URBAN WILDLIFE MANAGEMENT
IN ATHENS-CLARKE COUNTY, GEORGIA

Prepared for:

Athens-Clarke County Leisure Services

Prepared by:

Carol Flaute
Nate Hunt
Leif Stephens

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INTRODUCTION

Urban wildlife management is a principle that uses scientific knowledge and technical skills for conservation, control, and preservation of wildlife that occurs in urban areas. If humans can effectively manage urban wildlife, then human interest and wildlife needs can both be accommodated.

In order to sustain urban wildlife populations we must provide habitat that compensates for habitat degradation resulting from development and urban sprawl. As human populations continue to grow, communities must increasingly balance the preservation of wildlife habitat with urban development. The expansion of human land use into the natural environment often results in habitat degradation, habitat fragmentation, and an overall reduction in the quantity of habitat available for use by wildlife. These changes combine to reduce the biological carrying capacity, which is the level of wildlife that a given area can sustain. This often leads to an increase in human/wildlife conflicts and ultimately to the endangerment of a stable wildlife population.

To help wildlife adapt to environmental change, measures must be taken to provide the essentials for wildlife populations: food, cover, water, and habitat. These essential components can be incorporated into landscape designs, greenways, and parks. Including public education in an urban wildlife management plan will help encourage environmentally-sensitive land use among private property owners. An important part of the education process is to define the goals for a given area. For example, if a community or resident wants to encourage songbirds or neotropical migrants, then fruit bearing shrubs or plants need to be established (blackberries, beautyberry, pokeberry, etc.). Public education is a must. As the public realizes that wildlife and humans can coexist peacefully, urban wildlife habitat can be managed more effectively and with greater cooperation and understanding from the public. Habitat management tools for specific wildlife goals can be found in the reference notebook that accompanies this report.

Constant development and road construction lead to decreased wildlife habitat and increased habitat fragmentation. Urbanization often leaves animals with small, isolated patches of habitat that are separated by buildings, roads, neighborhoods, and farms. These infrastructure and habitat changes often create impassable barriers to wildlife migration, and the fragmentation of wildlife habitats can make it difficult for a wildlife population to sustain itself in isolated areas. When animals attempt to move between habitat patches, their interactions with development can be fatal, especially when crossing roads. Effective urban wildlife management can minimize these problems of habitat fragmentation.

Mike Wharton and the Athens-Clarke County Leisure Services Department are concerned about how to improve the management of the county’s urban wildlife and forests. For this project we investigated three urban wildlife management topics provided by Mike Wharton. These three topics relate to establishing wildlife corridors to permit safer animal passage within and across the county. The following three chapters will serve as a
resource for future urban wildlife management, sustainable development, and greenspace planning in Athens Clarke-County, Georgia:

**Chapter One**
An overview of wildlife road crossings including information on the importance of road crossings, various designs and features employed to accommodate certain wildlife species, and determining the proper location for road crossings in order to achieve maximum effectiveness.

**Chapter Two**
A wildlife management plan developed for a utility right-of-way located in Sandy Creek Park. This management plan provides reference material and plans to enhance urban wildlife utilization.

**Chapter Three**
GIS habitat distribution maps for the vertebrate species found in Athens-Clarke County. This chapter and accompanying materials are intended as background information for urban wildlife management tools such as those presented in the previous chapters.
CHAPTER 1:
AN OVERVIEW OF WILDLIFE ROAD CROSSINGS
Table of Contents

I. Introduction ........................................................................................................................................... 1

II. The Impact of Roads on the Environment ............................................................................................ 2

III. Why Are Wildlife Road Crossings Important? .................................................................................... 4
    a. Ecological Advantages ...................................................................................................................... 4
    b. Wildlife Road Crossings Benefit Humans ........................................................................................ 5
    c. Effectiveness of Wildlife Road Crossings ........................................................................................ 6

IV. Determining the Appropriate Type of Wildlife Road Crossing ............................................................ 10
    a. Road Crossing Designs .................................................................................................................... 11
    b. Road Crossing Features .................................................................................................................. 14

V. Determining the Appropriate Location for Wildlife Road Crossings ...................................................... 21

VI. Costs of Wildlife Road Crossings ........................................................................................................ 23

VII. Conclusion ......................................................................................................................................... 24
I. Introduction

Across the United States, metropolitan areas like Athens-Clarke County seek to balance between growth and habitat preservation. Increased development and population growth in concentrated areas have a range of detrimental effects on the natural environment and its wildlife. These negative effects include, but are not limited to, water and air pollution, degradation and destruction of habitat, fragmentation of contiguous wildlife areas, and an increase of negative interactions between humans and wildlife. In an urban setting, development that fragments pre-existing larger tracts of land can result in detrimental effects on local wildlife populations. A major source of habitat fragmentation is the development of roads. Roads can disrupt a habitat’s ecological balance while increasing the risk of potential harmful wildlife/vehicle collisions. This paper addresses the impact roads have on habitats and wildlife whose habitat has been divided. More specifically, this paper reviews the most recent research on wildlife road crossing structures being implemented to provide wildlife a safe way of traversing roads. This paper does not address road crossings directed towards the movement of aquatic animals. Information on stream crossing and culvert designs for aquatic species can be obtained from the Etowah Habitat Conservation Plan’s website at http://www.etowahhcp.org/.

Addressing conflicts arising from the interaction of humans and wildlife on roads is a relatively new area of research for conservationists, biologists, and road developers. Due to the fact that this is a “new” conservation issue, research conducted on the actual effectiveness of wildlife road crossings is limited. Consequently, practical application of road crossing mechanisms is not widespread throughout the United States. However,
both the research of and actual use of road crossings has increased in the past two decades. Joint efforts between biologists and engineers have resulted in an increase in the number of wildlife crossing structures in the United States. Considering the wide range of species in the United States as well as in smaller areas such as Athens-Clarke County, designing road crossings to accommodate varying species within a particular area is a challenging task. In an effort to increase awareness of wildlife road crossings as well as provide a general overview of wildlife road crossings three main questions will be addressed in this paper: 1) Why are wildlife road crossings important? 2) How do you determine the type of road crossing design? and 3) Where should road crossings be implemented? The ultimate purpose of this paper is to provide a basic foundation of information on road crossings which can be used in exploring options to mitigate the effects roads have on wildlife in Athens-Clarke County.

II. The Impact of Roads on the Environment

In 2002, there were an estimated 3.9 million miles of public roads across the United States used by an estimated 200 million vehicles (U.S. Department of Transportation (DOT), 2005). These numbers will continue to increase as population grows and more people buy cars in regions like northern Georgia. While roads cover an estimated one percent of America’s land, approximately 15 to 20 percent of the landscape is directly affected ecologically by roads and vehicles (Portland State University (PSU), 2003). As roads are built, more natural habitats are divided, resulting in smaller fragmented areas of habitat where larger contiguous plots of land once existed. Habitat fragmentation is directly correlated with habitat degradation (PSU, 2003). First, the
separation of larger tracts of land into smaller habitat “islands” results in a significantly higher edge to interior ratio resulting in a smaller buffer zone between wildlife and human development (Hartmann, 2003). This edge effect decreases the number of native species a particular fragmented patch of habitat can support (PSU, 2003). Secondly, as roads divide habitat, wildlife avoid habitat areas close to roads due to the noise and human activity associated with the noise. This road avoidance by wildlife further decreases the size of habitat suitable for the wildlife. Research has shown that both large and small mammals tend to have lower population densities in areas within 100 to 200 meters of roads (Forman, 1998). Areas of habitat affected by roads can extend for hundreds of meters depending on the species and the frequency and noise from the road. Moreover, according to research, these areas generally exhibit “lower breeding densities and reduced species richness” (Forman, 1998). Third, roads are channels by which other human interferences such as air pollution, light pollution, and invasion of exotic species degrade surrounding habitat. Fourth, roads increase human exploitation of habitat and wildlife—highways provide access for hunting and poaching which may reduce populations of certain wildlife and exacerbate the problem of wildlife avoidance of roads (Harmon, 2002).

Finally, habitat fragmentation divides wildlife populations into smaller, isolated groups. Smaller animal populations “are less stable and, over time, face extinction from predators or natural causes” (U.S. DOT, 2005). In addition to having a higher extinction rate than large populations, small populations are susceptible to inbreeding and genetic defects (Harmon, 1998). Forest carnivores are particularly vulnerable to habitat fragmentation due to their small populations, low reproductions rates, and large home
ranges (U.S. DOT, 2005). As areas of natural habitat become isolated, movement between patches of habitat becomes increasingly important for the sustainability of wildlife populations. Roads act as barriers to animal movement between isolated patches of habitat. A wide road may be an insurmountable obstacle for small mammals with limited mobility such as mice or wetland species, including amphibians and turtles, which have shown a reduced tendency to cross roads (Forman, 1998). Likewise, road noise may prevent larger mammals from crossing roads to reach other areas of similar habitat. Unfortunately, when animals do cross roads they face the risk of being hit by an automobile. This is increased on roads which have a high volume of traffic.

III. Why Are Wildlife Road Crossings Important?

a. Ecological Advantages

Wildlife road crossings can help mitigate the negative impact of fragmentation of natural habitats and reduce the barriers roads present to wildlife movement between isolated habitats. The health of a species population within a region is directly related to the total amount of available habitat (University of California, Santa Barbara (UCSB), 2005). The viability of populations is maintained if animals are able to move between habitat islands. Although these isolated habitats are too small to sustain a healthy population, collectively a group of connected isolated habitats can provide a population with a sufficient area of land to meet the needs of a particular species. Wildlife road crossings allow for and facilitate the movement of wildlife between isolated, smaller patches of habitat. The movement of wildlife between habitat islands assists in maintaining the genetic diversity within wildlife populations. Increasing the mobility of
animals like white-tailed deer during breeding season plays a crucial role in maintaining genetic interchange within a species (Donaldson, 2005). Also, wildlife crossings allow for wildlife to search for more adequate food sources which is essential for the survival of regional populations (PSU, 2003). Moreover, in urban areas like Athens-Clarke County an effective network of road crossings can allow for local populations to safely migrate to larger habitat areas that are outside of the urban area (PSU, 2003).

b. Wildlife Road Crossings Benefit Humans

According to the Humane Society of the United States and the Urban Wildlife Research Center, one million vertebrates are hit and killed by automobiles each day in the United States (PSU, 2003). This number only includes reported road kill and not animals that die after leaving the road subsequent to being hit by an automobile. Providing ways in which animals can travel over or under roads can reduce the fatal interactions with automobiles. Wildlife road crossings provide an intangible benefit to humans by ensuring the existence of local populations which may be affected by roads. Yet, increasing the safety of humans may be a more convincing argument for implementation of wildlife road crossings. Wildlife on roads present significant safety issues. According to the National Highway Traffic Safety Administration (NHTSA), a reported 292,000 animal-related collisions occurred in 2001; 19,000 of the collisions resulted in human injury and 165 resulted in a human death (PSU, 2003). According to the U.S. Department of Transportation, approximately 1.5 million automobile collisions with deer occur annually resulting in over 29,000 human injuries and 200 human deaths (U.S. DOT, 2005). Additionally, vehicle collisions with animals can be expensive—approximately $1.1 billion in vehicle damage is caused each year by collisions with deer
Donaldson, 2005). A Virginia study of deer collisions in 2003 showed that the average property damage for a reported deer collision was $2,530 which in sum resulted in more than $42 million dollars for one year (Donaldson, 2005).

Numerous studies have shown the number of animal-related collisions continues to increase. The NHTSA Fatality Analysis Reporting System showed a 39% increase in fatal collision involving animals from 1992 to 2001 (Curtis, 2005). In addition to individuals bearing the cost of collisions, state transportation agencies are also being held accountable for road-wildlife interactions. In a 2001 court case, Jerry Booth v. Arizona, the State of Arizona was sued by a driver who hit an elk on a state highway. The jury awarded the driver $3.1 million in damages based on the reasoning that the Department of Transportation did not take preventive action along the highway in light of foreseeable risks posed by the growing elk and human populations and the existence of a foreseeable remedy including wildlife crossings and fencing (Donaldson, 2005).

Establishing wildlife road crossings may also reduce the costs of carcass disposal resulting from vehicle-wildlife collisions (Donaldson, 2005). For example, pickup and disposal costs for deer carcasses in Fairfax County, Virginia are $65 a trip. Considering an estimated 34,000 vehicle-deer collisions occur during each year in Virginia, the disposal costs for the Virginia Department of Transportation could be millions of dollars a year (Donaldson, 2005).

c. Effectiveness of Wildlife Road Crossings

The number of research and exploratory road crossing projects has grown in recent years. Yet, the general consensus among biologists is that the level of effectiveness of certain road crossings is uncertain (Clevenger and Waltho, 1999).
Canadian biologist Tony Clevenger, who studies the efficacy of one of the most well-known road crossing projects in Banff National Park, Alberta, Canada, comments, “this field of applied ecology still is very much in its infancy” (Hartmann, 2003). In light of all the variables involved in determining the type of wildlife road crossing—the diverse range of species involved and the habitat which the road divides—it is unclear what types of structures are the most effective. Clevenger states that “virtually nothing is known regarding the effectiveness between the overpasses and underpasses, or even between the different types of underpasses being tested” (Hartmann, 2003). A main source of the uncertainty is that no study has been able to show a comparison between the frequency of animal crossings prior to and after implementing a wildlife road crossing structure. In other words, researchers are unsure if wildlife road crossings facilitate and encourage more movement of wildlife between isolated habitats. (Hartman, 2002).

Current comprehensive and long-term research projects focusing on this comparative component are anticipated to provide information on the effectiveness of wildlife road crossings. Information on population density and the behavior of species without the presence of roads is useful in determining whether road crossings should be incorporated into certain road projects. Data collected after a road crossing has been built further assists in evaluating the effectiveness of the road crossing. An important factor in analyzing road crossing effectiveness is determining how long it takes for animals to adapt to the road crossing (Hartmann, 2003). Studies have shown that ungulates and other mammals remember the location of road crossing structures and adjust their movements accordingly (Hartmann, 2003). Yet, adapting to road crossings is a gradual process. Thus, the results of a study on wildlife crossing rates conducted in the first year
of implementing a road crossing may be notably different than the results five years later when animals have adapted to the crossing.

Despite uncertainties about the overall effectiveness of wildlife road crossings in facilitating wildlife movement between habitats there is a compelling argument for implementing road crossing structures: reducing road kill. By reducing the number of animals dying on roads humans are mitigating the negative effects roads have on the wildlife. There is a substantial amount of research showing that wildlife road crossings reduce road kill. Additionally, the aforementioned data on vehicle-wildlife collisions reveal that reducing road kill can significantly decrease monetary costs incurred by humans. Below are several case studies illustrating the effectiveness of wildlife road crossings in reducing the numbers of animals killed on roads:

**Banff Nation Park, Alberta, Canada:**

After experiencing years of wildlife fatalities on park roads traveled by over 14,000 vehicles a day, Banff National Park increased habitat connectivity by building 22 underpasses and two overpasses on the main four-lane highway through the park. The underpasses ranged from large natural habitat corridors under bridges to smaller box culverts (Donaldson, 2005). Additionally, fencing 2.4 meters high was constructed on both sides of the crossing structures. Since being completed in 1997, there has been an 80% reduction of accidents involving wildlife in the park and a 97% decrease in the number of elk killed while crossing the highway (Donaldson, 2005, LSA Associates, 2003). Biologists studying the effectiveness of Banff National Park’s road crossing project attribute the decrease to the fact that animals are adapting their natural travel
patterns because of the road crossings and fencing (Clevenger and Waltho, 1999, Hartmann, 2003).

**Florida’s I-75 (“Alligator Alley”)**

Florida, concerned with the small population sizes and low reproductive rates of the endangered Florida panther and black bear, implemented road crossing along I-75 where a high density of these two species are located. Between 1978 and 1994, 20 panther deaths and 6 injuries were documented resulting from vehicle-panther collisions (Hartmann, 2003). In the mid-1990’s, Florida installed 24 underpasses along a 64 kilometer fenced portion of the highway (Hartmann, 2003). Continuous monitoring and analysis of the crossing structures has revealed that they have been successful in reducing road fatalities of panthers and black bears—no panther has been killed since the inception of the project. Monitoring has also shown that the crossings have been used by numerous other non-target species such as bobcat, deer, and wild turkey (Hartmann, 2003).

**Salamander Tunnels in Amherst, Massachusetts**

Each spring, on a particular stretch of road in Amherst, spotted salamanders migrate across the road to wetland ponds at night to breed (PSU, 2003). An inordinate number of salamanders were killed by cars. In order to facilitate a safe migration, two small culverts (two feet high by two feet wide) were placed 200 feet apart near the area of annual migration. The culvert’s ceilings (road surface) were slotted to allow light and rain to permeate the tunnel in order to maintain the natural conditions preferred by salamanders (PSU, 2003). Additionally, a short fence was added along side the road in order to guide the salamanders towards the culverts. Salamanders were marked for purposes of monitoring the effectiveness of the culverts and results showed more than
75% of the salamanders that reached the culverts successfully used them to traverse the road. (Hartmann, 2003).

The above case studies are only three of numerous success stories where road crossing structures have greatly reduced the amount of road fatalities. They illustrate the varying complexity and scope of wildlife road crossing projects. A large-scale road crossing project may involve a comprehensive long-term plan involving biologists, engineers, and land managers focusing on vast areas of land and a wide range of species. Determining the success of the Banff National Park road crossing project will depend on years of research required to obtain data on crossing rates, movement patterns, and population densities. Researching and monitoring road crossings in addition to building the crossings can require a large amount of money and resources. Or, alternatively, a smaller more localized project with significantly smaller costs can be effective for facilitating safe road crossings by species like the salamanders in Amherst, Massachusetts. The next sections address the various factors that must be considered in determining the appropriate design of a road crossing and where the road crossings should be implemented.

**IV. Determining the Appropriate Type of Wildlife Road Crossing**

There are a number of factors to consider in the construction of a wildlife road crossing. First and foremost, one must determine the particular species of wildlife the road crossing is intended to benefit. Each individual species has different needs which makes designing a structure that accommodates all species within an area impractical (Hartmann, 2003). In order to provide a road crossing for more than one species a
generalized design should be constructed to benefit as many species as possible. However, in certain situations like that of the spotted salamander, a specific design will allow the most effective means of crossing a road for a project’s target species. In the first stages of designing a road crossing the involvement of biologists is pertinent in determining the species within a particular area that will potentially use the road crossing (See Chapter 3 for wildlife habitat distributions in Athens-Clarke County). It is also important to keep in mind that habitat fragmentation affects larger mammals more than smaller species because of their need for “significant home ranges and slow population rates” (UCSB, 2005). Additionally, in areas where the road density is high, facilitating overall habitat connectivity may be of a more concern than designing a structure for a particular species (Jackson and Griffin, 2000). Below are the primary designs of road crossing structures used today as well as key elements to consider when determining what road crossing design to implement.

a. Road Crossing Designs

Pipe Culverts

Pipe culverts are usually made of smooth steel, corrugated metal, or concrete material and are used primarily to convey water under roads (UCSB, 2005). Pipe culverts can serve the dual purpose of conveying water while also allowing wildlife to use culverts especially when the pipes are dry. Moreover, the pipe culverts can be modified relatively inexpensively to enhance their use by certain species. For example, providing natural substrate, such as dirt and rocks, on the bottom of the pipe culverts will increase usage by wildlife. Also, providing ledges within the culvert will provide dry passage through the culvert during normal high water periods (Jackson and Griffin, 2000)
(See Appendix A for examples of pipe culverts and Appendix B for examples of ledges in culverts). Pipe culverts typically range from one to six feet in diameter; the larger the pipe culvert the more likely it will be used by larger mammals such as deer and bobcat (UCSB, 2005). Pipe culverts are the least expensive wildlife road crossing structure and retrofitting already existing pipe culverts by building ledges and adding natural substrate is an inexpensive way of facilitating wildlife usage. Because pipe culverts are inexpensive compared to other mitigation measures biologists are exploring ways of making culverts more effective as road crossings. Studies have shown pipe culverts should be placed as frequently as possible and should vary in size in order to be useful for a wide range of species within particular habitat (Hartmann, 2003).

**Box Culverts**

Box culverts transmit water only during periods of rain events and are dry most of the year. During dry periods these culverts can be used to cross roads by a range of wildlife. (UCSB, 2005) (See Appendix C for examples). Generally, box culverts are larger and more open then pipe culverts which may enhance species usage (Jackson and Griffin, 2000). Natural surfaces in box culverts, including sediment and vegetation, are preferable because some animals are deterred by man-made surfaces such as concrete (PSU, 2003). Generally, the larger the box culvert the more potential for animal usage; however, in order to accommodate smaller wildlife box culverts should include shelter such as rocks and dense vegetation.

