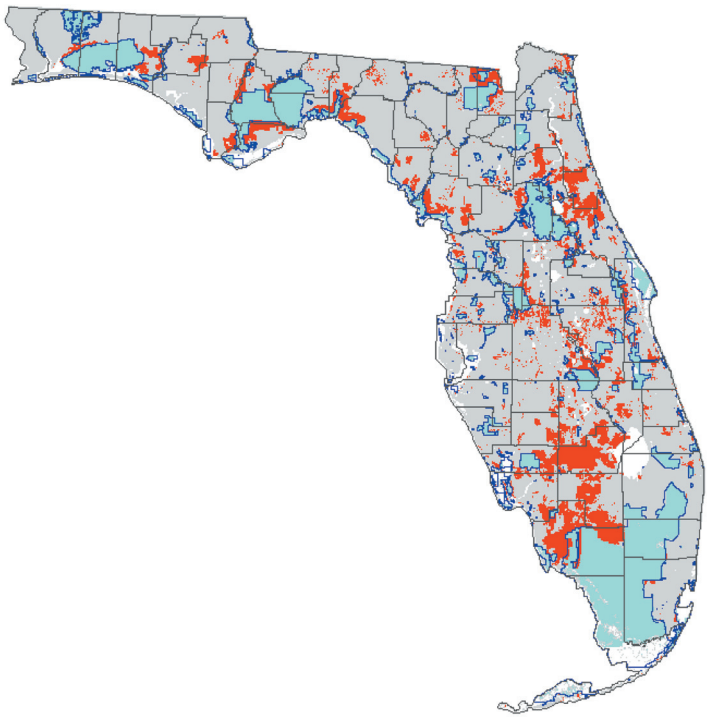
Closing the Gaps In Florida's Wildlife Habitat Conservation System

Recommendations to meet minimum conservation goals for declining wildlife species and rare plant and animal communities.



James Cox, Randy Kautz, Maureen MacLaughlin, and Terry Gilbert

Office of Environmental Services
Florida Game and Fresh Water Fish Commission
620 South Meridian Street
Tallahassee, Florida 32399-1600

1994

Closing the Gaps In Florida's Wildlife Habitat Conservation System

Recommendations to meet minimum conservation goals for declining wildlife species and rare plant and animal communities.

James Cox, Randy Kautz, Maureen MacLaughlin, and Terry Gilbert

Office of Environmental Services
Florida Game and Fresh Water Fish Commission
620 South Meridian Street
Tallahassee, Florida 32399-1600

1994

FOREWORD

When Spanish anchors first dropped into Florida waters nearly 500 years ago, Florida was essentially one large nature preserve that also supported a population of about 1,000,000 native Americans. Wildlife at this time roamed freely across 35 million acres in search of food, shelter, and water, while individual human settlements covered less area than most modern-day parking lots (and certainly occurred with less regularity). The state's road system in pre-Columbian times consisted of narrow foot paths that were used by panthers, bobcats, and black bears as frequently as by native Americans, and the few human edifices present quickly gave way to a surrounding landscape consisting of tall, majestic trees, most hundreds of years old, and extensive open prairies and marshes.

Today, many species of wildlife are caught in a state of siege as the habitats needed to sustain wildlife populations rapidly disappear. In just the last 50 years more than 8 million acres of forest and wetland habitats (about 24% of the State) were cleared to accommodate an expanding human population. This area is 16-times larger than our state's largest national forest and exceeds the total land area found south of approximately Port Charlotte. As Florida's human population continues to grow towards an estimated 16 million residents by the year 2000, increasing demands will be placed on our remaining natural systems, and wildlife populations will be forced into smaller and smaller areas as a result.

If wildlife populations are to persist in the face of such sweeping changes, we must conserve a base of habitat that is capable of sustaining wildlife populations far into the future. This habitat base should consist of preservation areas that are publicly owned and managed primarily for natural conditions, but it must also include private lands where special land-use agreements are arranged that allow natural resources to be conserved without sacrificing all private uses of the land.

