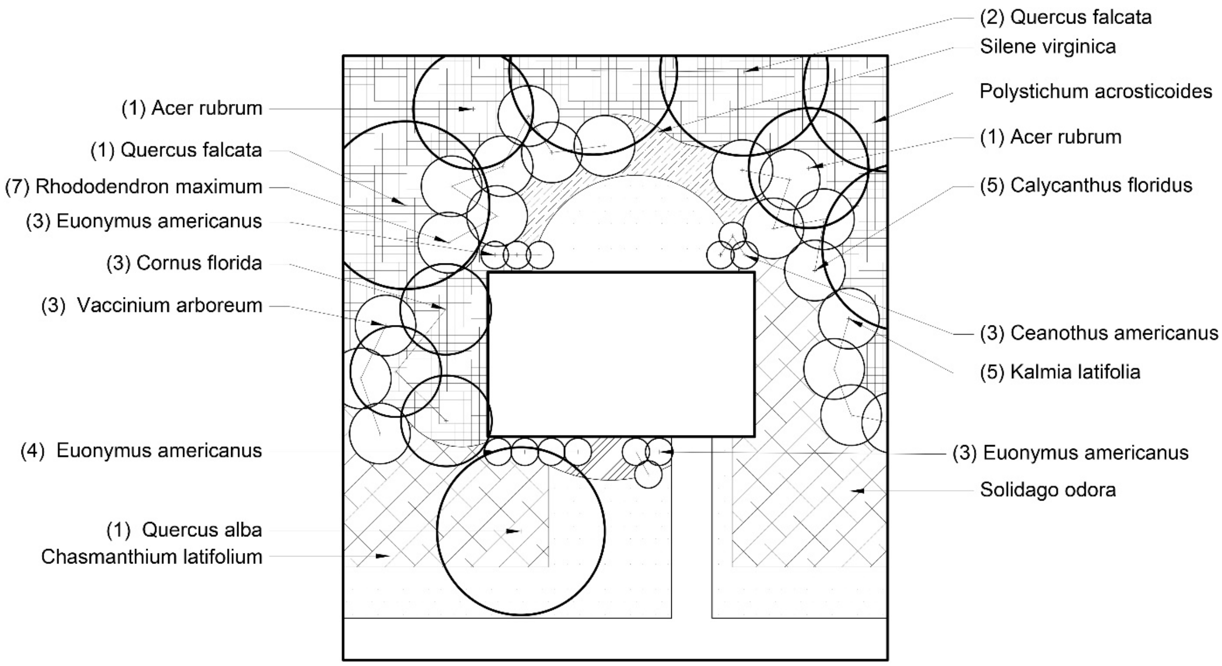


Figure 58: Planting plan for suburban yard in oak-hickory-pine forest suitability

Transition from Oak-Hickory-Pine Forest Suitability to Mesic Forest Suitability

The planting plan featured below is designed for a property transitioning from the oak-hickory-pine forest suitability to the mesic forest suitability further down the hill. Similar to the previous design, this one includes a dense canopy behind the house, which potentially links to other neighborhood properties, foundation and privacy screening shrubs close to the house, and unmowed ground covers in front of the house to provide visibility, and legibility to the public facing side of the property. Plants were selected from the Oak-Hickory-Pine Archetype plant list for the upslope and from the Mesic Forest Archetype plant list on the down slope.