**Bridge Underpasses**

Underpasses conducive to animal travel are located where roads span over rivers, streams, or other roads via a bridge (Jackson, 200) (See Appendix D for examples).
Large underpasses maintain the natural habitat which allows for relatively unconfined passageways for animals to travel underneath roads. Bridges are often built over a ravine or water source which naturally funnels animals through the underpass (PSU, 2003). If a bridge spans over water the underpass should be wide enough to allow for dry land on both sides of the water. Higher bridges with wider areas underneath are generally more successful than lower bridges and culverts (Jackson and Griffin, 2000). The higher the bridge the less artificial noise will be heard by wildlife passing at ground level and the more open the passageway will appear to animals. Although less expensive than overpasses described below, creating adequate wildlife underpasses can significantly add to the cost of building a bridge (UCSB, 2005). On Highway 46 in Sanford, Florida, the Wekiva River Bridge was extended 153 feet to allow unsubmerged land use by wildlife. The project cost approximately $433,000 more than it would have cost without the expansion to accommodate wildlife (PSU, 2003).

**Viaducts**

Viaducts are long elevated roadways which span over waterways and land (Jackson and Griffin, 2000) (See Figure 6.23 in Appendix D for an example). Similar to underpasses, the height and width of the viaduct is directly related to its success as a wildlife corridor. A high viaduct allows for the natural integrity of the land to remain intact. Essentially, viaducts are compatible with any type of species because the natural habitat below the viaduct is left untouched and seemingly wide open.

**Wildlife Overpasses**

Overpasses, also referred to as wildlife bridges, are large vegetative crossings over roads (See Appendix E for examples). Overpasses have been constructed in several
European countries but are less prevalent in the United States (Jackson and Griffin, 2000). The most effective overpasses range from 165 wide on each end narrowing to 25-115 feet in the center, to wildlife bridges that are as wide as 650 feet (UCSB, 2005). The soil on the overpasses ranges from 1.5 to 7 feet deep—suitable for growth of herbaceous vegetation, shrubs, and small trees. Some wildlife overpasses even contain small ponds (UCSB, 2005). Research has shown that overpasses can accommodate more species than most underpasses and culverts. The main advantages to overpasses are their vast width, quietness, and their ability to maintain the natural, ambient conditions of rainfall, temperature, and light (Jackson and Griffin, 2000). Not only do overpasses serve as a passageway across roads but also as intermediate habitats for smaller species like reptiles, amphibians, and small mammals (Jackson and Griffin, 2000). Without this intermediate habitat, smaller species would have no potential way of crossing large roads such as highways. The primary drawback to wildlife overpasses is their expense which can exceed $2 million dollars for an overpass spanning a four lane divided highway (UCSB, 2005).

b. Road Crossing Features

A habitat divided by a road can host a diverse array of species each requiring different features in a wildlife road crossing. Wildlife road crossing designs include many different characteristics which can be tailored to meet the preferences of certain species. However, as previously mentioned, it is virtually impossible to create a structure to accommodate all species within a habitat area (Hartmann, 2003). Clevenger states, “species do not function in isolation but are components of ecological systems that inherently fall into the category of organized complexity…any single-species mitigation
structure is likely to have cascading effects, some positive, some negative, on non-target species” (Clevenger and Waltho, 2000). Thus, in order to maximize the effectiveness of a road crossing it is important to analyze the effects a particular structure will have on wildlife in the area and then determine what features will accommodate the highest number of species. Below are the primary features considered when determining an appropriate road crossing structure.

**Size of Road Crossing Structure**

The appropriate size of a crossing structure varies with the species; however, in general, the larger the culvert, underpass, or wildlife bridge the more species it will accommodate. The size of a pipe or box culvert should relate to the width of the road. As the number of lanes increases, the culvert size should increase which allows for animals to see the opposite end of the culvert. “Most researchers have concluded that animals using an underpass [or culvert] should have an unobstructed view of habitat on the far side” which will decrease “potential threatening feelings” (Hartmann, 2003). Generally, large culverts are between one and 1.5 meters in diameter which facilitate the use of the culvert by medium-sized mammals such as coyotes, whereas smaller culverts between .5 to one meters in diameter accommodate smaller animals such as squirrels, raccoons, and foxes (Clevenger and Waltho, 2000). Again, the larger a culvert, the more effective it will be as a road crossing (Jackson and Griffin, 2000). Larger culverts between eight and twelve feet in height accommodate larger species such as deer while still being suitable for smaller animals (Donaldson, 2005). Studies have shown for optimal usage of larger animals such as deer, coyote, and bobcats a culvert should be at least six feet high (UCSB, 2005). A large, open culvert may preclude some smaller
mammals from crossing through because predation risks are higher (Clevenger and Waltho, 2000). However, steps can be taken to provide adequate safety in large culverts for smaller mammals such as providing shelter in form of stumps, rocks, and shrubs.

**Light**

Openness is a significant factor in determining the relative effectiveness of a culvert. Larger, open culverts allow more ambient light making a structure more attractive to an animal. Allowing sufficient ambient light in a structure lessens the need for artificial light which studies have shown to be a deterrent to animal use (Jackson and Griffin, 2000). The level of lighting necessary to facilitate use of the crossing depends on the animal. Yet, the more ambient light within a culvert the more the culvert replicates the natural environment and thus, the more comfortable wildlife will feel. Moreover, for some species such as frogs and salamanders light within a culvert is essential (Jackson, 1996). Ambient light in box and pipe culverts can be increased through the use of grated ceilings or slots in the top of the culvert that allow natural light to enter (Hartmann, 2003). A disadvantage of including top openings is that the openings increase the artificial noise of traffic within a culvert and thus may deter some animals.

**Noise**

Noise within and surrounding a road crossing structure can be a major deterrent of animal usage. Animals are sensitive to noise associated with the use of roads by humans and automobiles (UCSB, 2005). According to a study conducted in Banff National Park, traffic noise was one of the primary sources of deterrence affecting wildlife use of culverts within the park (Clevenger and Waltho, 2000). An effective way of reducing artificial noise while also providing a more natural setting within a culvert is placing
dense vegetation or dirt berms (raised banks) around the structure’s openings. Additionally, applying natural materials such dirt to the surface of a box or pipe culvert will reduce noise transmission (UCSB, 2005). Providing a roughly textured interior surface in the culvert or underpass reduces artificial noise (Jacobson, 2002). Also, builders should avoid using products that leave a petroleum odor which deters deer (Jacobson, 2002). Biologists have recommended, as a general rule, that noise in an underpass or culvert should not exceed 60 decibels during the expected time of use (Hartmann, 2003).

**Moisture and Temperature**

Some studies have shown moisture and temperature of culverts to be a factor in certain animals’ usage. Neither is a major factor with larger crossing structures such as bridge underpasses, viaducts, and wildlife bridges because they are large enough to maintain natural conditions such as airflow. Moisture in a culvert may be a determining factor in whether some amphibian species use the road crossing (Jackson and Griffin, 2000). Natural wet conditions can be maintained by grated or slotted culvert ceilings. While moisture may attract certain amphibious species, studies have shown that proper drainage of culverts is important because animals are less likely to use structures containing standing water (Jackson and Griffin, 2000). In general, “wildlife behavior often fulfills a need to conserve energy…and if given a choice many animals will travel along a water course instead of through water” (Wildlife Crossing Kit, 2005). Culverts tend to speed water flow. Thus, where there is continuous running or standing water within a road crossing structure the availability of elevated ledges within the culvert will allow for a dry animal crossing.
Wildlife will be more likely use a culvert if its temperature is consistent with the outside temperature (Jackson and Griffin, 2000). Maintaining a culvert’s temperature comparable to the external temperature can be achieved also by the utilization of slotted openings in the ceiling of the culvert.

**Substrate: Providing A Natural Surface**

Although not conclusive, studies have shown that providing a natural substrate in a crossing structure maintains a natural habitat continuity which is more appealing to animals (Jackson and Griffin, 2000). An effective crossing will have some kind of natural surface spanning the length of the crossing and should have materials which match those characteristics of the external habitat surrounding the crossing such as dirt, rocks, logs, and shrubs. Many small animals that use camouflage to avoid detection by predators will require sufficient cover within the crossing structure. Providing cover by placing substrate in a culvert will lessen a smaller animal's vulnerability leading to a higher probability that the animal will feel secure using the crossing (Wildlife Crossing Kit, 2005). Also, placing attractive food for certain species may assist in facilitating habitual use. For example, using food such as apples or grain within a culvert for a few seasons may increase the use of the road crossing by deer (Jacobson, 2002).

The difficulty of maintaining natural substrates within a culvert has been related to the size of the culvert—small culverts tend to lack adequate moisture and light to support vegetation (PSU, 2003). Adapting existing drainage culverts to resemble streambeds may increase the likelihood that small aquatic animals such as salamanders, frogs and aquatic invertebrates will use the culvert (Hartmann, 2003). The bottom of a
culvert should be made deep enough so natural streambed materials will not wash away during high water periods (US DOT, 2005).

Fencing

Fencing on both sides of a crossing structure’s openings is now viewed as a necessary feature for most road crossings to be effective (PSU, 2003) (See Appendix F for examples). Fencing which separates the road from natural habitat serves two purposes. First, fencing guides and directs animals towards the road crossing structure. Secondly, it prevents animals from circumventing the structure and keeps animals off the road. Research shows that deer often try to avoid underpasses and will only use them if all other access to the road is barred (Jackson and Griffin, 2000). A fence that is three to six feet tall is generally sufficient to prevent medium sized animals from jumping or climbing over the fence (UCSB, 2005). In preventing deer from jumping over a fence a height of eight to ten feet is adequate (Donaldson, 2005). Fence materials such as chain link or wire mesh are strong enough to prevent animals from penetrating the road (UCSB, 2005). Research suggests that the fence should be buried “to a depth appropriate for the type of species in the area” in order to keep animals such as coyotes from digging under the fence (UCSB, 2005). Another consideration in ensuring adequate fencing is to make sure that there are no trees or tall brushes that could be used by the animal to climb over the fence (UCSB, 2005). There is no definitive length a fence should extend from a road crossing structure. Studies suggest that the longer a fence extends from a structure the more effective it will be as a funneling mechanism towards the structure. However, in general, fencing should extend beyond the edge of a suitable habitat or “beyond the natural break in an animal’s ability to traverse” the road (UCSB, 2005). For example, a
fence could extend to an unsuitable habitat such as residential neighborhood or a natural barrier such as a body of water.

An alternative to fencing is building a shorter concrete or metal wall around a culvert opening (See Appendix F-2 for examples). A wire chain link fence can be penetrated by a small animal whereas a 3 ½ foot concrete wall can prevent frogs, toads, snakes, and other amphibians from crossing the road (Hartmann, 2003). A concrete wall can also direct animals towards the culvert. These retaining walls also require less maintenance then large chain link fences (Jackson and Griffin, 2000).

Despite their effectiveness in facilitating road crossing use, fences have some drawbacks. First, fences contribute to the fragmentation of habitats by precluding wildlife migration across roads. It is uncertain whether the combination of road crossings and fencing counteract the effects fences have on isolating habitat and wildlife populations. Unfortunately, if an animal does permeate a fence it may be trapped between the fences on both sides of the road (Jackson and Griffin, 2000). Precautions must be taken to allow for escape such as building one-way gates along the fencing. Also, maintaining fences is a cost additional to building the road crossing structure. The price of chain link fencing ranges between $8 and $12 per linear foot (PSU, 2003). Finally, research shows that fencing has been used by predators such as coyotes and wolves as a “death trap” by herding ungulates into fencing which provides no escape (Hartmann, 2003).
V. Determining the Appropriate Location for Wildlife Road Crossings

Proper placement of wildlife road crossings has been described as the most important factor in their success (Hartmann, 2003, Jackson and Griffin, 2000). In determining the appropriate location biologists and engineers should refer to historical road kill data and known wildlife road crossing points (Hartmann, 2003). Research has shown that placing a structure close to traditional migration routes or animal trails will increase the effectiveness of the crossing. For example, research on deer crossings indicate that placing a structure close to game paths provides a natural funneling mechanism which leads deer to the crossing (Hartmann, 2003). Similarly, locating a road crossing in proximity to topography which will naturally lead animals to the crossing will enhance its effectiveness. Hilly topography surrounding a crossing has been observed to serve as a natural guide for deer towards underpasses (Donaldson, 2005). Also, “linear guideways such as ridgelines and drainages have been found to correlate with road crossing hotspots” (Donaldson, 2005). Hence, designing culverts to serve the dual purpose of water drainage and a wildlife crossing can create natural drainages which may attract wildlife.

Regardless of a wildlife crossing’s success in attracting animals, if both habitats that are connected are not suitable for the species using the crossing then the purpose of the road crossing is undermined. Road crossings are intended to enlarge a species’ potential habitat range by connecting two separated areas of similar habitat. One way of determining where a road crossing will be most effective is identifying the most valuable habitat for wildlife and wildlife movement in the areas—analyzing size, resources available, and absence or presence of human interference in the habitats (Jackson and...
Griffin, 2000). Although targeting certain species is an essential component in determining the design and location of a crossing, biologists assert that the most practical approach is to focus on the actual habitat that is being connected. Determining the specific species that a crossing structure is intended to accommodate is important; however, directing attention to the goal of maintaining overall habitat connectivity may be the most cost effective way of protecting wildlife (Jackson and Griffin, 2000). In other words, the determination should be centered on what structure and what location will most effectively maintain the “natural continuity of the landscape” (Barnum, 2001).

A general design placed in a proper location will be used by a variety of wildlife. Wildlife, especially mammals, are very adaptable and may alter their movement patterns over time to cross roads through crossing structures (Donaldson, 2005). The risk of human disturbance should be minimized. Structures should be placed a considerable distance from hiking and bike paths (Jackson and Griffin, 2000). Also, structures should be located in areas where the approach (area surrounding a crossing’s opening) is as similar as possible to the habitat that is being connected. Vegetation around the opening of the wildlife crossing “plays significant role in overall effectiveness” (Hartmann, 2003). Areas where habitat extends up to the opening of the culvert will result in higher usage of the culvert by wildlife (Wildlife Crossing Kit, 2005). Regardless of the structure type, natural cover near the openings will provide both small and large wildlife a sense of security of their preferred environment (Hartmann, 2003). Integrating the structure with the surrounding habitat presents crossing as a natural rather than artificial passageway.
VI. Costs of Wildlife Road Crossings

Unfortunately, there is lack of information on the specific costs of road crossings or the designs themselves. The primary reason is that the costs of road crossing structures are embedded in the costs of the overall road project and structures are installed while the road is being constructed—most wildlife road crossing structures are not stand alone projects. The lack of information on costs was conveyed to me by Sandra Jacobson, a wildlife biologist with the USDA Forest Service in Arcata, California. Jacobson stated, “almost no information is available on the net costs of a wildlife crossing…. most wildlife crossings are built in locations that would require water conveyance structures (bridges or culverts) anyway” (Jacobson, 2005). According to Jacobson, the costs vary dramatically by “region of the country, topography, target species, how many lanes, if fencing is considered as part of the costs, size and type of the structure” (Jacobson, 2005, Camissa, 2005). Although costs are site specific, certain case studies do provide an idea of the costs of crossing structures (PSU, 2003). For example, in Hillsboro, Oregon, two culverts roughly 8 feet wide and 10 feet high, which included simulated stream bottoms comprised of soil and rock, cost a total of $152,000 (PSU, 2003). Box culverts built for deer in Virginia, with measurements of 10 feet wide, 12 feet high, and 192 feet long were close to $250,000 a piece (Donaldson, 2005).

Proponents of road crossing structures in areas like Athens-Clarke County should anticipate the general argument that these structures are too costly. However, roads are expensive, and funds spent for the construction of a culvert designed for drainage as well as wildlife usage can be relatively low compared to the overall road construction cost. Additionally, vehicle collisions with wildlife cause almost 5% of all automobile accidents
in the United States, causing over a billion dollars in damages to vehicles (UCSB, 2005). Currently, the Federal Highway Administration estimates the cost of a human fatality from vehicle/wildlife collisions at $1.5 million per person (USDOT, 2005). A basic cost-benefit analysis shows that the price of one road crossing can be offset by the reduction of vehicle/wildlife collisions and their associated costs.

VII. Conclusion

The need for wildlife road crossings will increase in Athens-Clarke County as more roads are built and natural habitats are isolated. Variables that must be considered in constructing a road crossing include the various species the crossing is intended to accommodate, the features of a crossing structure such as size, light, noise, and substrate used, the design of the crossing, and the location of the crossing. In general, research shows that the primary goals in implementing a road structure are determining a general design that accommodates the optimal number of species, and achieving natural connectivity between separate, suitable habitats. The information provided by this paper should serve as a means of support in advocating the implementation of wildlife road crossings in Athens-Clarke County.
References


APPENDICES

The attached appendices are page excerpts from a paper prepared by the University of California, Santa Barbara in 2005 entitled, “Designing Roads for Safe Wildlife Passage.”

Please see the preceding “References” page for more information.
CHAPTER 2: RIGHT-OF-WAY MANAGEMENT FOR WILDLIFE
Introduction
Sandy Creek Nature Center is a 225 acre preserve located in Athens-Clarke County. This preserve hosts a variety of animals and a diversity of plants. Wildlife habitat varies from hardwood wetlands to hardwood/pine uplands. The Nature Center also provides the public a sense of wildlife education through information and events held at the preserve (see Map 1).

This preserve joins the North Oconee Greenway and the Cook’s Greenway Trail. The North Oconee Greenway was developed by Oconee Rivers Greenway Commission to protect the resources of the Oconee River and its tributaries. It provides the public opportunities to experience nature through non-motorized use. This greenway is approximately three miles long and follows the North Oconee River south towards downtown Athens (see Map 2).
Purpose

Sandy Creek Nature Center contains a wide variety of habitats including an electrical transmission right-of-way (ROW). The ROW is maintained by Georgia Power and is located on the southern portion of the preserve (see Map 1 for details). In concern for urban wildlife, a management plan was developed to maximize wildlife usage within the ROW. The ROW is currently enrolled in a wildlife incentive program developed by Georgia Power.

Incentive Program Background

The need for expansion and development continues to rise with population growth. Electrical transmission lines are constructed constantly to fuel existing and future development. In the midst of development, wildlife habitat is declining. In an attempt to balance human interests and wildlife needs, several incentive programs have been developed to compensate for habitat degradation. Some of these programs include:
WINGS (Wildlife Incentives for Nongame and Game Species), WHIP (Wildlife Habitat Incentives Program), HFRP (Healthy Forests Reserve Program), WRP (Wetland Reserves Program), etc. For the purpose of this project we will focus on the WINGS program.

Photo 1. WINGS sign located on Sandy Creek ROW

Georgia Power and the Two Rivers Resource Conservation and Development Council have developed an incentive program for ROW management under electrical transmission lines for wildlife habitat. This is a three year program that offers cash grants and professional advice to land owners who are interested in participating. The allocation of funds is based on the management practices implemented by the land owner. These allocations include $100 an acre for annual and permanent plantings and $60 an acre for fallow disking and chemical brush control. The first year in the program allows a maximum payment of $100 per acre. In the second year, the payment is a standard rate of $35 per acre with no compensation in the third year. The three year contract may not exceed a maximum payment of $1,350. After the three year term, landowners will receive no compensation for three additional years. Landowners can again apply for cash grants after three years of no compensation. This is a new program and details may change as time progresses. Stipulations of the program include tree maintenance within the ROW. No vegetation can exceed 15’ in height.

Sandy Creek Nature Center is currently enrolled in this incentive program. Current management practices include harrowing the ROW every three years. The goal of this project is to develop a more comprehensive wildlife management plan for the ROW and provide general information about urban wildlife management.
Wildlife Management Plan

In order to develop a wildlife management plan one must understand the layout of the land (topographic-Map 3 and aerial-Map 4), landowner goals (what kind of wildlife to attract), and current conditions of the site. 

![Sandy Creek Nature Center](image)

Map 3. Topographic map of Sandy Creek Nature Center

The goal of ACC Leisure Service is to provide habitat that is beneficial to an array of charismatic species. These species include: white-tailed deer, Eastern cottontail, swamp rabbit, wild turkeys, raccoons, beaver, waterfowl, and an assortment of songbirds and neotropical migrants. Good wildlife habitat includes vegetation that provides food and cover. Food and cover is dependant on the wildlife species targeted. This plan details habitat modification that is beneficial for white-tailed deer, wild turkey, Eastern cottontail, woodducks, gamebirds, various songbirds, and neotropical migrants.
Current site conditions

An investigation was performed in October to assess the current conditions of the site. This analysis included a vegetative review within the ROW. Vegetation observed on upland areas included: goldenrod (*Solidago canadensis*), dogfennel (*Eupatorium capillifolium*), blackberry (*Rubus* sp.), tall fescue (*Festuca arundinacea*), etc. Vegetation found on wetland areas included: smartweed (*Polygonum* sp.), buttonbush (*Cephalanthus occidentalis*), switch cane (*Arundinaria gigantea*), etc. (see Photo 2 and 3).
Current vegetation on the site does provide some wildlife value but only targets a few species. Observed species use included: white-tailed deer, Eastern cottontail, beaver, and some songbirds. Creation of edge habitat (confluences of two different habitats) is essential for wildlife travel corridors. Current conditions on the site resemble little use of edge habitat. The potential of this site for optimal wildlife utilization is very high. For more pictures documenting current site conditions please see attachment 1.