Florida has succeeded in protecting many habitat areas through ambitious land acquisition and land-use planning efforts, but large gaps still exist in the statewide system of wildlife conservation lands. For example, no existing conservation area is large enough to support a viable population of Florida panthers or Audubon's crested caracaras. Furthermore, the habitat base provided to other rare species by existing conservation areas is dangerously small, and some species (e.g., Florida black bear, American swallow-tailed kite, and short-tailed hawk) may be extirpated unless we enlarge the land base that can be managed on behalf of wildlife. The gaps in the statewide system of wildlife conservation areas identified in this report must be closed if we are to maintain these and other rare species as part of the Florida landscape.

Although closing the gaps requires perseverance, money, education, and political and community support from today's generation of decision makers, the results of these and other planning efforts will be most important to future generations. This fact might cause members of the current generation to feel no sense of urgency. However, the next decade represents a critical turning point in efforts to conserve habitat for several rare species. If we fail to act now, the chances of successfully maintaining species such as Florida panther, Audubon's crested caracara, Florida black bear, and others will diminish greatly. Just as we now blame past generations for the extinction of the passenger pigeon, Carolina parakeet, and ivory-billed woodpecker, future Floridians will ultimately hold our generation responsible for the manner in which we conserve the species and natural resources that we inherited. Perhaps the greatest insult we could ever bear would be to document the problems that threaten some of Florida's rarest plants and animals, propose solutions to these problems, and then fail to act with proper speed and resolve.

ACKNOWLEDGEMENTS

Many individuals contributed their valuable time towards the completion of this report. Ken Haddad and Gail McAuley, Florida Department of Environmental Protection, assisted in procuring the Landsat imagery used to create a statewide map of land cover. The quality of the land-cover map developed from Landsat imagery and used in most analyses was the result of the dedicated efforts of Greg Mauldin, Jessie Day, Khaleda Hatim, Doug Holman, and other personnel currently or formerly employed by the Florida Department of Transportation. Lance Ham piloted the helicopter used during the land-cover classification work and was always willing to go the extra mile needed to complete the analyses within the brief time allowed. Mark Kopeny assisted in the construction of range maps used in our abbreviated "gap analysis" (described in Section 6.3.4). We also owe thanks to staff of the Florida Natural Areas Inventory and Florida Game and Fresh Water Fish Commission who helped to develop and maintain important databases describing the occurrence of rare species and natural communities throughout Florida. We are especially grateful to Dr. Allen Egbert and Colonel Robert Brantly for their support for this project from beginning to end.

Extremely helpful comments on earlier drafts of this report were provided by a courageous group that persevered through a somewhat byzantine structure and a mountain of infelicitous prose. We appreciate the constructive comments and guidance provided by Brian Barnett, Jim Beever, Jim Brady, Mike Delany, Kim Dryden, Diane Eggeman, John Fitzpatrick, Phil Frank, Jeff Gore, Paul Gray, Brad Hartman, Tom Logan, Dave Maehr, Ken Meyer, Brian Millsap, Paul Moler, Frank Montalbano, Steve Nesbitt, Katy NeSmith, Larry Perrin, Mary Ann Poole, Doug Runde, Beth Stys, and John Wooding.

Finally, Sharon Arnold, Amber Ayers, and John Stys provided invaluable assistance by helping to prepare the numerous figures, cumbersome tables, and lengthy text for final publication. This report is a product of Florida's Nongame Wildlife Program.