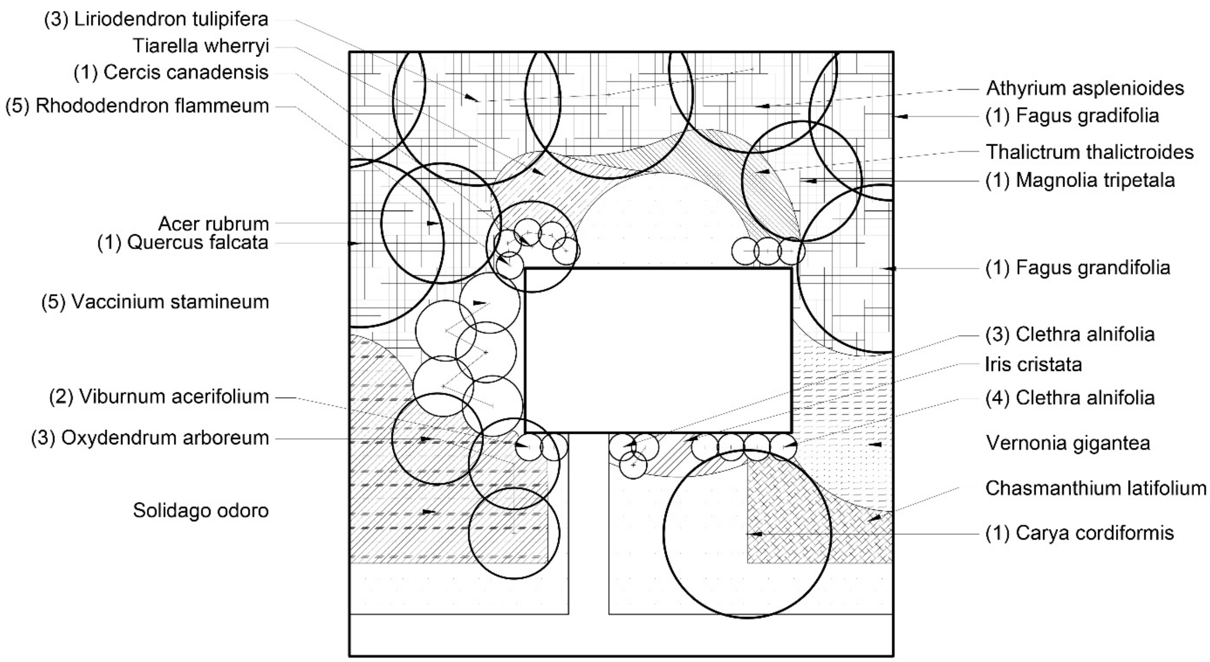


Figure 59: Planting plan for suburban yard in transition from oak-hickory-pine forest suitability to mesic forest suitability

Transition from Mesic Forest Suitability to Bottomland Forest/Freshwater Wetland Suitability

The planting plan featured below is designed for a property transitioning from the mesic forest suitability to the bottomland forest/freshwater wetland suitability further down the hill. Once again, this design includes a dense canopy behind the house, which potentially links to other neighborhood properties, foundation and privacy screening shrubs close to the house, and unmowed ground covers in front of the house to provide visibility, and legibility to the public facing side of the property. Additionally, a dense canopy of trees was included as a buffer for the riparian corridor, providing runoff filtration, and key habitat linkage along one of the most important habitats for connectivity across the landscape. Plants were selected from the Oak-Hickory-Pine Archetype plant list for the upslope and from the Mesic Forest Archetype plant list on the down slope.

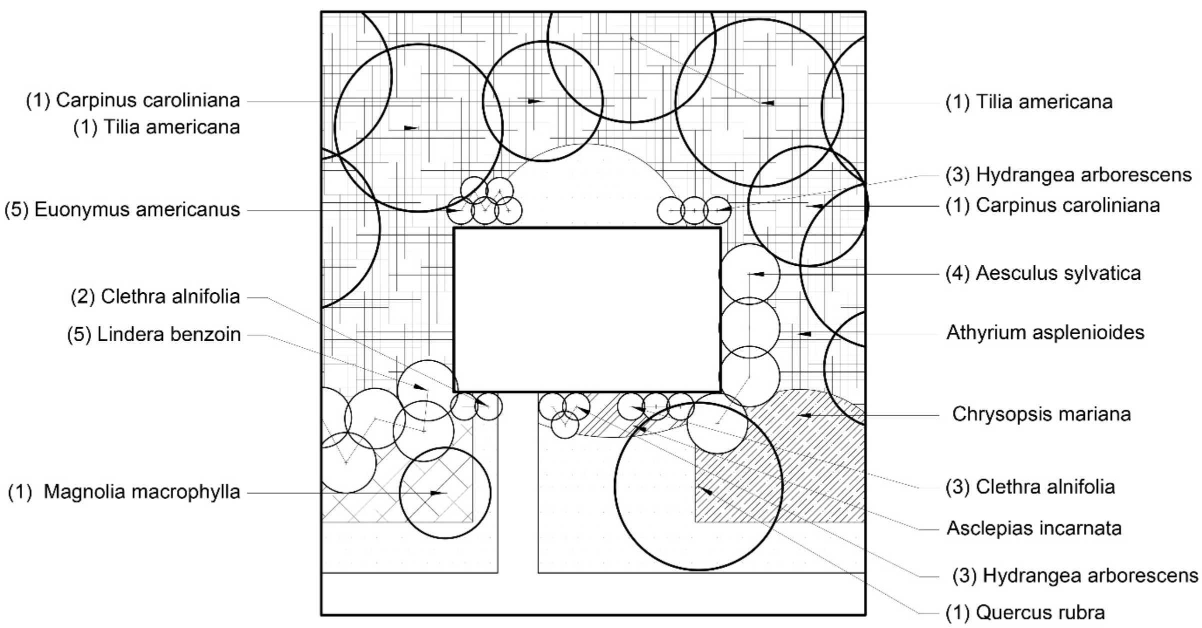


Figure 60: Planting plan for suburban yard in transition from mesic forest suitability to bottomland forest/freshwater wetland suitability

Canebrake and Piedmont Savanna Suitability

The planting plan featured below is designed for a property bisected by a stream. The left bank is the continuation of the bottomland forest/freshwater wetland from the previous property, and the right bank is a canebrake, followed by piedmont savanna.