Management strategies

Incremental harrowing will encourage the natural recruitment of different plant species which could be utilized by an assortment of wildlife. Also, planting of winter annuals
will provide a supplemental food source to wildlife during those months where vegetation is scarce. Bird box installations along the ROW would encourage nesting songbirds and waterfowl to utilize the area. Also, planting a shrub riparian buffer on the streams which border the ROW will create wildlife travel corridors and potential nesting structures. Native plant encouragement and elimination of invasive exotics, such as tall fescue, should also be considered. The map below (Map 5) illustrates recommendations regarding the incorporation of wildlife plantings, bird box installations, and creation of edge habitat.

Map 5. Aerial view of ROW detailing management plan

*Bird box installation*

A couple of bluebird boxes should be installed along the edge of the ROW to encourage songbird nesting. Placement of blue bird boxes at the confluence of the ROW and the hardwood/pine forest will provide box occupants a diversity of strata and habitat for foraging. These boxes should be installed in the uplands.

A couple of woodduck boxes should be installed to encourage waterfowl nesting. These boxes should be placed near the edge of ROW and adjacent to water influences (North Oconee River and Sandy Creek). The wetland areas near the waterways provide good foraging for box occupants.
Shrub Plantings

The riparian buffers located inside the ROW do provide some wildlife value. Wildlife value would increase if shrubs were planted within the riparian zones. A shrub that should be encouraged and native to Georgia is buttonbush (*Cephalanthus occidentalis*). Buttonbush is a large woody shrub that will grow up to 10’ high and occurs in open wetland areas. The flowers are readily utilized by butterflies and ruby throated hummingbird and seeds produced are consumed by waterfowl. This shrub also provides nesting habitat for various songbirds.

Switchcane (*Arundinaria gigantea*) was prevalent near Sandy Creek and should be encouraged. Switchcane is a native plant species and provides good cover for woodcocks, swamp rabbit, etc. The combination of buttonbush and switchcane will provide great foraging and nesting opportunities for songbirds, waterfowl, and small mammals. For more information about buttonbush please refer to the Urban Wildlife Management book.
Supplemental Food Plots

Supplemental food plots should be encouraged to provide forage for wildlife during winter stress periods. Food plots should provide a variety or mixture of forage which would target different wildlife preferences. For example, a mixture of regal ladino clover, wheat, and annual rye can be used for encouraging turkeys, white-tailed deer, Eastern cottontail, bobwhite quail, and various song birds to use specified areas. Site preparations for plantings include mowing and harrowing designated areas. Planting entails use of a drill or broadcast mechanically or by hand. Planting dates depends on the plant species and soil type. See chart 1 for planting specifics and chart 2 for mixture types.

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<td>SEP &amp; FEB</td>
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<td>Rye</td>
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† chufa is a perennial sedge that requires replanting

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Chart 1. Details planting specifics for perennial and annual grasses and forbs that are native or exotic to Georgia. Information provided by Georgia Department of Natural Resources.
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*A=annual, P=perennial, AR=annual reseeding

Chart 2. Details planting mixtures and specifics for supplemental food plots. Information provided by Georgia Department of Natural Resources.

**Harrowing increments**

Harrowing once every three years is the current practice on the site. Although very cost effective, it provides little wildlife value. The ROW management plan should include incremental harrowing. Harrowing provides plant species present in the seed bank an opportunity to be established. Harrowing should take place in February, just before the initiation of the growing season. Harrowing in sections and increments would create edges for wildlife species to utilize. It would also increase plant species diversity which would provide optimal foraging opportunities for wildlife. Harrowing should encourage native species such as lespedeza, blackberries, greenbriar, milkpea, beggar ticks, etc. These plant species would provide a foraging habitat for songbirds, gamebirds, neotropical migrants, white-tailed deer, wild turkeys, Eastern cottontail, etc.

**Exotic species**

Site investigations revealed that an invasive exotic species, tall fescue, occurred on the site. The area of concern is located adjacent to each side of the greenway that crosses the ROW. Fescue was first introduced in the U. S. as a cattle forage. It now proliferates...
in cow/horse pastures and fallow fields across the U.S. It is an invasive bunch grass which has minimal wildlife value. Elimination of this species should be encouraged to promote native vegetation. Herbicide use, such as round-up, would be the best practice to eliminate the species from the current seed bank.

*Economics*

If machinery use and manpower is provided for habitat manipulations, then the cost of supplemental plantings and harrowing should be covered within the WINGS program. Planting of shrubs and purchasing of bird boxes would be a one time expense and should be considered for ROW management. To get the public involved and to be more cost effective, construction of bird boxes could be held as an event at Sandy Creek Nature Center.

Buttonbush cost approximately $11 per five seedlings. Planting of 25 stems adjacent to each waterway should be sufficient for wildlife usage. Again, this should be a one time expense and would maintain the riparian corridor of each waterway. Again, getting the public involved in planting the shrubs would be more cost effective.

Herbicide use to eliminate invasive exotic plant species should be encouraged. Elimination of fescue will create opportunities for native vegetation to grow. A couple applications may be needed to discourage new fescue growth. Because the fescue is dense in small areas, application cost should be covered within the incentive program.

*Conclusion*

Increasingly, local governments and private developers are adopting wildlife management strategies to compensate for wildlife habitat degradation in urbanizing areas. Several different incentive programs can be utilized to encourage the enhancement of wildlife habitat. Project WINGS is an excellent program that should be incorporated in wildlife habitat management for specified properties.

Sandy Creek Nature Center is a beautiful place for the public to view wildlife and to relax from life’s daily routine. The current practice within the ROW provides minimal food and cover for wildlife species. If the recommended management is incorporated, then the ROW will provide food and cover for multiple species. If economics is a problem, then creation of edges through incremental harrowing and shrub plantings near adjacent waterways should be included in ROW management. Habitat edges and shrub riparian zones will create wildlife corridors or travelways from one habitat to another. Refer to the Urban Wildlife Management book on any questions about supplemental plantings, specific species habitat, and general research on ROWs.
ATTACHMENT 1

Photographs of Current Site Conditions
Photo 1. Typical upland vegetation with exotic species, tall fescue

Photo 2. Photograph of blackberries near edge of ROW
Photo 3. West view of upland vegetation in ROW

Photo 4. East view of upland vegetation in ROW
Photo 5. View of ROW from upland forest edge

Photo 6. View of beaver slide within the ROW on North Oconee River
Photo 7. View of smartweed (preferred waterfowl food) next to Sandy Creek

Photo 8. View of buttonbush next to Sandy Creek
Photo 9. View of North Oconee River Greenway that passes through ROW

Photo 10. View of vegetation height in ROW.
CHAPTER 3:
WILDLIFE HABITAT DISTRIBUTIONS
Introduction

Tools such as wildlife corridors, utility right-of-way management plans, and road crossing devices are useful for managing urban wildlife. First, of course, the managers should determine which species they wish to address; reviewing the current habitat distribution of each species present in the jurisdiction is the first step in that process. This chapter includes habitat distribution maps for each amphibian, bird, mammal, and reptile species that has potential habitat in Athens-Clarke County (ACC), Georgia, using data from the Georgia Gap Analysis Project (Kramer et al., 2003).

The Georgia Gap Analysis Project (Kramer et al., 2003) includes potential distribution maps for vertebrate species throughout the state of Georgia. The full version of the Georgia Gap Analysis report can be found at http://narsal.ecology.uga.edu/gap.html. We have also included the data CDs from the Georgia Gap Analysis (4 discs) with this report. These maps predict likely presence/absence of a species based on habitat type (Appendix 5), and also take into account habitat features including elevation and slope, stream size, water features, wetlands, road density and distance, geology, habitat patch size, proximity of one habitat type to another, and mixed habitats. It is important to note that the Gap Analysis maps are based on maps created at a 1:100,000 or finer scale, and are intended to be used at the landscape level (homogeneous areas generally covering 1,000 to 1,000,000 hectares and made up of more than one kind of natural community). Therefore, the maps from the Gap Analysis that were modified for this report can be used at this coarse scale for a general idea of predicted habitat distributions within the county (Kramer et al., 2003).

Methods

Using ArcView GIS 3.3 (ESRI), every distribution map (in grid format) from the Georgia Gap Analysis Project was inspected to determine whether likely habitat existed within ACC. Each map with potential habitat in ACC was then cropped to the area surrounding ACC using the Spatial Analyst extension. Next, each grid file was converted to a shapefile. Finally, each shapefile was cropped to the boundary of ACC using the Geoprocessing Wizard extension. Both shapefiles for each species are provided on the enclosed CD labeled “ACC distribution maps.” The columns labeled “Extended Range Shapefile (*.shp)” and “Range within ACC Shapefile (*.shp)” on Tables 2 - 5 indicate the filenames that correspond with each species. The projection for all shapefiles is UTM Zone 17, NAD 83, meters. The digital orthophoto mosaic was obtained from the ACC planning department.

Afterwards, the vertebrate distribution maps for ACC were visually examined and sorted into one of the following categories based on the species’ general distribution and degree of fragmentation (See table 1). This organizational scheme can serve as a starting point for deciding what species might benefit from greater habitat connectivity. Note that for these categories, desirable species were not treated differently from nuisance species, as that distinction is a judgment decision best left up to the land manager. They are simply sorted according to the pattern of their distribution.
1. Patchy/fragmented; appears to be associated with water or riparian areas. Desirable species in this category might benefit greatly from increased habitat connectivity, especially along streams. Care should especially be taken to maintain connectivity between terrestrial and aquatic habitats of amphibian species (such as salamanders) that migrate between these two areas each year.

2. Patchy/fragmented; not clearly associated with water. Desirable species in this category might benefit greatly from increased habitat connectivity.

3. Common/connected in rural/forested/less developed areas. Species in this category currently appear to have reasonably common and connected habitat in the less developed portions of the county. However, because their range is limited to less developed areas, fragmentation could become more of an issue as ACC becomes increasingly urbanized.

4. Common/connected in urban/highly developed areas. These species were common and strongly associated with the most developed parts of the county. Their ranges are likely to expand as ACC becomes increasingly urbanized.

5. Common/connected; associated with water or riparian areas. These species appear to be associated with streams and other water bodies and their habitat is common and widespread along water sources within the county. However, because they are restricted to aquatic or riparian habitats, connectivity could be somewhat of an issue. Care should especially be taken to maintain connectivity between terrestrial and aquatic habitats of amphibian species (such as salamanders) that migrate between these two areas each year.

6. Common/connected throughout ACC (except, in most cases, in the most developed areas, such as Atlanta Highway and downtown). These are habitat generalists, and show no indication of needing any special effort to increase habitat connectivity.

7. Edge of range. ACC contains the edge of these species’ ranges.

8. Other. These species did not fit neatly into any of the above patterns.

**Products/Results**

The primary products of this section are provided on the enclosed CD entitled “ACC distribution maps.”

Final, presentation-quality maps of each species’ projected habitat distribution can be most easily viewed by inserting this CD and double clicking on the Powerpoint file “Habitat maps.ppt.” Within this file, distribution maps are color-coded by and alphabetized within taxonomic group (amphibians - yellow, birds – green, mammals – purple, reptiles – dark red). Also included, for reference, is a digital orthophoto (aerial photograph) of the county overlaid with major roads and streams. This is included to give a visual picture for understanding the habitat associations of the species and to help the user navigate the range.
maps. In addition, images of each individual map are presented in the folder “Final Species Range Maps.” The column titled “Presentation layout (*.wmf)” on Tables 2 - 5 indicates the filenames that correspond with each species. The folder “GIS” contains the shapefiles used to create these maps, for you to use as needed.

The ACC Community Tree Council’s 2002 GIS vegetation map of the county is also provided on this CD as supplemental material. We were not able to pair up species ranges with the vegetation maps, because the vegetation maps take into account many fewer parameters than those modeled by the Gap Analysis. However, the Tree Council’s vegetation maps were produced at a finer scale than the Gap Analysis, and so would be useful for a land manager when trying to gain a more detailed picture of what vegetation exists in a specific location.

At the end of this chapter, appendices 1 - 5 are adapted from the Georgia Gap Analysis and should be used in combination with the range maps when trying to establish wildlife corridors and make other urban wildlife management decisions. Appendices 1 - 4 describe the habitat and distribution of each species, indicate the habitat types modeled to create the distributions, and list references for each species. Appendix 5 indicates the habitats that correspond to the codes in Appendices 1 - 4.

Reference

Table 1. Habitat patterns. Each species’ habitat map was sorted visually into a general distribution/fragmentation pattern category. Seven general patterns were identified and are listed here approximately in order from most to least fragmented or specific, followed by an “other” category for species whose habitat distributions did not fall neatly into any category. U and XU refer to maps on which utility line right-of-ways stand out visual from the surrounding areas: species denoted by U currently have appropriate habitat along utility corridors but not in the surrounding area, while those denoted by XU have appropriate habitat in the surrounding area but not in the utility corridors.

<table>
<thead>
<tr>
<th>Habitat Pattern Type</th>
<th>Amphibians</th>
<th>Birds</th>
<th>Mammals</th>
<th>Reptiles</th>
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<tbody>
<tr>
<td>1. Patchy/fragmented; appears to be associated with water or riparian areas (including a few species with habitat that is common except in urban areas)</td>
<td>Bird-voiced treefrog, Bullfrog, Marbled salamander, Mud salamander, Northern slimy salamander, Red salamander, Three-lined salamander</td>
<td>Acadian flycatcher, Bald eagle, Great blue heron, Green heron, Hooded warbler, Kentucky warbler, King rail, Least bittern, Louisiana waterthrush, Mallard duck, Northern parula, Osprey, Prothonotary Warbler, Scarlet tanager, Swainson’s warbler, Virginia rail, Wood duck, Worm-eating warbler, Yellow-billed cuckoo</td>
<td>Marsh rice rat, Meadow jumping mouse, Silver, Swamp rabbit</td>
<td>Common musk turtle, Eastern mud turtle, Painted turtle, Plainbelly water snake, Queen snake, Ribbon snake, River cooter</td>
</tr>
</tbody>
</table>
| 3. Common/connected in rural/forested/less developed areas | American toad | Common barn-owl  
Dickcissel  
Eastern bluebird  
Eastern kingbird – U  
Eastern meadowlark  
Eurasian collard-dove  
European starling  
Field sparrow – U  
Grasshopper sparrow  
Horned lark  
House sparrow  
Killdeer – U  
Loggerhead shrike – U  
Northern rough-winged Swallow  
Ovenbird  
Pine warbler  
Prairie warbler – U  
Purple martin – U  
Red-eyed vireo  
Red-winged blackbird – U  
Rock dove  
Solitary vireo  
Tree swallow  
White-eyed vireo  
Wood thrush  
Yellow-throated warbler | Blue-gray gnatcatcher – XU  
Chuck-wills-widow  
Common yellowthroat  
Eastern wood pee-pee – XU  
Hairy woodpecker – XU  
Indigo bunting  
Northern bobwhite  
Pileated woodpecker – XU  
Whip-poor-will  
Wild turkey  
Yellow-breasted chat | Big brown bat  
Bobcat – XU  
Common gray fox  
Coyote  
Eastern harvest mouse  
Eastern spotted skunk  
Eastern harvest rat  
Eastern spotted skunk  
Least shrew  
Long-tailed weasel  
Oldfield mouse  
Red fox | Black/eastern kingsnake  
Black racer  
Box turtle  
Coachwhip  
Canebreak/timber rattlesnake  
Eastern hognose snake  
Fence lizard  
Mole kingsnake  
Pigmy rattlesnake  
Southeastern crowned snake  
Southeastern five-lined |
<table>
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<tr>
<th>4. Common/connected in urban/highly developed areas</th>
<th>Southeastern shrew White-tailed deer</th>
<th>Black rat House mouse Norway rat</th>
<th>skink Slender glass lizard</th>
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</thead>
<tbody>
<tr>
<td>Common nighthawk – U House finch – U House wren Northern Mockingbird – U</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Common/connected; associated with water or riparian areas</th>
<th>Eastern narrowmouth toad Eastern spadefoot toad Four-toed salamander Fowler’s toad Green frog/ Bronze frog Green treefrog Northern cricket frog’ Pickerel frog Red-spotted/ central newt Southern two-lined salamander Spring peeper Upland chorus frog</th>
<th>Belted Kingfisher</th>
<th>American beaver Mink</th>
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<tbody>
<tr>
<td>American beaver Mink</td>
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</tbody>
</table>

| 7. Edge of range | Seal salamander | Yellow warbler | Nine-banded armadillo
|                 |               |               | Woodchuck - U |
| 8. Other        | Barred owl    |                | Six-lined racerunner |
|                 | Brown-headed nuthatch |       | |
|                 | Gray catbird  |                | |
|                 | Orchard oriole |            | |
|                 | Sharp-shinned hawk |        | |
|                 | Song sparrow – U |           | |
|                 | Yellow-throated warbler | | |
Table 2. File names used for amphibian habitat maps.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Extended Range Shapefile (*.shp)</th>
<th>Range within ACC Shapefile (*.shp)</th>
<th>Presentation layout (*.wmf)</th>
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**Table 4.** File names used for mammal habitat maps.

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Table 5. File names used for reptile habitat maps.

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Appendix 1, Amphibian Habitat and Distribution. Habitat and distribution information used in the Georgia GAP Analysis. Copied and adapted (to include only ACC species) from the CD-ROM A Gap Analysis of Georgia, Disc 3, August 2003 Final Report that was included with this report (follow \GISData\Verts\Amphibians\spreadsheet\amphibian_methods.doc). For a list of the habitat codes used in the models, see Appendix 5, Habitat Code List). This appendix is included to assist the user in making habitat management and connectivity decisions, in conjunction with the habitat range maps provided for each species.

**American Toad, Bufo americanus, AAABB01020, G5, S5**

Habitat and distribution: American toads are common residents of Georgia mainly north of the Fall Line. They are adaptable in their habitat requirements and may be found in forests, floodplains, and suburban areas. They require shallow bodies of water for breeding, and moist hiding places such as leaf litter, rocks, or logs for daytime shelter.

Model: Applied 90 meter buffer to 1:24,000 stream coverage and 120 meter buffer to National Wetlands Inventory (NWI) freshwater wetlands. Kept habitats 22, 72, 73, 80, 201, 202, and 203 within buffers. Kept habitats 11 (shallow freshwater only), 410, 411, 412, 414, 415, 422, 424, 425, 433, 434, 440, 900, 930, and 980 in all cases. Clipped by digitized range.


**Bird-voiced Treefrog, Hyla avivoca, AAABC02030, G5, S4**

Habitat and distribution: Residents of wooded, swampy habitats, bird-voiced treefrogs occur in Georgia along the edges of tupelo-cypress swamps, in floodplains, and in other damp forested areas, almost always very near water.

Model: Habitats 890 and 900 within digitized range.


**Bullfrog, Rana catesbeiana, AAABH01070, G5, S5**

Habitat and distribution: Widespread in the eastern U.S., bullfrogs occur throughout Georgia in aquatic habitats. They need relatively permanent bodies of water for breeding, and may be found in lakes, ponds, and medium to large-sized streams.


**Cope's Gray Treefrog, Hyla chrysoscelis, AAABC02050, G5, S5**

Habitat and distribution: Widespread in the eastern U.S., Cope’s gray treefrogs are found throughout Georgia, with the exception of the area immediately in and around the Okefenokee swamp. Grey treefrogs often inhabit hardwood or mixed pine-hardwood forests containing small ponds, roadside ditches or other standing water for breeding.


**Eastern Narrowmouth Toad, *Gastrophryne carolinensis*, AAABE01010, G5, S5**

Habitat and distribution: Eastern narrowmouth toads are found throughout Georgia, with the exception of the Blue Ridge. They may occur in a variety of situations that provide moisture and shelter. Suitable habitats include pinewoods, bottomland hardwoods, maritime forests and cypress swamps. They typically breed in aquatic habitats with shallow water.

Model: Applied 30 meter buffer to 1:24,000 stream coverage and 120 meter buffer to NWI freshwater wetlands. Kept habitats 20, 22, 31, 72, 73, 80, and 201, 202, and 203 within buffers. Kept habitats 410, 411, 412, 414, 420, 433, 440, 441, 512, 620, 890, 900, 930, and 990 in all cases. Clipped by digitized range.


**Eastern Spadefoot Toad, *Scaphiopus holbrookii*, AAABF01040, G5, S5**

Habitat and distribution: Although they are less common north of the Fall Line, eastern spadefoot toads occur throughout Georgia in forested areas. Fossorial toads, they prefer areas with sandy soil in which they can burrow. Eastern spadefoot toads typically breed after heavy rains in temporary pools or ponds of rainwater.