TABLE OF CONTENTS

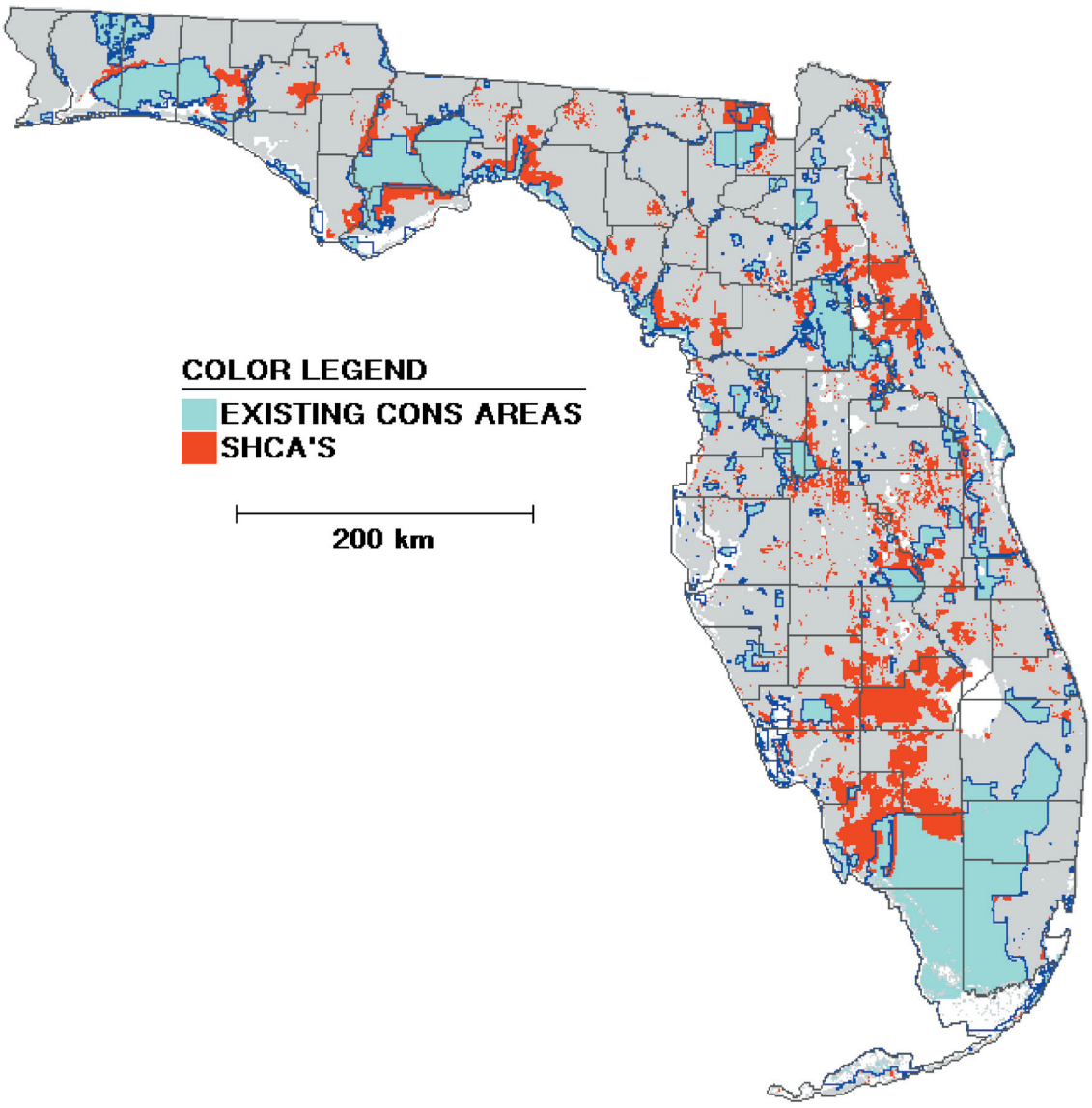


Figure 1. Proposed Strategic Habitat Conservation Areas for Florida.