The right portion of the design incorporates sparsely placed trees that create a 30-75% canopy cover, a dense ground layer of assorted forbs and grasses, with a mowed firebreak around the house, foundation shrubs, and a dense thicket of cane along the riverbank. Plants were selected from the Bottomland Forest/Freshwater Wetland Archetype plant list, the Canebrake Archetype plant list, and the Piedmont Savanna Archetype plant list.

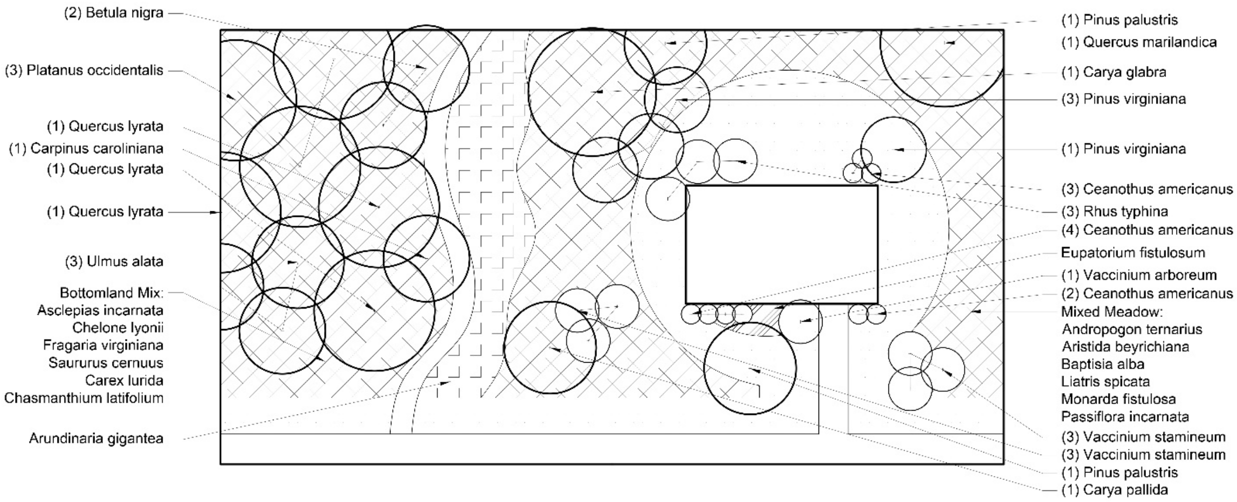


Figure 61: Planting plan for suburban yard with suitability for bottomland forest/freshwater wetland, canebrake, and piedmont savanna

CHAPTER 7

CONCLUSION

The destruction of earth's ecosystems, and subsequently their ecological services, is a complex and wicked problem. One answer, among the many necessary to address this global issue, is targeting the ecologically barren suburbs and repurposing them into a landscape of simplified ecosystems, easily established and maintained by private landowners, and providing habitat for priority species as threatened by persistent habitat destruction and fragmentation. The intent of this research was to reveal how private landowners might provide improved habitat for native wildlife through plant selection and design, and what the challenges and opportunities for success are.

This thesis used research and analysis of nine reference ecosystems to distill six habitat archetypes suitable for implementation by private landowners across Athens-Clarke County. Each archetype outlined a suitable plant list for establishing the first trophic layer of the given habitat, with expectation of colonization by desired animal species, and increased ecological complexity as the ecosystem self-organized under thoughtful management. Suitability parameters where then generated for each archetype based off topographic, hydrologic, soil, and land-use requirements, in addition to ecological prioritization. A GIS suitability analysis was run using this information to find suitable locations for each archetype. Finally, this thesis generates a set of form based design guidelines for implementing the landscape archetypes across the county. The design addresses three different contexts, each with a different density and scale: urban, suburban, and rural. It outlines issues that pertain to each individual context, gives suggested solutions, and offers example design forms from which landowners can extrapolate personalized site-specific designs.

Findings suggest these methods would produce habitat targeted at 39 animal species on the Georgia DNR's *Wildlife Action Plan,* as well as numerous species that were not directly targeted. Roughly 74,000 acres of previously underutilized landscape would be converted to some form of ten different Georgia Piedmont terrestrial habitats. In the urban context, while minimal restoration of ecological function is expected, a low intensity renovation of streetscape plantings can potentially increase citizen awareness about the degradation of our local ecosystems. In the suburban context, roughly 60% of total property is projected for conversion into priority habitat, while an additional 25% would be converted to pollinator meadow; ecologically sterile and costly lawn would see an 88% reduction in total landcover. The rural context would see a projected reduction in 80% of lawns and the conversion of 89% of land to priority habitat.