Model: Habitats 410, 412, 420, 434, 440, 441, 620, and 900 within digitized range.


**Four-toed Salamander, *Hemidactylium scutatum*, AAAAD08010, G5, S2**

Habitat and distribution: Four-toed salamanders may be observed in scattered locations throughout much of Georgia in swamps, bogs, or marshy areas within hardwood or mixed forest. Although terrestrial or fossorial as adults, four-toed salamanders are aquatic as larvae, and require a breeding habitat near water, preferably with sphagnum or other mosses present.


**Fowler's Toad, *Bufo fowleri*, AAABB01180, G5, S5**

Habitat and distribution: Widespread in the eastern U.S., Fowler’s toads occur in Georgia as far south as the southern Coastal Plain. These adaptable toads may be present in many habitat types: hardwood, mixed or pine forests, farmlands, and in gardens and residential areas. Fowler’s toads require a breeding habitat of small ponds, shallow areas in lakes or rivers, wet ditches or streams.

Model: Applied 30 meter buffer to 1:24,000 stream coverage and 120 meter buffer to NWI freshwater wetlands. Kept habitats 22, 31, 72, 73, 80, 201, 202, and 203 within buffers. Kept habitats 410, 411, 412, 414, 422, 424, 425, 431, 433, 434, 440, 900, and 980 in all cases. Clipped by digitized range.


**Green Frog/Bronze Frog, *Rana clamitans*, AAABH01090, G5, S5**

Habitat and distribution: Widely distributed throughout the eastern U.S., green frogs occur statewide in Georgia in a variety of habitats. Semi-aquatic amphibians, they may occupy just about any place where there is shallow, semi-permanent water: springs, creeks, bogs, ditches, etc.
Model: Applied 90 meter buffer to 1:24,000 stream coverage, 120 meter buffer to NWI freshwater wetlands, and 90 meter buffer to habitat 11 (shallow freshwater only). Kept habitats 7, 20, 22, 31, 33, 72, 73, 80, 201, 202, 203, 411, 420, 422, 425, 434, 440, 441, 512, and 620 within buffers. Kept habitats 11 (shallow freshwater only), 410, 412, 414, 424, 433, 890, 900, 930, 980, and 990 in all cases. Clipped by digitized range.


**Green Treefrog, Hyla cinerea**, AAABC02060, G5, S5

Habitat and distribution: These relatively widespread treefrogs are residents of forested areas and swamps in the Coastal Plain and Piedmont of Georgia. They may be expanding their range further northward.

Model: Applied 30 meter buffer to 1:24,000 stream coverage and 30 meter buffer to NWI freshwater wetlands. Kept habitats 20, 31, 72, 73, 201, 202, 203, and 434 within buffers. Kept habitats 410, 412, 414, 620, 890, 900, 930, 980, and 990 in all cases. Clipped by digitized range.


**Marbled Salamander, Ambystoma opacum**, AAAAA01100, G5, S5

Habitat and distribution: Marbled salamanders are residents of the Piedmont and most of the Coastal Plain. They may be abundant in floodplains in a variety of forested habitats, but are sometimes also observed in drier situations, usually near breeding areas. Marbled salamanders require a breeding habitat characterized by winter flooding.


**Mud Salamander, Pseudotriton montanus**, AAAAD13010, G5, S4

Habitat and distribution: Although not commonly observed, mud salamanders have a wide distribution in Georgia, occurring throughout the Coastal Plain and Piedmont. They are most often encountered in muddy springs, sluggish floodplain streams, swampy wooded areas, and other damp, low-lying situations.

Model: Habitats 890, 900, 980, and 990 within digitized range.


**Northern Cricket Frog, Acris crepitans**, AAABC01010, G5, S5

Habitat and distribution: Found in the mountains, Piedmont, and parts of the Coastal Plain of Georgia, northern cricket frogs may be observed in habitats with permanent bodies of shallow water which possess some vegetative cover. They often prefer marshy areas and relatively open, grassy margins of shallow water, but may also be found in or near small, slow-moving streams, and in ditches or mudflats.


**Pickerel Frog, Rana palustris**, AAABH01160, G5, S4
Habitat and distribution: In Georgia, pickerel frogs occur chiefly north of the Fall Line, in shaded streams where water is cool and clear, or in other damp places in hardwood forest. In a few places on the Coastal Plain of southeast Georgia they may inhabit the relatively warm, turbid water of floodplain swamps.


**Red Salamander, Pseudotriton ruber**, AAAAD13020, G5, S5

Habitat and distribution: Relatively widespread in Georgia, red salamanders typically inhabit slow-moving springs or seepages in thick leaf litter or other appropriate cover. They are somewhat terrestrial, and nonbreeding adults may sometimes be found in forested areas adjacent to streams. Red salamanders are normally absent from large, swiftly flowing streams.

Model: Above fall line: from flowaccumulation grid, created stream grid based on minimum values in different precipitation zones. Where annual precipitation is between 80 and 100 inches, minimum value for stream is 25. Where precipitation is between 60 and 80, minimum value for stream is 35. Where precipitation is < 60, minimum value for stream is 45. Used maximum value of 10,000 in all cases. Used resultant grid as mask for habitats 410, 411, 412, 413, 414, 415, 424, 425, 431, 432, 433, 434, 890, and 900. Below fall line: from flowaccumulation grid, kept pixels where values were between 100 and 10,000. Used resultant grid as mask as for habitats 410, 411, 412, 413, 414, 415, 424, 425, 431, 432, 433, 434, 890, 900, and 990. Clipped by digitized range.


**Red-spotted/Central Newt, Notophthalmus viridescens**, AAAAF01030, G5, S5

Habitat and distribution: These salamanders occur in a variety of habitats throughout Georgia. Adults may inhabit ponds, marshes, swamps, and other permanent or semipermanent bodies of water that lie within or adjacent to forested areas. These newts are notable for the presence in their life-cycle of a terrestrial eft phase; this phase typically moves from aquatic habitat into forested situations.


**Seal Salamander, Desmognathus monticola**, AAAAD03060, G5, S5

Habitat and distribution: Most abundant in the Blue Ridge, seal salamanders typically inhabit areas in and around cold, well-aerated mountain streams, seepages or brooks. In the Piedmont, they may occur locally in small streams within cool, forested ravines.

Model: From flowaccumulation grid, created stream grid based on minimum values in different precipitation zones. Where annual precipitation is between 80 and 100 inches, minimum value for stream is 25. Where precipitation is between 60 and 80, minimum value for stream is 35. Where precipitation is < 60, minimum value for stream is 45. Used maximum value of 10, 000 in all cases. Used resultant grid as mask for habitats 410, 411, 412, 413, 414, 415, 424, 425, 431, 432, 433, 434, 890, 900, and 990. Eliminated all single pixels of habitat. Clipped by digitized range.


**Southern Leopard Frog, Rana sphenocephala**, AAABH01220, G5, S5

Habitat and distribution: Southern leopard frogs occur throughout Georgia in all types of freshwater environments, ranging from permanent and semi-permanent woodland ponds to potholes. In late summer and fall, southern leopard frogs may venture away from water into mesic woodlands.
Model: Applied 90 meter buffer to 1:24,000 stream coverage, 90 meter buffer to NWI freshwater wetlands, and 90 meter buffer to habitat 11 (shallow freshwater only). Kept habitats 20, 22, 31, 33, 72, 73, 80, 201, 202, 203, 411, 422, 425, 434, 440, 441, and 620 within buffers. Kept habitats 7 (associated with freshwater), 11 (shallow freshwater only), 410, 412, 424, 433, 890, 900, 930, 980, and 990 in all cases. Statewide range.


**Southern Two-lined Salamander**, *Eurycea cirrigera*, AAAAD05140, G5, S5

Model: Kept habitats 410, 414, 424, and 433, 890, 900, and 980 in all cases. Above fall line: kept pixels where values were > 45. Used resultant grid as mask for habitats 201, 202, 203, 411, 412, 425, 431, 432, 434, and 440. Kept habitat 412 if within 30m of 1:24,000 streams. Below fall line: Used rasterized 1:24,000 streams as mask for habitats 201, 202, 203, 413, 420, 422, 432, 434, and 440. Kept habitat 412 if within 30m of 1:24,000 streams. Clipped by digitized range.


**Spotted Dusky Salamander**, *Desmognathus conanti*, AAAAD03040, G5, S5

Habitat and distribution: Abundant in Georgia throughout the Piedmont and present in a few localities in the mountains, spotted dusky salamanders are especially abundant along the margins of small streams in locations with rocks, logs or mosses, and are also frequently encountered in bottomland hardwoods, swamps, springs and seepage areas.

Model: From flowaccumulation grid, created stream grid based on minimum values in different precipitation zones. Where annual precipitation is between 80 and 100 inches, minimum value for stream is 25. Where precipitation is between 60 and 80, minimum value for stream is 35. Where precipitation is < 60, minimum value for stream is 45. Used maximum value of 10,000 in all cases. Used resultant grid as mask for habitats 410, 411, 412, 413, 414, 424, 425, 431, 432, 433, 434, and 900. Applied additional mask of elevations < 548 m (1900 feet). Eliminated all single pixels of habitat. Clipped by digitized range.


**Spotted Salamander**, *Ambystoma maculatum*, AAAAA01090, G5, S5

Habitat and distribution: Occurring in roughly the northern two-thirds of Georgia, spotted salamanders breed in late winter or early spring in temporary or ephemeral ponds within larger areas of hardwood or mixed forest. During most of the year, adults lead a fossorial existence in surrounding forests.


**Spring Peeper**, *Pseudacris crucifer*, AAABC05090, G5, S5

Habitat and distribution: Widespread in the eastern U.S. and Canada, spring peepers occur throughout Georgia in many types of wooded situations. They particularly favor areas which possess shrubby secondary growth, and in which there are temporary ponds, ditches, or other semi-permanent water for breeding. After breeding, spring peepers move to damp, wooded places, where they become secretive and hard to find.

Model: Applied 120 meter buffer to mosaic of habitats 11 (freshwater only), 900, 930, 980, and 990. Kept habitats 31, 72, 73, 80, 201, 202, 203, 422, 425, 434, 440, 441, 620 within buffer. Kept habitats 11 (shallow freshwater only), 410, 411, 412, 414, 415, 420, 424, 431, 433, 900, 930, 980, and 990 in all cases. Statewide range.

**Spring Salamander**, *Gyrinophilus porphyriticus*, AAAAD06020, G5, S4

Habitat and distribution: Spring salamanders may be found in Georgia in upland locations, usually near the edges of small, clear streams and springs. They require cool, moist surroundings in forested areas.

Model: From flowaccumulation grid, created stream grid based on minimum values in different precipitation zones. Where annual precipitation is between 80 and 100 inches, minimum value for stream is 25. Where precipitation is between 60 and 80, minimum value for stream is 35. Where precipitation is < 60, minimum value for stream is 45. Used maximum value of 10,000 in all cases. Used resultant grid as mask for habitats 410, 411, 412, 414, 424, 425, 431, 433, and 434. Eliminated all single pixels of habitat. Clipped by digitized range.


**Three-lined Salamander**, *Eurycea guttolineata*, AAAAD05290, G5, S4S5

Habitat and distribution: Three-lined salamanders range throughout most of Georgia in low-lying areas. Suitable environments for them include floodplain forests, swamps, boggy streams, and some shaded seepage areas.

Model: Habitats 890, 900, and 980 within digitized range.


**Upland Chorus Frog**, *Pseudacris feriarum*, AAABC05070, G5T5, S5

Habitat and distribution: Occurring from the upper Coastal Plain northward in Georgia, upland chorus frogs may be observed in many types of open and forested wetlands. Habitats include moist woodlands, river swamps, and open habitats such as wet meadows and boggy or marshy wetlands with shrubs and grasses.

Model: Kept habitats 410, 412, 434, 900, 930, 980, and 990. Kept habitats 20 and 31 where they intersect with NWI freshwater wetlands. Kept habitat 11 (shallow freshwater only) where it is part of a clump of habitat 11 < 100 ha. Clipped by digitized range.


**References for the works cited above can be found on the CD-ROM A Gap Analysis of Georgia, Disc 1 that was included with this report (follow \GISData\Verts\Amphibians\spreadsheet\vertreferences.doc).**
Appendix 2, Bird Habitat and Distribution. Habitat and distribution information used in the Georgia GAP Analysis. Copied and adapted (to include only ACC species) from the CD-ROM A Gap Analysis of Georgia, Disc 2, August 2003 Final Report that was included with this report (follow \GISData\Verts\Birds\spreadsheet\bird_methods.doc). For a list of the habitat codes used in the models, see Appendix 5, Habitat Code List). This appendix is included to assist the user in making habitat management and connectivity decisions, in conjunction with the habitat range maps provided for each species.

Acadian Flycatcher, Empidonax virescens, ABPAE33020, G5, S5

Habitat and distribution: Acadian flycatchers breed statewide in Georgia. They are found in deciduous forests near streams, in bottomland hardwoods, and in other rich deciduous or mixed forest types. They generally prefer large forest tracts to small patches.


American Crow, Corvus brachyrhynchos, ABPAV10010, G5, S5

Habitat and distribution: American crows breed throughout Georgia, nesting in deciduous, coniferous, or mixed forest, and may be particularly abundant around forest edges. Other suitable habitats include farmlands, orchards, suburbs, parks, and woodlots. They are true habitat generalists.


American Goldfinch, Corvus brachyrhynchos, ABPBY06110, G5, S5

Habitat and distribution: American goldfinches breed in northern Georgia and much of the Coastal Plain. They may nest at the edges of woods or in shrubby places, marsh edges, overgrown fields, and orchards. Goldfinches are especially attracted to thistle.

Model: Habitats 20, 22, 31, 72, 73, 80, 201, 202, 203, 930, and 980 within digitized range.


American Kestrel, Falco sparverius, ABNKD06020, G5, S3

Habitat and distribution: American kestrels in Georgia prefer extensive open country with scattered trees for nesting. They forage over open areas such as pasture and woodland margins. Open longleaf pine provides a suitable natural forest habitat. They breed at scattered areas throughout the state.

Model: Habitats 80 and 620 within digitized range.


American Redstart, Setophaga ruticilla, ABPBX06010, G5, S5

24
Habitat and distribution: In the upper Coastal Plain and Piedmont, American redstarts are generally found in bottomland hardwoods. In the mountains they may be associated with cove hardwoods or mixed mesophytic forest.

Model: Selected habitats 410, 411, 412, 414, 890, and 900. Kept contiguous clumps of habitat greater than 1 ha (11 pixels, approximate home range size). Applied mask of elevations < 1219 m (4000 feet). Clipped by digitized range.


**American Robin**, *Turdus migratorius*, ABPBJ20170, G5, S5

Habitat and distribution: American robins nest in most of Georgia. They may be found near the edges of most types of forest, and in diverse habitats of other kinds, especially those with short grass, shrubs or trees.

Model: Habitats 20, 22, 24, 31, 72, 73, 80, 201, 202, 203, 410, 411, 412, 413, 414, 415, 422, 424, 425, 431, 432, 433, 434, 440 within digitized range.


**American Woodcock**, *Scolopax minor*, ABNNF19020, G5, S5

Habitat and distribution: American woodcocks breed locally in most of Georgia in a variety of wooded habitats. They prefer a mix of deciduous forest, particularly bottomland hardwood, with clearcuts, pasture, and shrubby areas.

Model: Applied 1 km moving window (FOCALSUM function using rectangle) to grid of suitable open habitats (20, 31, and 80) reclassed to value of 1. Kept areas where values were > 24. Applied 1 km moving window (FOCALSUM function using rectangle) to grid of suitable forested habitats (410, 412, 414, 415, 434, 900, 980) reclassed to value of 1. Kept areas where values were > 26. Mosaiced results of 2 FOCALSUM functions, and used as mask of all suitable habitats. Clipped by digitized range.


**Bald Eagle**, *Haliaeetus leucocephalus*, ABNKC10010, G4, S2

Habitat and distribution: Always around water, bald eagles nest in large living trees, often choosing the largest and sturdiest in the area. They forage over estuaries, reservoirs, large ponds, open marshes, and along shorelines – both freshwater and saltwater.

Model: Habitats 11 and 890. Statewide range, except areas of open ocean.


**Barn Swallow**, *Hirundo rustica*, ABPAU09030, G5, S5

Habitat and distribution: Barn swallows may be seen throughout Georgia in open habitats including clearcuts, farm lands, and rural or suburban areas. They prefer locations near water. They may nest on dams or under bridges at lakes and ponds, as well as in barns or sheds in open country.

Model: Habitats 11, 18, 20, 22, 31, 33, 34, 72, 73, 80, 83, 920, 930, and 980. Statewide range, except areas of open ocean.


**Barred Owl**, *Strix varia*, ABNSB12020, G5, S5
Habitat and distribution: Barred owls may be found throughout Georgia. They prefer mature forests, with swamps and bottomlands their most common habitat on the Piedmont and Coastal Plain. In the mountains, they may be found in uplands, hemlocks, coves, and along wooded streams.


**Belted Kingfisher, Ceryle alcyon, ABNXD01020, G5, S5**

Habitat and distribution: Belted kingfishers breed throughout Georgia, always in places near water. Fresh, brackish, and saltwater all may provide suitable habitat.

Model: Kept all rasterized 1:24, 000 streams, as well as habitats 7, 11 (shallow fresh and saltwater), 890, 920, and 930. Statewide range.


**Black Vulture, Coragyps atratus, ABNKA01010, G5, S5**

Habitat and distribution: Black vultures breed throughout Georgia at lower elevations. They may be seen foraging over many forested and non-forested habitats, frequently in agricultural areas near livestock, or around dumps.


**Black-and-white Warbler, Mniotilta varia, ABPBX05010, G5, S5**

Habitat and distribution: Black-and-white warblers in Georgia usually breed in mature deciduous or mixed forest. On the Piedmont, they may favor bottomlands. In the mountains, they are frequently found in cove hardwoods. They generally range from the upper Coastal Plain northward.


**Blue Grosbeak, Guiraca caerulea, ABPBX63010, G5, S5**

Habitat and distribution: Blue grosbeaks breed throughout Georgia at moderate and lower elevations. They like open country and brushy places such as clearcuts, abandoned fields, powerline rights-of-way, wood margins or agricultural areas.

Model: Habitats 20, 31, 73, 80, 83, 512, and 513 within mask of elevations < 762m (2500 feet). Statewide range.


**Blue Jay, Cyanocitta cristata, ABPAV02020, G5, S5**

Habitat and distribution: Nearly ubiquitous in Georgia, Blue jays are found in a wide variety of habitats including deciduous, mixed and coniferous forest. They may also be seen around farms, gardens, parks, and residential areas.
Blue-gray Gnatcatcher, *Polioptila caerulea*, ABPBJ08010, G5, S5

Habitat and distribution: Blue-gray gnatcatchers breed throughout much of Georgia at moderate and low elevations. They often nest in moist deciduous forests of bottomlands and swamps, but may also be found in sandhills, upland deciduous, mixed forest, and many pine stands.


Broad-winged Hawk, *Buteo platypterus*, ABNKC19050, G5, S5

Habitat and distribution: Broad-winged hawks breed in Georgia mainly from the Fall Line northward, nesting and foraging in deciduous or mixed forest.


Brown Thrasher, *Toxostoma rufum*, ABPBK06010, G5, S5

Habitat and distribution: Brown thrashers are permanent residents throughout much of Georgia, where they inhabit brushy places, usually in dry areas. Overgrown fields, woodland borders, clearcuts, thickets, brier patches, fencerows, open woods and residential areas may provide suitable thrasher habitat.


Habitat and distribution: Brown-headed cowbirds breed throughout Georgia, parasitizing nests of other species near open areas. They often choose a fragmented habitat including agricultural areas, small blocks of forest or forest edges, residential areas, etc.


Habitat and distribution: Brown-headed nuthatches are year-round residents throughout much of Georgia. They inhabit pine forests, especially those with mature trees. Brown-headed nuthatches are also seen in parks and residential areas with mature pines.

Model: Habitats 72, 73, 201, 202, 203, 422, 432, 434, 440, 441, and 620 within mask of elevations < 670m (2200 feet). Clipped by digitized range.
Canada Goose, *Branta canadensis*, ABNJB05030, G5, S4

Habitat and distribution: Mainly feral, nonmigratory birds in Georgia, Canada geese breed throughout most of the state. They may inhabit marshes, meadows, small islands and other open situations in and about fresh or brackish water. Flocks may sometimes be seen in urban parks with lakes or rivers.

Model: Habitats 7 (coastal beaches omitted), 11 (shallow freshwater only), 73, 80, and 930 within digitized range.


Carolina Chickadee, *Poecile carolinensis*, ABPAW01020, G5, S5

Habitat and distribution: Year-round residents throughout Georgia, Carolina chickadees may be found wherever trees are present, both in deep woods and in wooded residential areas. They like forests of all types, including mixed, coniferous and deciduous, and may also inhabit swampy areas. They are not found in much of the Okefenokee.