EXECUTIVE SUMMARY

This report describes habitat areas in Florida that should be conserved if key components of the state's biological diversity are to be maintained. The project employed a computerized Geographic Information System to manipulate geographic data sets and create distribution maps for selected species of wildlife, threatened species of plants, and rare plant communities. The geographic data sets used in the project included a statewide land-cover map derived from Landsat satellite imagery; over 25,000 geographically referenced points documenting known occurrences of rare animals, plants, and communities; digitized maps of public and private lands devoted to some extent to conservation; a digitized general soils map; a digitized map of the statewide road network; a digitized map of selected private lands; and a digitized map of county boundaries.

Drawing from techniques recently developed in the fields of wildlife management and conservation biology, the Geographic Information System was used to assess the degree of security provided to rare species by the current system of conservation lands and to identify important habitat areas not currently protected. The lands recommended in the report for additional protection are referred to as **Strategic Habitat Conservation Areas** and are displayed in Figure 1. Strategic Habitat Conservation Areas depict lands needed to meet minimum conservation goals for the following:

* 30 species of wildlife inadequately protected by the current system of conservation lands,
* high quality sandhill sites,
* high quality scrub sites,
* high quality pine rocklands sites,
* high quality examples of tropical hardwood hammocks,
* bat maternity caves and winter roost caves,
* wetlands important to the breeding success of eight species of wading birds, and
* lands important to the long-term survival of 105 globally rare species of plants.

The Strategic Habitat Conservation Areas encompass 4.82 million acres, or approximately 13% of the land area of Florida. These lands are essential to providing some of the state's rarest animals, plants, and natural communities with the land base necessary to sustain populations into the future. The existing system of conservation lands in Florida covers 6.95 million acres, or 20% of the land area of the state. Thus, if all of the Strategic Habitat Conservation Areas were protected, approximately 11.7 million acres, or about 33% of the land area of Florida, would fall into some type of conservation land use.

It seems unlikely that all lands within the identified Strategic Habitat Conservation Areas will ever come under State ownership, even if all landowners were willing to sell. Since 1974, the State has spent an average of $1,182 per acre to purchase land for recreation, conservation, and historical preservation. At this rate, $5.7 billion would be needed to purchase all 4.82 million acres within the Strategic Habitat Conservation Areas, much more than the $3.2 billion authorized under Preservation 2000. Fortunately, many of the lands within the Strategic Habitat Conservation Areas are in low intensity land uses, such as silviculture and rangeland, that are compatible with the habitat conservation needs of many species. In fact, the management of wildlife habitat on many private lands has been excellent, and conservation measures should focus on maintaining existing land uses on private lands through positive incentives such as tax breaks, conservation easements, or cooperative agreements with landowners. These techniques have the potential to provide adequate protection without the need for fee-simple acquisition by the State.

During the course of this project, a large database of known locations of many animals, plants, and natural communities was assembled. A separate set of maps, referred to as **Regional Biodiversity Hot Spots** maps, was created to display as much of this information as possible within each of the 11 Regional Planning Council regions of Florida. The Regional Biodiversity Hot Spots maps display the following information:

* areas where large numbers of 52 selected species co-occur,
* areas supporting rare plant and wildlife communities,
* over 25,000 known locations of rare plants, animals, and natural communities,
* county boundaries and conservation land boundaries, and
* coastal areas that support key components of biological diversity.

Each regional map is accompanied with a description of the biological resources occurring in key areas within each region. The purpose of the Regional Biodiversity Hot Spots maps is to convey more detailed information on the known locations of as many components of biological diversity as possible, regardless of whether or not they fall within proposed Strategic Habitat Conservation Areas, to help meet the need for conservation information at regional and local levels.

The maps appearing in this report are intended to provide guidance to decision makers involved in public land acquisition, land use planning, development regulation, and other land conservation efforts. The maps represent our best estimate of those Florida lands that require some form of conservation to ensure that biodiversity is maintained for future generations. However, these maps represent only a snapshot of Florida's conservation needs at one time. For example, the vegetation map used to create species distribution maps was based on satellite imagery dated 1985-1989; the species occurrence information is current through 1991-1993, depending on the species; and the database of public land boundaries extends only through 1992. As a consequence, some areas identified for protection may already be in public ownership or may no longer support the habitat features or species predicted to occur there, and the maps should not be incorporated into law or rule as inviolate zones in which no development may occur. Rather, the maps should be used as a layer of information when decisions are made concerning land acquisition, land-use planning, and development regulation.