While this research demonstrates a strong potential for habitat creation on private property in the suburban landscape, there remains the question of how successful it can be when actualized in the real world. This issue provides several opportunities for future research monitoring and evaluating several conditions going forward. These include:

- The state of a given site biota before the framework is implemented, and at successive intervals in the future
- The current and continued rate of sightings of the Georgia Wildlife Action Plan's priority animal species in Athens-Clarke County as a whole
- The number of implementations of the framework by private owners
- The demographics of private owners adopting the framework

One particularly pertinent subject for continued research is the possible effects of climate change on this and similar projects, and how such a projects might potentially mitigate the effects of climate change on biodiversity. With the global temperatures increasing, there is a threat of untold damage to the biodiversity the worlds ecosystems. There is a possibility for specifically targeting habitat fragments to help migrate ecosystems to new latitudes where they can continue to persist. Because suburban landscapes have already been so heavily disturbed, they may provide an ideal experimental landscape for such endeavors.

Additionally, research uncovered several issues important to this thesis, but outside of its scope. While researching plants for the habitat framework it became apparent that the dearth of important natives in residential design does fall solely on the shoulders of private landowners. In fact, it is clear that the options of plant species are largely relegated to exotics and a handful of native species because of limited selection offered by commercial nurseries. If there is any hope of breaking the trend of overuse of ecologically useless exotic plant, it must be addressed at the level of the plant producers. Further research should be done on commercial propagation and sale of native species, and efforts should be taken by growers to increase the availability of native species. Events like the native plant sales put on by organizations like the State Botanical Gardens and Trees Atlanta are essential to these efforts and should be expanded.

Another important area for continued research is effective suburban landscape management for maximized wildlife habitat. While this thesis focused on the targeted implementation of a planting framework, the success of such a plan is heavily dependent on a maintenance regime which allows for the site to self-organize into a more complex and diverse ecosystem through native species colonization. Further research should be conducted exploring practical management practices for private citizens that encourage ecological complexity and ecosystem self-organization. Furthermore, because burn regimes are so essential to many of the habitat archetypes listed in this thesis, as well as numerous other ecosystems, research should be conducted into the public perception of periodic burning in the suburban context, its potential as a limiting factor in ecological restoration, and the potential changes in said perception after continued implementation of local restoration efforts.

It has also become clear that the efforts laid out in this thesis become moot without significant community support. It is essential to have landowners interested in retrofitting their property and the support of organizations with expertise in the field to help implement the plans. Several organizations in Athens-Clarke County have already showed considerable interest in local habitat restoration and should be incorporated as key stakeholders for any plans moving forward. These organizations include:

- The University of Georgia
- The Mimsie Lanier Center for Native Plant Studies
- The Sandy Creek Nature Center
- Stroud Elementary School

The need for stake holder involvement also creates questions about the best means for disseminating information and garnering interest. While my personal opinion is that there should be a physical representation of the information in the form of a printer pamphlet or small booklet, the fine grain of information of the suitability map calls for additional and different treatment, be it mobile app or webpage, that allows an individual to zoom into a location on the

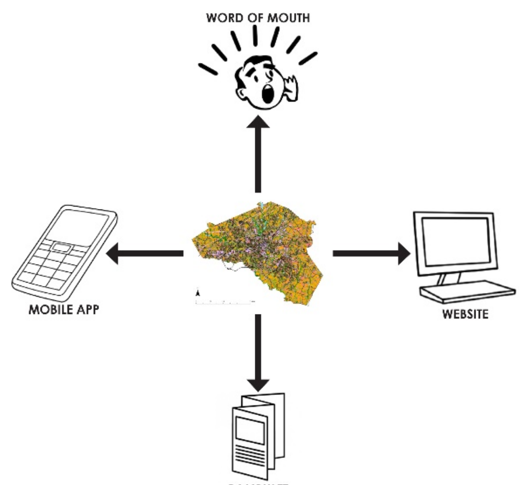


Figure 62: Illustration of methods of disseminating information

map. While this is a necessary part of the implementation of this, or any similar project, it may also be utilized as a study to see what methods are most effective in communicating information about and garnering support for native species biodiversity and restoration.

This thesis has shown that there is a great potential for habitat creation in Athens-Clarke County, and has laid out strategies for its implementation. Harnessing the untapped resource of the underutilized suburban landscape can increase biodiversity, ecological health, and as a result the ecological services the community often unknowingly enjoys. With the efforts of some key stakeholders, and the support and energy of the local community, Athens-Clarke County has the potential to set an example of ecological responsibility for other like-minded communities to follow.

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