Carolina Wren, *Thryothorus ludovicianus*, ABPBG06130, G5, S5

Habitat and distribution: Carolina wrens are year-round residents throughout Georgia, occupying a wide variety of habitats that provide at least some tree cover. They like brushy or tangled areas in the understory of forests, and are also common in residential areas, parks, and overgrown or brushy fields.


Chimney Swift, *Chaetura pelagica*, ABNUA03010, G5, S5

Habitat and distribution: Chimney swifts breed throughout Georgia, and inhabit both open places and woodland. Swifts are largely dependent on the availability of suitable nest sites: chimneys, silos, wells, rafters, hollow trees, etc., and for this reason, they are often common around human habitation. They forage over either forested or open areas.


Chipping Sparrow, *Spizella passerina*, ABPBX94020, G5, S5

Habitat and distribution: Chipping sparrows breed throughout most of Georgia, with the exception of the lower Coastal Plain. They nest in areas having scattered trees and short grass: wooded residential areas, farmyards, golf courses, etc. They may also inhabit open coniferous and occasionally deciduous woods.

Model: Habitats 20, 22, 31, 72, 73, 80, 201, 202, 203, 411, 412, 413, 422, 431, 432, 434, 440, 441, 512, and 620 within digitized range.

**Chuck-wills-widow, Caprimulgus carolinensis**, ABNTA07010, G5, S4S5

Habitat and distribution: Chuck-will’s widows breed throughout much of Georgia at moderate and lower elevations. They prefer dry or mesic mixed forest, but may also inhabit pine or oak woods. They may forage over adjacent fields or clearings.

Model: Habitats 9, 20, 31, 80, 410, 411, 412, 413, 420, 422, 432, 434, 440, 441, 512, 513, and 620 within mask of elevations < 518 m (1700 feet). Statewide range.


**Cliff Swallow, Petrochelidon pyrrhonota**, ABPAU09010, G5, S3S4

Habitat and distribution: Cliff swallows in Georgia may nest under bridges or at dams on large lakes. Their distribution is strongly tied to large rivers. Foraging may take place over lakes, fields, cutover forests or other open areas near nest sites.

Model: Applied 1 km buffer to 1:100,000 stream coverage, kept habitats 7, 11, 20, 31, 33, 34, 73, 80, 83, and 930 within buffer. Clipped by digitized range.


**Common Barn-owl, Tyto alba**, ABNSA01010, G5, S3S4

Habitat and distribution: Common barn-owls breed throughout most of Georgia, although they are usually absent from mountainous or heavily forested areas. They favor open country, especially pastures and fields. They most often nest in buildings; availability of nest sites is perhaps the primary limiting factor in their distribution.

Model: Kept classes 80 and 83, recoded to single value and expanded 1 pixel. Kept expanded clumps > 100 ha, using as mask for habitats 20, 31, 34, 80, and 83. Clipped by digitized range.


**Common Grackle, Quiscalus quiscula**, ABPBXB6070, G5, S5

Habitat and distribution: Common grackles are permanent residents throughout Georgia. They inhabit a wide variety of habitats, especially near residential or agricultural areas.

Model: Habitats 7, 9, 11 (shallow fresh water only), 18, 20, 22, 24, 72, 73, 80, 83, 201, 202, 203, 413, 420, 422, 423, 432, 434, 440, 441, 512, 513, 620, 890, 900, 930, 980, and 990. Statewide range, except coastal beaches and open ocean.


**Common Ground-dove, Columbina passerina**, ABNPB06020, G5, S5

Habitat and distribution: Common ground-doves are permanent residents of Georgia south of the Fall Line. They nest in places with shrubs or small trees, in open habitats such as roadides or fields, along forest edges, and in residential areas.

Model: Habitats 9, 20, 22, 31, 72, 73, 80, 83, 201, 202, 203, 420, 422, 440, 441, 512, 513, and 620 within digitized range.


**Common Nighthawk, Chordeiles minor**, ABNTA02020, G5, S5

Habitat and distribution: Common nighthawks are permanent residents of Georgia south of the Fall Line. They nest in places with shrubs or small trees, in open habitats such as roadsides or fields, along forest edges, and in residential areas.

Model: Habitats 9, 20, 22, 31, 72, 73, 80, 83, 201, 202, 203, 420, 422, 440, 441, 512, 513, and 620 within digitized range.


**Common Nighthawk, Chordeiles minor**, ABNTA02020, G5, S5
Habitat and distribution: Common nighthawks breed throughout much of Georgia, where they inhabit open or bare areas. Along the coast, they are often encountered around sand dunes. Inland, they are primarily found around cities and towns, but may also be seen in clearcut areas, fields or very sparse forest.

Model: Habitats 9, 20, 22, 24, 31, 33, 34, 72, 73, 80, 83, 201, 202, 203, 420, 512, 513, and 620. Statewide range.


**Common Yellowthroat, Geothlypis trichas, ABPBX12010, G5, S5**

Habitat and distribution: Common yellowthroats breed throughout Georgia. Favored habitat is usually open country, including brushy places near wet or moist areas, shrubby brackish or freshwater marshes, old fields, swamp edges, etc.


**Cooper’s Hawk, Accipiter cooperii, ABNKC12040, G5, S3S4**

Habitat and distribution: Cooper’s hawks breed throughout Georgia in a wide variety of wooded habitats. They are often spotted foraging over openings near forests, and in edge environments.


**Dickcissel, Spiza Americana, ABPBX65010, G5, S3S4**

Habitat and distribution: Generally considered a Midwestern or prairie species, Dickcissels are rare, occasional breeders in Georgia, primarily during invasion years. They inhabit open grassy areas such as pastures.

Model: Habitat 80, within digitized range.


**Downy Woodpecker, Picoides pubescens, ABNYF07030, G5, S5**

Habitat and distribution: Downy woodpeckers breed throughout Georgia. They favor middle-aged to mature woodlands, although they are tolerant of earlier successional stages. Other habitats include residential areas, parks and orchards.


**Eastern Bluebird, Sialia sialis, ABPBJ15010, G5, S4S5**

Habitat and distribution: Eastern bluebirds breed throughout Georgia. Birds of open country, they inhabit areas with little understory and sparse ground cover. Orchards, open fields, farmyards, roadways, open residential areas, as well as open pine forests, may provide good bluebird habitat. Bluebirds are often abundant around residences with artificial nest boxes.

Model: Habitats 20, 22, 31, 72, 73, 80, 83, 422, 512, and 620 within mask of elevations < 1219 m (4000 feet). Statewide range.

**Eastern Meadowlark, Sturnella magna, ABPBXB2020, G5, S5**

Habitat and distribution: Eastern meadowlarks are year-round residents in much of Georgia, except coastal areas. Meadowlarks are birds of open areas, occupying pastures and other grass-dominated habitats.

Model: Habitat 80 within digitized range.


**Eastern Phoebe, Sayornis phoebe, ABPAE35020, G5, S5**

Habitat and distribution: The eastern phoebe breeds in Georgia from the upper Coastal Plain northward in wooded or partially wooded areas near streams, often preferring edges. Other habitats include farmyards, hedgerows and wooded residential areas.

Model: Habitats 7, 11 (shallow water only), 18, 22, 33, 34, 72, 73, 80, 201, 202, 203, 410, 411, 412, 414, 415, 424, 425, 431, 433, 890, 900, 930, and 980 within digitized range.


**Eastern Screech-owl, Otus asio, ABNSB01030, G5, S5**

Habitat and distribution: Eastern screech-owls breed throughout Georgia, nesting in a wide variety of habitats including deciduous, coniferous and mixed forest. They are frequently found in small woodlots or patches of forest, often near the edges of agricultural land, as well as in forested residential areas.


**Eastern Towhee, Pipilo erythrophthalmus, ABPBX74030, G5, S5**

Habitat and distribution: Eastern towhees are year-round residents throughout Georgia, where they may be found in a variety of brushy or wooded habitats, including overgrown fields, thickets, forest edges, or the understory of open or cutover woodlands. They may also be found in residential areas.


**Eastern Wood-pewee, Contopus virens, ABPAE32060, G5, S5**

Habitat and distribution: Eastern wood-pewees breed throughout Georgia, inhabiting open to medium-growth forests, primarily deciduous but also mixed and coniferous. They may also be found in parks, wooded suburbs, hedgerows or isolated clumps of trees.


**Eurasian collared-dove, Streptopelia decaocto, ABNPB02030, G5, SE**

Habitat and distribution: Rapidly expanding their range, Eurasian collared-doves now breed throughout most of Georgia. These doves are typically associated with human populations in habitats such as suburbs, small towns, and agricultural areas where suitable food grains are present.

Model: Habitats 22, 24, 72, 80, and 83 within digitized range.


**European Starling, Sturnus vulgaris, ABPBT01010, G5, S5**

Habitat and distribution: European starlings are found throughout Georgia. They may breed in either agricultural or urban locations.

Model: Habitats 22, 24, 72, 73, 80, and 83. Statewide range.


**Field Sparrow, Spizella pusilla, ABPBX94050, G5, S5**

Habitat and distribution: Field sparrows are permanent residents throughout most of Georgia, breeding more commonly north of the Fall Line. They primarily inhabit old fields and other grassy areas with low shrubs, and are partial to briers, fencerows, forest edges, cut-over pine woods, etc.

Model: Habitats 20, 31, 80, and 512 within digitized range.


**Fish Crow, Corvus ossifragus, ABPAV10080, G5, S5**

Habitat and distribution: A year-round Georgia resident, the fish crow is experiencing a range expansion northward into much of the Piedmont. It may be found in a wide variety of habitats including shores, marshes, shallow water, thickets, woodlands, fields, pastures and towns.

Model: Habitats 7, 9, 11, 18, 20, 22, 24, 31, 33, 72, 73, 80, 83, 201, 202, 203, 410, 412, 420, 422, 434, 440, 441, 513, 620, 890, 900, 920, 930, 980, and 990 within digitized range.


**Grasshopper Sparrow, Ammodramus savannarum, ABPBXA0020, G5, S4**

Habitat and distribution: Grasshopper sparrows breed throughout much of Georgia north of the Fall Line, and in scattered pockets below, where they nest in larger open areas such as grassy fields or pastures.

Model: Habitats 80 and airports, where they are tracts > 10 ha, within digitized range.


**Gray Catbird, Dumetella carolinensis, ABPBK01010, G5, S5**

Habitat and distribution: Gray catbirds breed throughout Georgia. They nest in thickets and other dense shrubby vegetation. Fencerows, abandoned farmland, residential areas, and pine plantations provide suitable habitat. The may also be present in dense underbrush in forested situations.


**Great Blue Heron, Ardea herodias, ABNGA04010, G5, S5**

Habitat: Great blue herons are year-round residents in much of Georgia, where they nest in small groups of heronries in wooded areas, chiefly swamps or in isolated areas on islands. They forage in shallow water, in fresh or saltwater wetlands, and occasionally in fields and surf areas.

Model: Habitats 7, 11 (shallow fresh and saltwater), 73, 420, 513, 890, 900, 920, 930, 980, and 990 within digitized range.


**Great Crested Flycatcher, Myiarchus crinitus, ABPAE43070, G5, S5**

Habitat and distribution: Great-crested flycatchers breed statewide in Georgia. Inhabiting forest or forest edge, they may be found in deciduous, coniferous or mixed woodland. Other habitats include parks, wooded suburbs, and hedgerows with mature trees.


**Great Horned Owl, Bubo virginianus, ABNSB05010, G5, S5**

Habitat and distribution: Great horned owls breed throughout Georgia, generally in deciduous, mixed, or coniferous woods. They often choose fragmented landscapes, including pasture, croplands and fields as well as forest. They may be absent from heavily urban areas.

Model: Created grid of “edge” pixels between suitable open habitats (18, 20, 22, 31, 34, 72, 73, 80, 83, 201, 202, and 203) and suitable forested habitats (410, 411, 412, 413, 414, 420, 422, 423, 424, 425, 431, 432, 433, 434, 440, 441, 512, 513, 620, 890, 900, 980 and 990). Applied 1 km moving window (FOCALMEAN using rectangle), keeping areas where values were > 6. Used results of this as a mask for all suitable habitats. Statewide range.


**Green Heron, Butorides striatus, ABNGA08010, G5, S5**

Habitat and distribution: Green herons breed statewide in Georgia. They nest in wet woodlands, swamps and thickets. Green herons prefer fresh water, but they may also be found in brackish or saltwater.

Model: Kept all rasterized 1:24,000 streams, as well as habitats 7, 890, 900, 920, 930, 980, and 990. Statewide range.


**Hairy Woodpecker, Picoides villosus, ABNYF07040, G5, S4**

Habitat and distribution: Hairy woodpeckers breed throughout Georgia. They inhabit upland or lowland forests of many types, often selecting mature stands of deciduous forest, near edges. They may also be found in mature managed pine stands. They are generally more scarce near human habitation.

Hooded Warbler, *Wilsonia citrina*, ABPBX16010, G5, S5

Habitat and distribution: Hooded warblers breed throughout Georgia primarily in fairly large tracts of moist, mature deciduous forests, especially bottomlands, and near streams or in ravines. Sometimes they are also found in mature pine forests.


Horned Lark, *Eremophila alpestris*, ABPAT02010, G5, S3S4

Habitat and distribution: Horned larks have experienced a range expansion in Georgia, and are now found throughout much of the state. Formerly considered a prairie species, they are birds of open country. In Georgia they are most often seen around cultivated fields and pastures.

Model: Habitats 80 and 83 within digitized range.


House Finch, *Carpodacus mexicanus*, ABPY04040, G5, S5

Habitat and distribution: House Finches are expanding their range in Georgia after being introduced from the Western U.S., and are now permanent residents throughout most of the state. They breed chiefly in urban and suburban areas, and sometimes in agricultural areas. These finches are frequently encountered around bird feeders.

Model: Habitats 20, 22, 24, 72, 73, 80, 83, 201, 202, and 203 within digitized range.


House Sparrow, *Passer domesticus*, ABPBZ01010, G5, SE5

Habitat and distribution: Introduced from the Old World, house sparrows are permanent statewide residents in Georgia. Always found near humans, they may nest in cities or agricultural areas. They are absent from forest, including forested residential areas.

Model: Habitats 22, 24, 80, and 83. Statewide range.


House Wren, *Troglodytes aedon*, ABPBG09010, G5, S4

Habitat and distribution: House wrens in Georgia breed from just above the Fall Line northwards. During the breeding season, they occupy small blocks of forest with abundant shrubbery and openings. Suburban wooded residential areas are ideal.

Model: Habitats 22, 72, 73, 201, 202, and 203 within digitized range.


Indigo Bunting, *Passerina cyanea*, ABPBX64030, G5, S5
Habitat and distribution: Indigo buntings breed throughout most of Georgia, except for a large part of the Okefenokee Swamp. They prefer open places such as forest openings or clearcuts, power line rights-of-way, and pastures.


**Kentucky Warbler, Oporornis formosus, ABPBX11010, G5, S5**

Habitat and distribution: Kentucky warblers breed throughout much of Georgia, except on the coast and lower Coastal Plain. They like any type of rich, moist hardwood forest at moderate elevations; habitat includes bottomlands and ravines with laurel and rhododendron.


**Killdeer, Charadrius vociferous, ABNNB03090, G5, S5**

Habitat and distribution: Killdeer are permanent residents of open areas throughout Georgia. Although often associated with water, they may also be found at some distance from it. Pastures, plowed fields, recent clearcuts, golf courses, airports, roadsides and large suburban lawns are all suitable habitats.

Model: Habitats 7, 9, 11 (shallow fresh and saltwater), 20, 22, 24, 31, 72, 73, 80, 83, 513, 920, and 930. Statewide range.


**King Rail, Rallus elegans, ABNME05020, G4G5, S4S5**

Habitat and distribution: Although common only in the Coastal Plain, King rails breed throughout much of Georgia. They favor a habitat of extensive freshwater or brackish marsh with abundant vegetation of sedges, bulrushes, and cattails.

Model: Habitat 930 within digitized range.


**Least Bittern, Ixobrychus exilis, ABNGA02010, G5, S4**

Habitat and distribution: Least bitterns breed commonly in Georgia along the coast and locally in much of the rest of the state. Breeding habitat is freshwater marshes with tall emergent vegetation.

Model: Habitat 930 within digitized range.


**Loggerhead Shrike, Lanius ludovicianus, ABPBR01030, G5, S4**

Habitat and distribution: Loggerhead shrikes are permanent residents throughout Georgia, except the Blue Ridge, parts of the upper Piedmont, and Okefenokee. Birds of open country, they may inhabit fields or pastures, particularly those with scattered trees for perching. Open longleaf pine also provides suitable habitat.

Model: Habitats 20, 80, 83, 513, and 620 within digitized range.
Louisiana Waterthrush, *Seiurus motacilla*, ABPBX10030, G5, S5

Habitat and distribution: Louisiana waterthrushes breed throughout Georgia, except the lower Coastal Plain. They are found in association with streams, particularly fast-flowing rocky streams or those with gravel bottoms. They favor deciduous forests, but may also breed near mud-bottomed streams in cypress swamps and bottomland forests.


**Mallard, Anas platyrhynchos**, ABNJB10060, G5, S5

Habitat and distribution: Believed to be feral birds in most of the South, mallards breed statewide in Georgia, except for a large part of the Okefenokee Swamp. They may be found in freshwater habitats such as marshes, lakes, or flooded bottomlands.

Model: Habitats 7 (only when associated with fresh water), 11 (fresh water only), 73, and 930. Statewide range, except much of the Okefenokee.


**Mourning Dove, Zenaida macroura**, ABNPB04040, G5, S5

Habitat and distribution: Mourning doves are permanent residents throughout Georgia, adaptable to a wide range of habitats. They may be found in open woods, often along the margins, in hedgerows, and in wooded residential areas.


**Northern Bobwhite, Colinus virginianus**, ABNLC21020, G5, S5

Habitat and distribution: Northern bobwhite quail may be found in a variety of brushy habitats throughout much of Georgia. Suitable habitats include brushy pastures or fields, abandoned agricultural land, woodland margins, and open pine woods.

Model: Habitats 20, 31, 80, 83, 420, 422, 423, 432, 434, 440, 441, 512, and 620 within mask of elevations < 975 m (3200 feet). Applied mask of road density < 80 m per ha to eliminate urban areas. Statewide range, except barrier islands.


**Northern Cardinal, Cardinalis cardinalis**, ABPBX60010, G5, S5

Habitat and distribution: Northern cardinals breed throughout Georgia, where they are widespread in many wooded and shrubby habitats. They are abundant in wooded residential areas and along the edges of forests.


Northern Flicker, *Colaptes auratus*, ABNYF10020, G5, S5

Habitat and distribution: Northern flickers inhabit open woods, forest edge, and residential areas throughout Georgia. They seem to prefer hardwoods for breeding, but are also found in mixed woods and pines. They are most often found along forest edges.

Model: Created grid of “edge” pixels between open habitats (20, 22, 31, 34, 72, 73, 80, 83, 201, 202, 203, and 930) and all forested habitats (410, 411, 412, 414, 415, 420, 422, 424, 425, 431, 432, 433, 434, 440, 441, 511, 512, 513, 620, 890, 900, 980 and 990). Applied 1 km moving window (FOCALMEAN using rectangle), keeping areas where values were > 0. Used results of this as a mask for all suitable habitats. Statewide range.


Northern Mockingbird, *Mimus polyglottos*, ABPBK03010, G5, S5

Habitat and distribution: Northern mockingbirds breed throughout most of Georgia. Most common around towns, suburbs, and along roadides, they may also be found in pastures or farm hedges, shrub patches, and woodland edges.

Model: Habitats 9, 20, 22, 24, 31, 34, 72, 73, 80, 83, 201, 202, 203, 512, 513, and 620. Statewide range.


Northern Parula, *Parula Americana*, ABPBX02010, G5, S5

Habitat and distribution: Northern parulas favor two different breeding habitat types in Georgia. On the Coastal Plain and Piedmont, they frequent swamps and mature bottomland hardwood. In mountain areas they are found in hemlock and mixed hemlock-deciduous forests, and occasionally pure hardwoods.


Northern Rough-winged Swallow, *Stelgidopteryx serripennis*, ABPAU07010, G5, S5

Habitat and distribution: Northern rough-winged swallows may be seen throughout most of Georgia in open country and woodlands, particularly in locations near streams. They nest in vertical banks of ponds, lakes, rivers, quarries or other embankments, and their distribution depends on the availability of these nesting sites.

Model: Kept clumps of habitat 11 greater than 10 ha. Expanded resultant grid 1.2 km. Used this as mask for suitable habitats 11, 20, 22, 31, 33, 34, 72, 73, 80, 83, 201, 202, 203, 900, 930, and 980. Statewide range, except areas of open ocean.


Orchard Oriole, *Icterus spurious*, ABPBXB9070, G5, S5

Habitat and distribution: Orchard orioles breed throughout Georgia in a variety of habitats. They may be found in clearcuts, agricultural areas, and sometimes around residential areas or parks.

Model: Habitats 20, 22, 31, 72, 73, 80, 83, 201, 202, 203, 512, and 513 within mask of elevations < 762 m (2500 feet). Statewide range.
Osprey, *Pandion haliaetus*, ABNKCC01010, G5, S3

Habitat and distribution: Ospreys breed throughout Georgia, although they are common only along the coast and in the Okefenokee Swamp; in the northern part of the state they are usually seen near reservoirs.

Model: Kept all rasterized 1:24,000 streams, as well as clumps of habitat 11 greater than 10 ha. Within a mosaicked grid of these areas, expanded them 2 km. Used this as mask for suitable habitats 11, 920, and 930. Kept all 11, 920, and 930 in Okefenokee area. Clipped by digitized range.


Ovenbird, *Seiurus aurocapillus*, ABPBX10010, G5, S5

Habitat and distribution: Ovenbirds breed in northern Georgia in extensive, mature, dry deciduous forests, usually in hilly areas. Occasionally they are found in mixed forest.


Pileated Woodpecker, *Dryocopus pileatus*, ABNYF12020, G5, S4

Habitat and distribution: Pileated woodpeckers breed throughout Georgia in mature coniferous, deciduous or mixed forest, from swampy areas to uplands. They require a large number of dead trees, and are more common on larger tracts of wooded land.

Model: From grid of all forested areas, expanded forest areas 1 pixel to cross roads, etc. From resultant grid, created mask of forested areas > 165 ha. Kept habitats 201, 202, 203, 410, 411, 412, 413, 414, 415, 420, 422, 424, 425, 431, 432, 433, 434, 440, 441, 620, 890, 900, and 990 within mask. Statewide range.


Pine Warbler, *Dendroica pinus*, ABPBX03170, G5, S5

Habitat and distribution: Pine warblers reside year-round throughout most of Georgia. They prefer mid-aged to mature pine stands, but may also be found in mixed forest.

Model: Habitats 422, 423, 425, 431, 432, 434, 440, 441, and 620 within mask of elevations < 914 m (3000 feet). Statewide range.


Prairie Warbler, *Dendroica discolor*, ABPBX03190, G5, S5

Habitat and distribution: Prairie warblers breed throughout Georgia. Habitat includes open brushy, shrubby areas, sand dunes, and young pine plantations. They may also be found in mature pine stands.


**Prothonotary Warbler, Protonotaria citrea, ABPBX07010, G5, S5**

Habitat and distribution: Prothonotary warblers in Georgia breed commonly south of the fall line and locally in the Piedmont and Ridge & Valley. They prefer swamps and moist bottomland forests near standing water.

Model: Habitats 890 and 900 within digitized range.


**Purple Martin, Progne subis, ABPAU01010, G5, S5**

Habitat and distribution: Found throughout Georgia at moderate and lower elevations, purple martins may be seen in open fields and cut over areas, especially in places near water. They commonly nest in purple martin houses placed around farms, ponds, or residences.

Model: Habitats 7 (coastal beaches omitted), 11 (freshwater only), 20, 22, 31, 73, 80, 83, 930, and 980. Statewide range.


**Red-bellied Woodpecker, Melanerpes carolinus, ABNYF04170, G5, S5**

Habitat and distribution: Red-bellied woodpeckers breed throughout Georgia in deciduous, pine or mixed forest at moderate and low elevations. Other suitable habitat includes parks or residential areas with mature trees, pecan groves and small woodlots.

Model: Habitats 31, 72, 73, 201, 202, 203, 410, 411, 412, 413, 414, 420, 422, 431, 432, 434, 440, 441, 512, 620, 890, 900, 980, and 990 within mask of elevations > 914 m (3000 feet).


**Red-eyed Vireo, Vireo olivaceus, ABPBW01240, G5, S5**

Habitat and distribution: Red-eyed vireos breed throughout Georgia in deciduous or mixed forest, although they are not common in forests where conifers predominate. They may be found in both bottomlands and uplands.


**Red-headed Woodpecker, Melanerpes erythrocephalus, ABNYF04040, G5, S4**

Habitat and distribution: Red-headed woodpeckers breed throughout Georgia in deciduous, coniferous, and mixed forests. They often are seen in open pine or oak woods. Other habitats include parks, golf courses, and residential areas.


**Red-shouldered Hawk, Buteo lineatus, ABNKC19030, G5, S4**

Habitat and distribution: The red-shouldered hawk breeds throughout Georgia at lower elevations. It is most common in and along the edges of wooded swamps, bottomlands, and moist, mature forests.

Red-tailed Hawk, *Buteo jamaicensis*, ABNKC19110, G5, S4

Habitat and distribution: Red-tailed hawks breed throughout most of Georgia. They have a wide tolerance of habitat types, but nest most commonly in mature deciduous or mixed woodlands. Red-tailed hawks prefer to forage in open areas and along forest edges.


Habitat and distribution: Red-winged blackbirds are year-round residents throughout Georgia. They may nest in freshwater or saltwater marshes, wet thickets, borders of lakes or ponds, and in open places in swamps. They may also be seen in pastures, old fields, and other early successional habitats.

Model: Habitats 7 (coastal beaches omitted), 11 (shallow freshwater only), 20, 31, 73, 80, 83, 890, 920, 930, 980, and 990. Statewide range.


Rock Dove, *Columba livia*, ABNPB01010, G5, SE5

Habitat and distribution: Introduced from Eurasia, rock doves are now found statewide in Georgia. They are not restricted to a particular breeding season, often nesting in midwinter. Rock doves are most frequently encountered in parks or other urban places, but may also be seen in agricultural areas.

Model: Habitats 24, 80, and 83. Statewide range.


Ruby-throated Hummingbird, *Archilochus colubris*, ABNUC45010, G5, S5

Habitat and distribution: Ruby-throated hummingbirds breed statewide in Georgia. They are most numerous in moist areas such as bottomland woods, but may also be found in upland forest, overgrown fields, clearcuts, and residential areas. They may be locally common where there are flowers such as honeysuckle or trumpetvine.


Scarlet Tanager, *Piranga olivacea*, ABPBX45040, G5, S5

Habitat and distribution: Scarlet tanagers breed throughout much of Georgia generally north of the Fall Line. They prefer upland deciduous forest, but may also be found in bottomlands, mixed forest, and, in some places, heavily forested suburban areas.


Sharp-shinned Hawk, *Accipiter striatus*, ABNKC12020, G5, S4

Habitat and distribution: Sharp-shinned hawks in Georgia breed above the Fall Line in forested areas, and are most numerous in mixed forest, although they also occupy hardwoods and coniferous woods.


Solitary Vireo, *Vireo solitarius*, ABPBW01160, G5, S5

Habitat and distribution: Solitary vireos breed in northern Georgia in a variety of forested habitats. In the mountains, they are most often found in mixed hemlock and white pine forests, and in deciduous forests at higher elevations. They may be found in deciduous and mixed forests at some Piedmont locations south to near the Fall Line.


Song Sparrow, *Melospiza melodia*, ABPBXA3010, G5, S5

Habitat and distribution: Song sparrows breed throughout much of Georgia north of the Fall Line. They nest in a variety of shrubby habitats in open country, including farmyards, pastures, hedgerows, and clearcuts. Song sparrows may also be found in residential areas.

Model: Habitats 20, 22, 31, 72, 73, 80, 83, 201, 202, 203, and 980 within digitized range.


Summer Tanager, *Piranga rubra*, ABPBX45030, G5, S5

Habitat and distribution: Summer tanagers breed in most of Georgia at moderate and lower elevations. They most often inhabit relatively dry stands of hardwood or mixed forest. However, they may also be found in wooded residential areas, pine stands, or bottomland hardwoods. They are quite rare in most of the Okefenokee.

Model: Habitats 410, 411, 412, 413, 420, 422, 432, 434, 440, 441, 512, 513, and 900. Applied masks of elevations < 762 m (2500 feet) and forested areas > 40 ha. Statewide range, except much of the Okefenokee.


Swainson's Warbler, *Limnotrothlypis swainsonii*, ABPBX09010, G4, S3

Habitat and distribution: Swainson's warblers breed throughout much of Georgia. On the Coastal Plain and Piedmont they may be found in moist bottomland hardwood stands, often in association with canebrakes. In the mountains they are usually found in ravines of hardwoods or mixed forest, in association with rhododendron or mountain laurel.


Tree Swallow, *Tachycineta bicolor*, ABPAU03010, G5, S5
Habitat and distribution: Expanding their range southward, tree swallows currently breed in much of Georgia north of the Fall Line. They inhabit open areas near larger lakes or rivers.

Model: Applied 1.2 km buffer to 1:100,000 stream coverage. Kept all clumps of habitat 11 greater than 40 ha. Mosaiced these two grids, and used as mask for suitable habitats 7, 11, 22, 80, 83, 930, and 980. Clipped by digitized range.


**Tufted Titmouse, Baeolophus bicolor, ABPAW01110, G5, S5**

Habitat and distribution: Year-round residents throughout Georgia, tufted titmice may be found in many woodland habitats. They tend to prefer deciduous forest, but may also be found in mixed. Titmice occur in both uplands and bottomlands, and are also very common in wooded residential areas.


**Turkey Vulture, Cathartes aura, ABNKA02010, G5, S5**

Habitat and distribution: Turkey vultures breed throughout Georgia, usually nesting in a woodland, cliff or other remote area. They may be seen foraging just about everywhere, including both open and forested habitat.


**Virginia Rail, Rallus limicola, ABNME05030, G5, S3S4**

Habitat and distribution: Virginia rails may breed at scattered locations in Georgia above the Fall Line. They inhabit freshwater marshes with emergent vegetation such as cattails or bulrushes. Virginia rails may forage over shallow water, moist soil or mudflats.

Model: Habitat 930 within digitized range.


**Whip-poor-will, Caprimulgus vociferous, ABNTA07070, G5, S5**

Habitat and distribution: Whip-poor-wills are expanding their range southward in Georgia, onto much of the Coastal Plain. They usually inhabit hardwood or mixed forest, as well as some pine types.


**White-breasted Nuthatch, Sitta carolinensis, ABPAZ01020, G5, S4S5**

Habitat and distribution: White-breasted nuthatches may be seen throughout much of Georgia, although they are rare in the southern part of the state. They are found in deciduous or mixed forest, particularly in mature stands. They prefer upland forests, but may also be found in bottomlands, parks and residential areas with mature trees. Birds on the Coastal Plain may be found in longleaf pine.

White-eyed Vireo, *Vireo griseus*, ABPBW01020, G5, S5

**Habitat and distribution:** White-eyed vireos breed throughout most of Georgia at lower elevations. They prefer areas of thickets, brambles, undergrowth, old fields, fencerows, clearcuts, and willows. They may also be found along streamsides or swampy woods, and in association with live oak or Carolina bays.


Wild Turkey, *Meleagris gallopavo*, ABNLC14010, G5, S5

**Habitat and distribution:** Wild turkeys are year-round residents throughout Georgia where they inhabit a variety of wooded habitats. They may be found in hardwood or mixed forests, particularly those with oaks; they are less common in pine forests. Wild turkeys often select habitats where forest is interspersed with other types of land cover, especially openings.

Model: Habitats 20, 31, 80, 410, 411, 412, 413, 414, 415, 420, 422, 431, 432, 434, 440, 441, 512, 620, 900, and 990. Applied mask of road density < 80 m per ha to eliminate urban areas. Clipped by digitized range.


Wood Duck, *Aix sponsa*, ABNJB09010, G5, S5

**Habitat and distribution:** Wood ducks are permanent residents throughout most of Georgia. They favor quiet inland waters near woodlands, and may also be found on ponds, in marshes, and along streams. They may nest in holes in trees or in bird boxes.

Model: Habitats 11 (freshwater only), 890, 900, and 930. Statewide range.


Wood Thrush, *Hylocichla mustelina*, ABPBJ19010, G5, S5

**Habitat and distribution:** Wood thrushes breed throughout Georgia, although they are somewhat rare in the extreme southern part of the state, and largely absent from the Okefenokee. Wood thrushes prefer rich deciduous forests such as bottomland hardwoods, but may also be found in mixed forests with a deciduous understory, and in some wooded residential areas.


Worm-eating Warbler, *Helmitheros vermivorus*, ABPBX08010, G5, S5

**Habitat and distribution:** Worm-eating warblers breed in Georgia in mature deciduous and mixed forests, particularly those with a rich understory of rhododendron or mountain laurel. Forest types include oak-hickory, beech-maple and eastern hemlock.


**Yellow Warbler**, *Dendroica petechia*, ABPBX03010, G5, S4

Habitat and distribution: Yellow warblers prefer open scrubby vegetation, often along streams or other water bodies. Willow or alder thickets, clearcuts, and old fields, particularly in damp areas, represent the best habitats.

Model: Kept habitats 7, 11 (shallow fresh water only), and 980. Kept habitats 20, 31, and 80 where they intersect with National Wetlands Inventory (NWI) freshwater wetlands. Clipped by digitized range.


**Yellow-billed Cuckoo**, *Coccyzus americanus*, ABNRB02020, G5, S5

Habitat and distribution: Yellow-billed cuckoos breed throughout Georgia in habitats with thick, tangled vegetation such as moist deciduous forests, bottomland woods, and thickets. They avoid areas of pure conifers.

Model: Habitats 410, 411, 412, 413, 414, 420, 431, 434, 890, and 900 within mask of elevations < 1066 m (3500 feet). Statewide range, except much of the Okefenokee.


**Yellow-breasted Chat**, *Icteria virens*, ABPBX24010, G5, S5

Habitat and distribution: Yellow-breasted chats breed at lower elevations throughout most of Georgia. They prefer overgrown fields, streamside thickets, brushy areas, and forest edges, often in dry areas or near briars. They become most common in harvested forests a few years after cutting.

Model: Habitats 20, 31, 80, 422, 440, 441, 513, and 620 within digitized range.


**Yellow-throated Vireo**, *Vireo flavifrons*, ABPBW01170, G5, S4

Habitat and distribution: Yellow-throated vireos breed throughout Georgia at moderate or low elevations. They favor sites near the edges of mature, moist deciduous or mixed forest, and are often seen in bottomlands. They generally avoid pure coniferous forests.

Model: Created grid of “edge” pixels between open habitats 20, 31, 80, and 513 and all suitable forested habitats (410, 411, 412, 414, 420, 431, 432, 434, 890, 900, and 990). Applied 1 km moving window (FOCALMEAN using rectangle), keeping areas where values were > 0. Used results of this as a mask for suitable forested habitats. Statewide range.


**Yellow-throated Warbler**, *Dendroica dominica*, ABPBX03130, G5, S5

Habitat and distribution: Yellow-throated warblers breed throughout Georgia. They favor broadleaf evergreen or bottomland hardwood forests, especially those mixed with some pines or cypresses. They are often found in association with Spanish moss on the Coastal Plain, and in pines in the mountains.

**References for the works cited above can be found on the CD-ROM A Gap Analysis of Georgia, Disc 2 that was included with this report (follow \GISData\Verts\Birds\spreadsheet\vert_references.doc).**
Appendix 3, Mammal Habitat and Distribution. Habitat and distribution information used in the Georgia GAP Analysis. Copied and adapted (to include only ACC species) from the CD-ROM A Gap Analysis of Georgia, Disc 3, August 2003 Final Report that was included with this report (follow |GISData|Verts|Mammals|spreadsheet! amphibian_methods.doc). For a list of the habitat codes used in the models, see Appendix 5, Habitat Code List). This appendix is included to assist the user in making habitat management and connectivity decisions, in conjunction with the habitat range maps provided for each species.

**American Beaver, Castor canadensis, AMAFE01010, G5, S5**

Habitat and distribution: American beavers are found throughout Georgia in a variety of aquatic habitats. They may occupy almost any stream, pond, swamp or lake with an adjacent supply of trees.

Model: Applied 30 meter buffer to 1:24,000 stream coverage. Kept habitats 410, 411, 412, 414, 424, 431, 433, 434, 890, 900, 980, and 990 within buffer and mask of slope < 4%. Kept habitats 7 (associated with freshwater), 11 (shallow freshwater only), 930, and 980 in all cases. Clipped by digitized range.


**Big Brown Bat, Eptesicus fuscus, AMACC04010, G5, S5**

Habitat and distribution: Widely distributed throughout the United States, big brown bats occur statewide in Georgia where they may be seen foraging over rivers, in pastures, at forest edges, along city streets, and in a variety of mostly open habitats. They may roost in hollow trees, caves, tunnels, and in other manmade structures.


**Black Rat, Rattus rattus, AMAFF21010, G5, SE**

Habitat and distribution: Not native to North America, black rats are now found throughout the Southeast in and around garbage dumps, granaries, warehouses, and other environments associated with human presence. Agile climbers, they are at home in roofs and attics, but may also live in feral situations in urban forests.

Model: Habitats 22, 24, 72, 83, 201, 202, and 203. Statewide range.


**Bobcat, Lynx rufus, AMAJH03020, G5, S5**

Habitat and distribution: Bobcats occur throughout Georgia in a variety of habitat types. They may be seen in practically any forest type, although they tend to prefer large tracts and may avoid humans.


Common Gray Fox, *Urocyon cinereoargenteus*, AMAJA04010, G5, S5

Habitat and distribution: Occurring throughout the Southeastern U.S., gray foxes may be found in a variety of wooded or brushy habitats. They prefer locations with a diversity of woods and fields.


Common Raccoon, *Procyon lotor*, AMAJE02010, G5, S5

Habitat and distribution: Occurring throughout Georgia, these adaptable animals may be found in every ecological community having trees, but are most abundant in habitats where there is water: hardwood swamps, floodplain forests, and fresh- and saltwater marshes. Other habitats include mesic hardwood stands, farmlands, and suburban residential areas.


Coyote, *Canis latrans*, AMAJA01010, G5, S4?

Habitat and distribution: Not native to the Southeast, coyotes have expanded their range and are now found statewide in Georgia. Although they prefer open woodlands, rangeland, and brushy or boulder-strewn areas, these extremely adaptable animals are able to survive almost anywhere.


Eastern Chipmunk, *Tamias striatus*, AMAFB02230, G5, S5

Habitat and distribution: Found primarily in forested habitats, chipmunks occur north of a line running from extreme southwest Georgia to the lower Piedmont (in east Georgia). Although most often associated with deciduous forests, they are also familiar inhabitants of manmade environments such as golf courses, parks, suburbs, backyards and gardens.


Eastern Cottontail, *Sylvilagus floridanus*, AMAEB01040, G5, S5

Habitat and distribution: Highly adaptable, eastern cottontails occur statewide in Georgia, except for high elevations and the barrier islands, in open, brushy environments. They are often most abundant in disturbed or transitional habitats such as fallow weedy fields with briars, hedgerows, brushlands with grassy openings, and open forest edges.

Model: Kept habitats 20, 22, 31, 72, 73, 80, 201, 202, 203, 410, 411, 412, 413, 414, 415, 420, 422, 423, 425, 431, 432, 433, 434, 440, 441, 512, and 620 within mask of elevations 1000 m (3280 feet). Clipped by digitized range.

**Eastern Fox Squirrel, Sciurus niger, AMAFB07040, G5, S5**

Habitat and distribution: Typically found in forests with a pine component, fox squirrels once ranged throughout much of Georgia, but are now limited to areas of the Coastal Plain and scattered populations in the Piedmont and Ridge and Valley. Fox squirrels often forage on the ground, and are more numerous in open forest.

Model: Kept habitats 73, 201, 202, and 203 on Coastal Plain. Kept habitats 420, 422, 432, 434, 440, 441, 512, and 620 in all cases. Clipped by digitized range.


**Eastern Gray Squirrel, Sciurus carolinensis, AMAFB07010, G5, S5**

Habitat and distribution: Common to abundant, gray squirrels may be found throughout Georgia. Primarily arboreal, they occupy forested habitats including mature hardwood forest with dense undergrowth, river bottoms, mixed forest, and dense or mature stands of oak and hickory. Gray squirrels also thrive in suburban and residential areas where there are trees.


**Eastern Harvest Mouse, Reithrodontomys humulis, AMAFF02020, G5, S4**

Habitat and distribution: Eastern harvest mice occur throughout Georgia in a variety of open habitats including old fields with broomsedges and other tall grasses, roadside ditches, and weedy areas with tangled briars or honeysuckle. They may also be found in marshy areas and in some pine stands.

Model: Kept habitats 20, 31, 80, 83, 422, 440, 441, 620, and 930 within mask of elevations < 500 m (1640 feet). Clipped by digitized range.


**Eastern Mole, Scalopus aquaticus, AMABB04010, G5, S5**

Habitat and distribution: Eastern moles may be found throughout Georgia in a variety of forested and grassland habitats. Fossorial mammals, moles spend most of their lives an underground system of tunnels, and are more abundant in areas with moist, loamy or sandy soil. They may be scarce or absent from heavy clay, stony or gravelly soil, or soil that is too wet or too dry.


**Eastern Pipistrelle, Pipistrellus subflavus, AMACC03020, G5, S5**

Habitat and distribution: Occurring throughout Georgia, eastern pipistrelles may be seen foraging at the edge of forested areas and in open pastures, often at sites near lakes or ponds. In cold climates, eastern pipistrelles hibernate in caves or mines, often returning to the same location year after year.

Eastern Red Bat, *Lasiurus borealis*, AMACC05010, G5, S5

Habitat and distribution: Common in the eastern United States, red bats occur throughout Georgia where they may be seen foraging over streams, small ponds, and forests. Red bats roost under loose bark or in the dense foliage of trees, often in edge habitats.


Eastern Spotted Skunk, *Spilogale putorius*, AMAJF05010, G5, S4

Habitat and distribution: Possibly occurring statewide in Georgia (southeast Georgia is questionable), spotted skunks may be found on the Piedmont and Coastal Plain in habitats possessing good cover such as fallow fields, weedy pastures, fencerows, and brushy or sparsely wooded areas. In the mountains, they more often found in open forests with rocky outcrops, or along streams with a heavy rhododendron cover.


Evening Bat, *Nycticeius humeralis*, AMACC06010, G5, S5

Habitat and distribution: Abundant throughout Georgia, evening bats may be seen foraging over clearings, farm ponds, in forest openings, and along watercourses. They typically form maternity colonies in hollow trees (frequently standing snags in beaver ponds), but also in sites such as culverts, attics and manmade structures. Relatively common throughout their summer range, evening bats are not often observed in winter.


Golden Mouse, *Ochrotomys nuttalli*, AMAFF04010, G5, S5

Habitat and distribution: Golden mice may be found throughout Georgia in forested habitats, including moist thickets, densely forested lowlands and floodplain forests. They may also be abundant in upland pine forest. In general, they prefer moist areas with a thick understory.


Hispid Cotton Rat, *Sigmodon hispidus*, AMAFF07010, G5, S5
Habitat and distribution: Hispid cotton rats are found throughout Georgia in open and semi-open habitats with sufficient cover to provide security from predation. They may be abundant in old fields with broomsedges and other grasses, in marshes, and in thickets and other habitats with dense growth of honeysuckle or blackberries.

Model: Habitats 9, 20, 22, 31, 72, 80, 83, 201, 202, 203, 422, 440, 441, 512, 513, 620, 920, 930, and 980. Statewide range.


**Hoary Bat, Lasiurus cinereus, AMACC05030, G5, S4**

Habitat and distribution: Hoary bats are found throughout Georgia in a variety of wooded habitats including pine, hardwood or mixed forest stands. In addition, they frequently forage over open areas such as clearcuts or small ponds in wooded areas.


**House Mouse, Mus musculus, AMAFF22010, G5, SE**

Habitat and distribution: Introduced from Europe and Asia, house mice are now ubiquitous throughout the United States. Although strongly associated with human habitats, they may also survive in the wild in fields, pastures, fencerows, weedy roadsides and sometimes even in wooded environments.

Model: Habitats 22, 24, 72, 73, 80, 83, 201, 202, and 203. Statewide range.


**Least Shrew, Cryptotis parva, AMABA04010, G5, S5**

Habitat and distribution: Occurring throughout the Southeast, least shrews generally inhabit fields or other open grassy areas, but may also be found in marshes or wooded habitats such as saw palmetto hammocks or managed stands of mature loblolly or shortleaf pine.

Model: Habitats 20, 31, 80, 420, 422, 434, 440, 441, 513, 620, and 930. Statewide range.


**Least Weasel, Mustela nivalis, AMAJF02020, G5, S1**

Habitat and distribution: Least weasels reach the southern end of their range in far northern Georgia. They are normally associated with riparian areas, especially around agricultural or pasture areas.

Model: Habitats 80, 930, and 980 within digitized range.


**Long-tailed Weasel, Mustela frenata, AMAJF02030, G5, S5**

Habitat and distribution: Long-tailed weasels may be found in a wide variety of habitats throughout Georgia. Frequently found near water, they may occupy every type of terrestrial community from forested to open habitats.


**Marsh Rice Rat, Oryzomys palustris, AMAFF01010, G5, S5**

Habitat and distribution: Marsh rice rats may be found throughout Georgia in wetland environments such as swamps, freshwater and saltwater marshes, and wet hammocks. Damp, grassy meadows, ditches, and the edges of lakes or streams also may provide suitable habitat for rice rats.

Model: Kept habitats 20, 31, and 80 where they intersect with NWI wetlands. Kept habitats 7, 9, 420, 890, 900, 920, 930, 980, and 990 in all cases. Clipped by digitized range.


**Meadow Jumping Mouse, Zapus hudsonius, AMAFH01010, G5, S3**

Habitat and distribution: Meadow jumping mice inhabit wet meadows or fields in the Blue Ridge and Piedmont provinces of Georgia. Although perhaps most often seen in meadows, jumping mice may also be encountered in vegetation along creeks, at the edges of woods, and occasionally in woodlands having a lush carpet of grasses, sedges and herbs.

Model: Applied 30 m buffer to 1: 24, 000 stream coverage. Kept habitats 80, 411, and 412 within buffer. Kept habitats 410, 414, 900, and 930 in all cases. Clipped by digitized range.


**Meadow Vole, Microtus pennsylvanicus, AMAFF11010, G5, S3S4**

Habitat and distribution: Generally found in the northeast Georgia mountains and upper Piedmont, meadow voles occur in a variety of grassland habitats such as wet meadows, upland fields, orchards, and openings in forests. They seem to prefer wet or moist areas.

Model: Kept habitats 20, 31, and 80 under moist conditions (where topographic relative moisture index ≥ 30). Kept habitat 930 in all cases. Clipped by digitized range.


**Mink, Mustela vison, AMAJF02050, G5, S5**

Habitat and distribution: Semi-aquatic mammals, mink may be found throughout Georgia in wetland habitats of all kinds. They may den in the banks of lakes, rivers, and other waterways, and may also inhabit swamps and freshwater, brackish or coastal salt marshes.

Model: Applied 30 m buffer to 1: 24, 000 stream coverage. Kept habitats 410, 414, 431, 433, and 990 within buffer. Kept habitats 7 (coastal beaches omitted), 11 (shallow fresh and saltwater; open ocean omitted), 890, 900, 920, 930, and 980 in all cases. Statewide range.


**Muskrat, Ondatra zibethicus, AMAFF15010, G5, S5**

Habitat and distribution: Found primarily above the Fall Line in Georgia (although well south of that in the Altamaha drainage), muskrats occupy aquatic habitats, including farm ponds, rivers, impoundments, and marshes.
Model: Habitats 7 (where associated with freshwater), 11 (shallow freshwater only), and 930 within digitized range.


**Nine-banded Armadillo, Dasypus novemcinctus, AMADA01010, G5, S4**

Habitat and distribution: Expanding their range northwards in Georgia, nine-banded armadillos prefer locations with moist, loose textured soil, and are rare in sites with heavy clay or rocky soil, as well as in waterlogged areas. In the Georgia Piedmont, they are making extensive use of creek and river bottoms.


**Northern River Otter, Lutra canadensis, AMAJFO8010, G5, S5**

Habitat and distribution: Northern river otters are found throughout Georgia in a variety of fresh- and brackish-water habitats. They are most abundant in food-rich coastal areas such as estuaries, and the lower portions of streams or rivers.

Model: Habitats 7 (coastal beaches omitted), 11 (shallow freshwater only), 890, and 930. Statewide range.


**Northern Short-tailed Shrew, Blarina brevicauda, AMABA03010, G5, S5**

Habitat and distribution: Northern short-tailed shrews may be found in the Piedmont and Blue Ridge of Georgia in almost any forested habitat having a thick layer of leaf litter or other ground cover. Other potential habitats for these shrews include brushy areas, old fields and wooded residential areas.


**Norway Rat, Rattus norvegicus, AMAFF21020, G5, SE**

Habitat and distribution: Introduced from Europe, Norway rats have spread throughout North America. Highly adaptable to climate and environmental conditions, they may be found in a variety of urban and rural habitats, almost always in association with man.

Model: Habitats 22, 24, 72, 83, 201, 202, and 203. Statewide range.


**Oldfield Mouse, Peromyscus polionotus, AMAFF03060, G5, S5**

Habitat and distribution: Found in much of the Georgia Piedmont and Coastal Plain, oldfield mice typically inhabit early successional stages of abandoned fields and other open, sandy habitats. They may also occupy grass-covered beach dunes.

Model: Habitats 7, 9, 20, 31, 80, 83, 420, 422, 440, 441, 512, 513, and 620 within digitized range.

Red Fox, *Vulpes vulpes*, AMAJA03010, G5, S5

Habitat and distribution: Red foxes occur throughout Georgia in forested and open country. They use edge environments heavily, and may also inhabit suburban areas, parks or golf courses if daytime hiding places are present.

Model: Habitats 20, 31, 80, 410, 411, 412, 413, 414, 415, 420, 431, 432, 433, 434, 511, 512, and 900 within digitized range.


Silver-haired Bat, *Lasionycteris noctivagans*, AMACC02010, G5, S5

Habitat and distribution: Occurring in Georgia north of the Fall Line, silver-haired bats inhabit forested areas and are often abundant in old-growth or mature forest, where they may roost in dense foliage, in hollow trees or under loose bark. They forage at tree-top level or over small ponds or streams. The winter habits of these bats are poorly known; they are believed to be migratory.

Model: Expanded suitable habitat types 410, 411, 412, 414, 431, 433, 434, and 900 2 pixels. Kept habitat 11 (shallow freshwater only) within expanded area. Retained all other suitable pixels. Clipped by digitized range.


Southeastern Shrew, *Sorex longirostris*, AMABA01060, G5, S4

Habitat and distribution: Southeastern shrews are found throughout Georgia in many open and forested situations. They are perhaps most abundant in moist habitats with a dense ground cover of plants such as wooded swamps, marshes, and floodplain forest. They may also occur in upland forests, old fields, and loblolly pine plantations.


Southern Flying Squirrel, *Glaucomys volans*, AMAFB09010, G5, S5

Habitat and distribution: Woodland dwellers, flying squirrels in Georgia are primarily associated with hardwood forests, especially those with abundant oaks and hickories, but may also inhabit coniferous or mixed forest. Wooded urban parks and residential areas may also provide suitable habitat.


Striped Skunk, *Mephitis mephitis*, AMAJF06010, G5, S5

Habitat and distribution: Occurring statewide in Georgia, striped skunks may be found in a variety of habitats. Abundant in agricultural land or open areas, they may also be found in brushy or rocky places, at the edges of woodlots, and in fencerows. They are also common along forest-field edges, and in suburban and residential areas.

Swamp Rabbit, *Sylvilagus aquaticus*, AMAEB01080, G5, S5

Habitat and distribution: Associated with river floodplains and other aquatic habitats, swamp rabbits occur in Georgia in swamps, marshes, and wet bottomlands. Although swamp rabbits occupy wet bottomlands and swamps, they need access to higher ground during flooding.

Model: Kept habitats 20, 31, and 80 where they intersect with NWI freshwater wetlands. Kept habitats 890, 900, 930, 980, and 990 in all cases. Clipped by digitized range.


Virginia Opossum, *Didelphis virginiana*, AMAAAA01010, G5, S5

Habitat and distribution: Virginia opossums are found statewide in Georgia and throughout most of the United States. Often selecting sites near water, opossums may be found in practically any habitat - even in heavily urban areas. They may show a preference for habitat diversity/edge effect.


White-footed Mouse, *Peromyscus leucopus*, AMAFF03070, G5, S5

Habitat and distribution: Present in Georgia north of the Fall Line, white-footed mice are primarily dwellers of forest edges, brushy areas, and other habitats possessing a tree or shrub canopy. They may also be plentiful in hedgerows bordering agricultural areas. They are less common at high elevations.

Model: Habitats 20, 31, 80, 201, 202, 203, 410, 411, 412, 413, 422, 423, 431, 432, 434, 440, and 900 within digitized range.


White-tailed Deer, *Odocoileus virginianus*, AMALC02020, G5, S5

Habitat and distribution: Although white-tailed deer are currently widespread throughout Georgia, this was not true as recently as the 1950’s. Deer thrive in various interspersed/forest edge habitats where they can find cover and ample forage. Deer are adaptable and very tolerant of human populations.


Woodchuck, *Marmota monax*, AMAFB03010, G5, S3

Habitat and distribution: Recently expanding their range southwards in Georgia, woodchucks may be found in open habitats such as fencerows, thickets or brushy woodland edges, especially along fields, roads or streams. Kudzu patches in the Piedmont are also favored.

Model: Habitats 20 and 80 within digitized range.
Woodland Vole, *Microtus pinetorum*, AMAFF11150, G5, S5

Habitat and distribution: Fossorial mammals, woodland voles are found in most of Georgia in forested habitats characterized by a thick layer of leaf litter. They may also occasionally be found in dense grass, orchards, pinelands, and fallow fields bordering forested areas.


**References for the works cited above can be found on the CD-ROM A Gap Analysis of Georgia, Disc 1 that was included with this report (follow GISData\Verts\Amphibians\spreadsheet\vert_references.doc).**
Appendix 4, Reptile Habitat and Distribution. Habitat and distribution information used in the Georgia GAP Analysis. Copied and adapted (to include only ACC species) from the CD-ROM A Gap Analysis of Georgia, Disc 1, August 2003 Final Report that was included with this report (follow GISData\Verts\Reptiles\spreadsheet\reptile_methods.doc). For a list of the habitat codes used in the models, see Appendix 5, Habitat Code List). This appendix is included to assist the user in making habitat management and connectivity decisions, in conjunction with the habitat range maps provided for each species.

Black Racer, *Coluber constrictor*, ARADB07010, G5, S5

Habitat and distribution: Black racers occur throughout Georgia, and are extremely adaptable in their habitat tolerance, occurring in most terrestrial environments - open pine woods, forest edges, brushy dunes, maritime forests, farmlands, bottomland hardwoods, etc..


Box Turtle, *Terrapene carolina*, ARAAD08010, G5, S5

Habitat and distribution: Box turtles occur throughout Georgia in most types of forest communities. They may also be present in open, early-seral environments such as old fields or recently cut-over areas.


Broadhead Skink, *Eumeces laticeps*, ARACH01080, G5, S5

Habitat and distribution: Broadhead skinks are found throughout Georgia in a variety of forested habitats. They prefer a moist environment with large, spreading trees such as live oak or water oak. Broadhead skinks are very arboreal, and may be observed in both living and dead trees.

Model: Habitats 72, 73, 201, 202, 203, 410, 411, 412, 420, 422, 423, 434, 440, 441, 513, 620, 900, and 990 within digitized range.


Brown Snake, *Storeria dekayi*, ARADB34010, G5, S5

Habitat and distribution: Widespread in the eastern U.S., brown snakes occur throughout Georgia in habitats including hardwood and pine forest, as well as open areas such as orchards, fields and pastures. Brown snakes are notable for their ability to survive in urban environments including parks, golf courses, and most types of residential areas.


**Brown Water Snake, Nerodia taxispilota, ARADB22070, G5, S5**

Habitat and distribution: Brown water snakes are relatively widespread in the Coastal Plain and much of the Piedmont in Georgia, occurring in slow-flowing rivers and streams, and sometimes in shallow waters of lakes and cypress swamps. These large snakes are arboreal, and may frequently be observed basking in trees or shrubs overhanging water.

Model: Applied 30 meter buffer to 1:24,000 stream coverage. Kept habitats 31, 410, 411, 412, 413, 420, 422, 423, 432, 434, 440, 441, 512, 620, 890, 900, 980, and 990 within buffer. Also kept habitat 31 where it intersects with NWIs freshwater wetlands. Kept habitats 7 (associated with freshwater), 11 (shallow freshwater only), 900, 930, and 980 in all cases. Clipped by digitized range.


**Canebrake/Timber Rattlesnake, Crotalus horridus, ARADE02040, G4, S4**

Habitat and distribution: Timber and/or canebrake rattlesnakes are widespread in Georgia, occurring almost statewide. North of the Fall Line, they typically inhabit ridge tops with rocky places that provide winter shelter. In the Coastal Plain, they occupy very diverse habitats including swamps, river floodplains, pine woods, and habitats of the barrier islands.


**Coachwhip, Masticophis flagellum, ARADB21020, G5, S5**

Habitat and distribution: Widespread in Georgia, coachwhips may be found in a variety of drier or open, grassy places. South of the Fall Line, they are typically associated with dry, sandy situations including areas of cut-over pines, pine flatwoods, maritime forest, and sandhills. In the Piedmont, they are usually found in drier forested or cutover areas.

Model: Habitats 9, 20, 31, 80, 411, 412, 413, 420, 422, 423, 432, 434, 440, 441, 512, 513, and 620 within digitized range.


**Common Musk Turtle, Sternotherus odoratus, ARAAE02040, G5, S5**

Habitat and distribution: Common musk turtles occur throughout Georgia, and may be plentiful in ponds, lakes, sloughs, and other still or sluggish water habitats. They require a soft substrate, in which they may hibernate, buried in mud. Although essentially aquatic, common musk turtles may occasionally be observed climbing or basking in the branches of trees overhanging water.

Model: Kept rasterized 1:100,000 streams where slope < 4%. Kept habitats 7 (associated with freshwater) and 11 (freshwater only). Statewide range.


**Copperhead, Agkistrodon contortrix, ARADE01010, G5, S5**
Habitat and distribution: Although absent from the southeastern corner of the state, copperheads may be found nearly everywhere else in Georgia. They are adaptable in their habitat tolerance, and may be found in hardwoods and most types of pine forest, meadows and fields, and frequently in residential areas.


**Corn Snake, Elaphe guttata, ARADB13020, G5, S5**

Habitat and distribution: These colorful snakes are widespread in Georgia, and are encountered throughout the state in xeric habitats like mixed forest, pine flatwoods, or sandhill environments, and sometimes in bottomland or other mesic hardwoods. They may also be abundant around abandoned farms and other places where small rodents thrive.


**Eastern Garter Snake, Thamnophis sirtalis, ARADB36130, G5, S5**

Habitat and distribution: True habitat generalists, garter snakes may be encountered throughout Georgia in most mesic habitats: hardwood and pine forests, on rocky hillsides, and in non-forested situations such as meadows and marshes. Garter snakes also occur in man-made environments such as roadside ditches, powerline rights-of-way, parks, golf courses and residential areas.


**Eastern Hognose Snake, Heterodon platirhinos, ARADB17020, G5, S5**

Habitat and distribution: Eastern hognose snakes occupy sandy and dry habitats throughout Georgia. Typical conditions include pine woods, maritime forests of the barrier islands, and sandhill forests of turkey oak and longleaf pine.


**Eastern Mud Turtle, Kinosternon subrubrum, ARAAE01050, G5, S5**

Habitat and distribution: Although absent from the Blue Ridge of Georgia, eastern mud turtles are widespread elsewhere in the state. They prefer muddy-bottomed locations in slow-flowing or still water of beaver ponds, swamps and sluggish streams.

Model: Kept rasterized 1:100,000 streams, as well habitats 11 (shallow freshwater only), 31 (where it intersects with NWI freshwater wetlands), 890, 900, 930, 980, and 990. Clipped by digitized range.

**Fence Lizard, *Sceloporus undulates*, ARACF14130, G5, S5**

Habitat and distribution: Fence lizards are abundant throughout Georgia, where they are typically associated with open-canopied, dry woodlands or rocky areas.


**Five-lined Skink, *Eumeces fasciatus*, ARACH01050, G5, S5**

Habitat and distribution: Five-lined skinks occur throughout Georgia, where they may be most commonly encountered in mesic hardwood forest. They often prefer locations in valleys and along the banks of streams, and are also frequently observed around residential areas.


**Green Anole, *Anolis carolinensis*, ARACF01010, G5, S5**

Habitat and distribution: Arboreal lizards, green anoles are widespread in Georgia, in moist habitats possessing abundant trees and vegetation of shrubs and vines. They may also be seen in residential areas on fences and other manmade structures.

Model: Habitats 20, 22, 31, 72, 73, 201, 202, 203, 410, 411, 412, 413, 420, 422, 434, 440, 441, 512, 890, 900, 980, and 990 within digitized range.


**Ground Skink, *Scincella lateralis*, ARACH03010, G5, S5**

Habitat and distribution: Occurring throughout Georgia, ground skinks occupy hardwood forests, most pines, and other forest types ranging from cypress-gum to maritime live oak.


**Midland Water Snake, *Nerodia sipedon*, ARADB22060, G5, S5**

Habitat and distribution: Midland water snakes are common inhabitants of a variety of aquatic environments north of the Fall Line and in southwest Georgia. Suitable habitat includes the flowing water of rivers and streams, and quiet, shallow waters of ponds, bogs, marshes and lakes.

Model: Kept rasterized 1:24, 000 streams, as well habitats 7 (associated with freshwater), 11 (shallow freshwater only), 900, 930, and 980. Clipped by digitized range.

**Mole Kingsnake, Lampropeltis calligaster, ARADB19010, G5, S5**

Habitat and distribution: Mole kingsnakes may be observed in Georgia north of the Fall Line and in some areas around the Fall Line. They typically inhabit upland, wooded situations including thickets, hardwood forest, and woods of Virginia pine and other upland pine species. They may also be found in open places such as fields and abandoned farmland.

Model: Habitats 20, 31, 80, 410, 411, 413, 422, 423, 432, 434, 440, and 512 within digitized range.


**Painted Turtle, Chrysemys picta, ARAAD01010, G5, S5**

Habitat and distribution: Painted turtles occur mostly north of the Fall Line in Georgia in freshwater habitats, including slow-moving streams and oxbows, lakes and ponds, and marshes, bogs, and flooded swamps.

Model: Kept rasterized 1:100, 000 streams where slope < 4%. Kept habitats 7 (associated with freshwater), 11 (freshwater only), 890, 900, 930, and 980. Clipped by digitized range.


**Pigmy Rattlesnake, Sistrurus miliarius, ARADE03020, G5, S5**

Habitat and distribution: Pigmy rattlesnakes have a relatively wide range throughout the Coastal Plain and much of the Piedmont in Georgia, and may be encountered in diverse wet and dry forested habitats. They may be encountered in bottomland hardwood or mixed forest, pine flatwoods, swamps and wet savannas, as well as drier situations such as upland mixed forest and longleaf pine-scrub oak. They use sandy or friable soils for burrowing.

Model: Habitats 31, 410, 411, 412, 413, 420, 422, 432, 434, 440, 441, 512, 620, and 900 within digitized range.


**Plainbelly Water Snake, Nerodia erythrogaster, ARADB22020, G5, S5**

Habitat and distribution: Plainbelly water snakes occur in aquatic habitats in much of Georgia. They are frequently associated with river swamps and floodplains, slow-flowing streams, and lakes or ponds with swampy margins, but may also inhabit marshes, ditches, and other permanent bodies of water.

Model: Kept habitats 410, 411, 412, and 434 where they intersect with rasterized 1:24, 000 streams. Kept habitat 31 where it intersects with NWI freshwater wetlands. Kept habitats 7 (associated with freshwater), 11 (shallow freshwater only), 890, 900, 930, 980, and 990 in all cases.


**Queen Snake, Regina septemvittata, ARADB27040, G5, S5**

Habitat and distribution: These slender, aquatic snakes are relatively widespread in Georgia, and are typically associated with small, rocky streams with overhanging branches. Surrounding forest types may include hardwood or mixed forest. Queen snakes thrive in locations abounding in crayfish, which comprise the major component of their diet.
Red-bellied Snake, *Storeria occipitomaculata*, ARADB34030, G5, S5

Habitat and distribution: Occurring in all physiographic regions of Georgia, red-bellied snakes are inhabitants of moist, wooded areas that are characterized by abundant ground litter. Typical habitat includes hardwood and mixed forest, forests of loblolly, shortleaf or longleaf pine, and wooded residential areas.


Ribbon Snake, *Thamnophis sauritus*, ARADB36120, G5, S5

Habitat and distribution: These slender, semi-aquatic snakes occur throughout Georgia in any type of wet situation. They may be particularly abundant along the coast and adjacent Coastal Plain near the edges of lakes, and in and around beaver ponds, marshes, bogs and swamps, and may also occur near flowing water along the edges of streams.

Model: Habitats 7 (associated with freshwater), 11 (shallow freshwater only), 31 (where it intersects with NWI freshwater wetlands), 890, 900, 930, 980, and 990. Statewide range.


Ringneck Snake, *Diadophis punctatus*, ARADB10010, G5, S5

Habitat and distribution: Ringneck snakes may be encountered throughout Georgia in forested habitats. They prefer mesic or moist forest types with friable soil for burrowing. Ringneck snakes require locations with abundant shelter of rotting logs, stumps, rocks and leaf litter. If these conditions are present, they may also be found in urban situations.


River Cooter, *Pseudemys concinna*, ARAAD07020, G5, S4S5

Habitat and distribution: Relatively widespread in Georgia, river cooters occupy several types of freshwater aquatic habitats. They typically prefer rivers and streams possessing moderate current, but may also be found in impoundments of these streams, and in other permanent bodies of water.

Model: Kept rasterized 1:100, 000 streams, as well habitats 7 (associated with freshwater), 11 (shallow freshwater only), and 890. Clipped by digitized range.


Rough Earth Snake, *Virginia striatula*, ARADB39010, G5, S4?
Habitat and distribution: Rough earth snakes are relatively widespread in Georgia south of the mountains. They are typically associated with mesic to dry forested environments, and are, in general, absent from aquatic and wetland habitats.

Model: Habitats 72, 201, 202, 203, 410, 411, 412, 413, 420, 422, 432, 434, 440, 441, and 620 within digitized range.


**Rough Green Snake, Opheodrys aestivus, ARADB23010, G5, S5**

Habitat and distribution: Rough green snakes occur in a variety of habitats throughout Georgia. They are most typically encountered in dense vegetation around lakes and streams, where they may sometimes be observed climbing in trees or shrubs overhanging the water. Suitable habitat for rough green snakes includes cypress or gum swamps, floodplain forest, pine flatwoods, and pocosins of pond pine and sweet bay. They tend to avoid xeric conditions.


**Scarlet Snake, Cemophora coccinea, ARADB03010, G5, S4S5**

Habitat and distribution: Inhabiting all of Georgia except most of the Blue Ridge, scarlet snakes are typically found in dry pine forest of Virginia or shortleaf pine, as well as sandhill environments of longleaf pine and scrub oak. They may also be present in open habitats having sandy, friable soil.

Model: Habitats 31, 201, 202, 203, 413, 420, 422, 423, 432, 434, 440, 441, 512, 513, and 620 within digitized range.


**Six-lined Racerunner, Cnemidophorus sexlineatus, ARACJ02110, G5, S5**

Habitat and distribution: Six-lined racerunners are found throughout Georgia in many types of dry, open environments such as fields, road cuts, rock outcrops, thicket margins and barren waste areas. In general, they favor habitats that are in the early seral stages of plant succession.


**Slender Glass Lizard, Ophisaurus attenuatus, ARACB02010, G5, S3**

Habitat and distribution: Snakelike in appearance, slender glass lizards are present throughout Georgia, where they inhabit grassy fields, brushy, cut-over woodlands and woodland margins. Suitable woodland environments include open forests of loblolly, Virginia, shortleaf or longleaf pine, as well as some xeric hardwoods.

Model: Habitats 20, 31, 80, 412, 413, 420, 422, 423, 432, 434, 440, 441, 512, and 620. Statewide range.


**Smooth Earth Snake, Virginia valeriae, ARADB39020, G5, S4?**
Habitat and distribution: Widespread in Georgia, smooth earth snakes are most often observed along the edges of woods, and in open-canopied, mesic to dry forest. Associated forest types include hardwood, pine, and mixed pine-hardwoods. Smooth earth snakes are, in general, absent from aquatic and wetland habitats.

Model: Habitats 72, 201, 202, 203, 410, 411, 412, 413, 414, 420, 422, 432, 433, 434, 440, 441, and 620 within digitized range.


**Snapping Turtle, *Chelydra serpentina*, ARAAB01010, G5, S5**

Habitat and distribution: Snapping turtles occur in all physiographic regions of Georgia, and may be abundant in most permanent freshwater habitat types. They thrive in swampy places, and in rivers and streams, ponds, lakes, marshes and bogs.

Model: Kept rasterized 1:24,000 streams where slope < 4%. Kept habitats 7 (associated with freshwater), 11 (freshwater only), 31 (where it intersects with NWI freshwater wetlands), 890, 900, 930, 980, and 990. Statewide range.


**Southeastern Crowned Snake, *Tantilla coronata*, ARADB35020, G5, S4**

Habitat and distribution: Occurring through the Piedmont and upper Coastal Plain of Georgia, Southeastern crowned snakes occur in a variety of wooded habitats. They generally prefer locations with relatively dry soil, and may be observed on dry, wooded hillsides or ridges, and in pine flatwoods and sandhills.

Model: Habitats 20, 31, 411, 412, 413, 422, 432, 434, 440, 441, 512, and 620 within digitized range.


**Southeastern Five-lined Skink, *Eumeces inexpectatus*, ARACH01070, G5, S5**

Habitat and distribution: Typically associated with dry, well-drained habitats, southeastern five-lined skinks occur throughout Georgia, with the exception of the Blue Ridge and Cumberland Plateau. They may be abundant in pine clearings, on ridge tops, and in other well-drained situations, and may also be present in sandy habitats of the barrier islands.

Model: Habitats 7, 9, 20, 31, 33, 34, 411, 412, 413, 420, 422, 423, 432, 434, 440, 441, 512, 513, and 620 within digitized range.


**Spiny Softshell, *Apalone spinifera*, ARAAG01030, G5, S5**

Habitat and distribution: Although absent from the Blue Ridge of Georgia and from the area in and around the Okefenokee Swamp, spiny softshell turtles are present in a variety of aquatic habitats throughout the remainder of the state. They are primarily associated with sandy-bottomed locations in rivers and large creeks, but may also be observed in bayous, oxbows, lakes, and other permanent bodies of water.

Model: Kept rasterized 1:100,000, 000 streams. Kept clumps of habitats 7 (associated with freshwater) and 11 (freshwater only) greater than 10 ha. Clipped by digitized range.

Stripeneck/Loggerhead Musk Turtle, *Sternotherus minor*, ARAAE02030, G5, S5

Habitat and distribution: At home in many freshwater environments, loggerhead musk turtles are widespread in southern and western Georgia, where they may inhabit swamps, marshes, and slow-flowing rivers, streams and oxbows. They may also be observed in the clear, shallow creeks of the Ridge and Valley and Cumberland Plateau.

Model: Kept rasterized 1:100, 000 streams. Kept habitats 7 (associated with freshwater), 11 (freshwater only), 890, and 990. Clipped by digitized range.


Worm Snake, *Carphophis amoenus*, ARADB02010, G5, S5

Habitat and distribution: These small, secretive snakes are north of the Fall Line in Georgia. Worm snakes are most abundant in mature, mesic hardwood forest, at sites having abundant humus and leaf litter. These fossorial snakes are secretive in nature, and are usually discovered under rocks, logs and debris on the forest floor.


Yellow/Black/Gray Rat Snake, *Elaphe obsoleta*, ARADB13030, G5, S5

Habitat and distribution: Abundant throughout Georgia, rat snakes are encountered in most types of forested habitats, as well as early-successional and residential areas. Rat snakes may be particularly abundant in areas of intermixed forest and farmland, where cover and a food supply of small rodents are readily available.


**References for the works cited above can be found on the CD-ROM A Gap Analysis of Georgia, Disc 1 that was included with this report (follow |GISData|Verts|Reptiles| spreadsheet|vert_references.doc).**
Appendix 5. Habitat Code List. A list of the habitat/land cover codes that were used in the Georgia GAP Analysis to model habitat distributions for each species (see appendices 1-4). Copied and adapted from A Gap Analysis of Georgia, Disc 1, August 2003 Final Report (follow |GISData|LandCover|LandCover_Manual.doc). Land cover types found in ACC are denoted by a * and printed in bold typeface.

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Beach</td>
<td>7</td>
<td>Open sand, sandbars, mud, and some sand dunes – natural environments as well as exposed sand from dredging and other activities. Mainly in coastal areas, but also inland, especially along the banks of reservoirs.</td>
</tr>
<tr>
<td>Coastal Dune</td>
<td>9</td>
<td>Sand dunes and associated vegetation.</td>
</tr>
<tr>
<td>*Open Water</td>
<td>11</td>
<td>Lakes, rivers, ponds, ocean, industrial water, aquaculture.</td>
</tr>
<tr>
<td>*Transportation</td>
<td>18</td>
<td>Roads, railroads, airports, and runways.</td>
</tr>
<tr>
<td>*Utility swaths</td>
<td>20</td>
<td>Open swaths maintained for transmission lines.</td>
</tr>
<tr>
<td>*Low Intensity Urban - Nonforested</td>
<td>22</td>
<td>Low intensity urban areas with little or no tree canopy.</td>
</tr>
<tr>
<td>*High Intensity Urban</td>
<td>24</td>
<td>Commercial/industrial and multi-family residential areas.</td>
</tr>
<tr>
<td>*Clearcut - Sparse Vegetation</td>
<td>31</td>
<td>Recent clearcuts, sparse vegetation, and other early successional areas.</td>
</tr>
<tr>
<td>*Quarries, Strip Mines</td>
<td>33</td>
<td>Exposed rock and soil from industrial uses, gravel pits, landfills.</td>
</tr>
<tr>
<td>Rock Outcrop</td>
<td>34</td>
<td>Rock outcrops and mountain tops.</td>
</tr>
<tr>
<td>*Parks, Recreation</td>
<td>72</td>
<td>Cemeteries, playing fields, campus-like institutions, parks, schools.</td>
</tr>
<tr>
<td>*Golf Course</td>
<td>73</td>
<td>Golf courses.</td>
</tr>
<tr>
<td>*Pasture, Hay</td>
<td>80</td>
<td>Pasture, non-tilled grasses.</td>
</tr>
<tr>
<td>*Row Crop</td>
<td>83</td>
<td>Row crops, orchards, vineyards, groves, horticultural businesses.</td>
</tr>
<tr>
<td>*Forested Urban - Deciduous</td>
<td>201</td>
<td>Low intensity urban areas containing mainly deciduous trees.</td>
</tr>
<tr>
<td>*Forested Urban - Evergreen</td>
<td>202</td>
<td>Low intensity urban areas containing mainly evergreen trees.</td>
</tr>
<tr>
<td>*Forested Urban - Mixed</td>
<td>203</td>
<td>Low intensity urban areas containing mixed deciduous and evergreen trees.</td>
</tr>
<tr>
<td>Mesic Hardwood</td>
<td>410</td>
<td>Mesic forests of lower elevations in the mountain regions (Blue Ridge, Cumberland Plateau, and Ridge and Valley) and upper Piedmont. Includes species such as yellow-poplar, sweetgum, white oak, northern red oak, and American beech.</td>
</tr>
<tr>
<td>Sub-mesic Hardwood</td>
<td>411</td>
<td>Moderately mesic forests of the mountain regions and upper Piedmont. Includes typical oak-hickory forests. The dominant natural cover class in most mountain areas.</td>
</tr>
<tr>
<td>*Hardwood Forest</td>
<td>412</td>
<td>Mesic to moderately mesic forests of the lower Piedmont and Coastal Plain. Includes non-wetland floodplain forests of yellow-poplar and sweetgum, ravines of oaks and American beech, and many upland oak-hickory stands.</td>
</tr>
<tr>
<td>*Xeric Hardwood</td>
<td>413</td>
<td>Dry hardwood forests found throughout the state, although most common in the mountain regions, and progressively more rare southward. Includes areas dominated by southern red oak, scarlet oak, post oak, and blackjack oak.</td>
</tr>
<tr>
<td>Deciduous Cove Hardwood</td>
<td>414</td>
<td>Mesic forests of sheltered valleys in the Blue Ridge and Cumberland Plateau at moderate to high elevations. Typically includes northern red oak, basswood, buckeye, and yellow-poplar.</td>
</tr>
<tr>
<td>Northern Hardwood</td>
<td>415</td>
<td>Restricted to the highest elevations of the Blue Ridge. Dominant tree species may include yellow birch, black cherry, and American beech.</td>
</tr>
<tr>
<td>Live Oak</td>
<td>420</td>
<td>Forests dominated by live oak. Most common in maritime strands along the Atlantic Coast. Also may occur in strip along southern border into southwest Georgia.</td>
</tr>
<tr>
<td>*Open Loblolly-Shortleaf Pine</td>
<td>422</td>
<td>Only mapped in the Piedmont. Includes older, fairly open stands that may be almost savanna-like in appearance.</td>
</tr>
<tr>
<td>Xeric Pine</td>
<td>423</td>
<td>Very dry evergreen forests restricted to the mountain regions and upper Piedmont. Includes Virginia, shortleaf, pitch, and table mountain pines.</td>
</tr>
<tr>
<td>Hemlock-White Pine</td>
<td>424</td>
<td>Mesic evergreen forests frequently associated with riparian areas. Restricted to Blue Ridge and Cumberland Plateau.</td>
</tr>
<tr>
<td>White Pine</td>
<td>425</td>
<td>Moderately mesic evergreen forests of the Blue Ridge, usually dominated by white pine.</td>
</tr>
<tr>
<td>Forest Type</td>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Montane Mixed Pine-Hardwood</td>
<td>431</td>
<td>Moderately mesic mixed forests of the Blue Ridge. Typical species include white pine, white oak, hickories, and yellow-poplar.</td>
</tr>
<tr>
<td>*Xeric Mixed Pine-Hardwood</td>
<td>432</td>
<td>Dry mixed forests found throughout the state, although most common in the mountain regions, and progressively more rare southward. Includes areas dominated by a mix of pines (most frequently shortleaf or Virginia in the mountains, and shortleaf or longleaf elsewhere) and hardwood species such as southern red oak, scarlet oak, post oak, and blackjack oak.</td>
</tr>
<tr>
<td>Mixed Cove Forest</td>
<td>433</td>
<td>Mesic mixed forests of sheltered valleys and riparian areas in the Blue Ridge and Cumberland Plateau at moderate to high elevations. Typically includes eastern hemlock, yellow-poplar, and black birch.</td>
</tr>
<tr>
<td>*Mixed Pine-Hardwood</td>
<td>434</td>
<td>Mesic to moderately dry forests of mixed deciduous and evergreen species found throughout the state at lower elevations. May include areas dominated by sweetgum, yellow-poplar, various oak species, and loblolly or shortleaf pine.</td>
</tr>
<tr>
<td>*Loblolly-Shortleaf Pine</td>
<td>440</td>
<td>Found from the upper Coastal Plain northward (rare in the Blue Ridge except at the lowest elevations). Includes many stands heavily managed for silviculture as well as areas regenerating from old field conditions.</td>
</tr>
<tr>
<td>Loblolly-Slash Pine</td>
<td>441</td>
<td>Found on the lower Coastal Plain. Includes many heavily managed stands as well as a few natural areas.</td>
</tr>
<tr>
<td>Shrub Bald</td>
<td>511</td>
<td>Restricted to mountain tops at high elevations of the Blue Ridge. May be dominated by mountain laurel, rhododendron, or blueberry.</td>
</tr>
<tr>
<td>Sandhill</td>
<td>512</td>
<td>Areas of scrub vegetation on deep, sandy soils on the Coastal Plain, especially near the Fall Line and along larger streams. May be dominated by turkey oak, blackjack oak, live oak, holly, and longleaf pine.</td>
</tr>
<tr>
<td>Coastal Scrub</td>
<td>513</td>
<td>Thickets between coastal dunes, typically dominated by wax myrtle. Sometimes found adjacent to saltmarsh areas.</td>
</tr>
<tr>
<td>Longleaf Pine</td>
<td>620</td>
<td>Open, savanna-type stands. Heavily managed plantations would likely be classed with 440 or 441. Most common on the lower Coastal Plain, although found up to the lower Piedmont and historically in the Ridge and Valley.</td>
</tr>
<tr>
<td>Cypress-Gum Swamp</td>
<td>890</td>
<td>Regularly flooded swamp forests mainly found on the Coastal Plain. May include either riparian or depressional wetlands. Usually dominated by pond or baldcypress and/or tupelo gum.</td>
</tr>
<tr>
<td>*Bottomland Hardwood</td>
<td>900</td>
<td>Less frequently flooded wetland forests found throughout the state, but most common on the Coastal Plain. To the north, may be dominated by sweetgum, elms, and red maple. To the south, wetland oaks (water oak, willow oak, overcup oak, swamp chestnut oak), black gum, and even spruce pine become more common.</td>
</tr>
<tr>
<td>Saltmarsh</td>
<td>920</td>
<td>Emergent brackish or saltwater wetlands dominated by Spartina or Juncus.</td>
</tr>
<tr>
<td>*Freshwater Marsh</td>
<td>930</td>
<td>Emergent freshwater wetlands found throughout the state. May be dominated by grasses or sedges.</td>
</tr>
<tr>
<td>*Shrub Wetland</td>
<td>980</td>
<td>Closed canopy, low stature woody wetland. Found throughout the state, although most common on the Coastal Plain. May be result of clearcutting of wetland forests. Frequently includes willows, alders, and red maple.</td>
</tr>
<tr>
<td>Evergreen Forested Wetland</td>
<td>990</td>
<td>Restricted to the Coastal Plain. Includes forests dominated by bay species, wet pine forests (typically slash or pond pine), or Atlantic white cedar.</td>
</tr>
</tbody>
</table>

66