New data are continually being added to the project database as new parcels of land come into public ownership, new records of the locations of rare species become available, and more up-to-date vegetation maps are created. As a result, the latest versions of the project maps actually reside in the computer. Before using the maps in this report for detailed management decisions, users should contact the Office of

Environmental Services, Florida Game and Fresh Water Fish Commission, 620 South Meridian Street, Tallahassee, Florida, 32399-1600, for the latest information. The maps presented in this report are available in hard copy at a variety of scales and in digital formats for use in computer mapping packages.

ORGANIZATIONAL OVERVIEW

This document is intended for use by a broad audience of decision makers, concerned citizens, land-use planners, land managers, biologists, and others. We have organized the report to suit these varied interests while also providing appropriate technical information for those who seek more detail. Because of the complexity and scope of some of the analyses performed, the report is not organized in the format of "Introduction, Methods, Results, and Discussion" traditionally used in technical journals and reports. Instead, we chose to subdivide the report into coherent sections that each may contain distinctive methods, results, and discussion elements. Literature citations and appendices follow the individual sections. The Appendices contain lengthy tables and more detailed information that is abbreviated elsewhere in the report. Appendix 1 is especially important to note since it contains the scientific names of all plant and animal taxa mentioned in the text.

SECTION 1. SCOPE AND SIGNIFICANCE OF THE PROBLEM

SECTION 1.1. COMPONENTS AND VALUE OF FLORIDA'S BIOLOGICAL DIVERSITY

Florida is widely recognized as one of North America's most important reservoirs of biological diversity. Millsap et al. (1990) reported that 668 terrestrial and freshwater vertebrate taxa occur regularly in Florida. This list includes 75 mammals, 283 birds (excluding some migratory species), 127 reptiles, 57 amphibians, and 126 fishes. About 115 (17%) of these are not found elsewhere in the United States (Muller et al. 1989). Florida also contains approximately 3,500 species of vascular plants, of which about 8% are endemic (Ward 1979, Muller et al. 1989). The total number of invertebrate species inhabiting Florida is not known, but at least 410 invertebrates are thought to be endemic (Muller et al. 1989). The existence of so many endemic species in Florida confers upon us a weighty responsibility: our conservation and management activities are of global importance in efforts to conserve the diversity of life on earth.

The diversity of life in Florida has been shaped by many events. Over geological time, changing sea levels isolated populations of plants and animals on sandy scrub islands and allowed them to evolve into unique life forms. Florida also represents a transitional area between the tropical West Indies and temperate North America, and the state contains faunal and floral elements of both. The diversity of life in Florida has been maintained to some degree by the fact that vast wetlands, a hot climate, and sandy soils made Florida unattractive to many early settlers. Rates of settlement lagged behind other eastern states (Tebeau 1971), and today Florida still has many large forested tracts that support several wide-ranging vertebrates. The only population of panthers (Figure 2) remaining in the eastern U.S. is restricted to remote areas of southwest Florida. Black bears (Figure 3) have been eliminated from much of their former range in Alabama, Georgia, Mississippi, and other southeastern states (Pelton 1985), but sizeable populations are found in several areas of Florida. Forest clearing and wetland alterations have eliminated American swallow-tailed kites (Figure 4) from most of their former range, but Florida's large tracts of forested wetlands support the most important populations of this elegant species remaining in North America (Meyer and Collopy 1990).

Figure 2. Florida supports the only population of panthers remaining in the eastern U.S.

Figure 3. Populations of black bear have been eliminated from large portions of their former range in the southeastern U.S.

Figure 4. Florida represents one of the last strongholds for populations of the American swallow-tailed kite found in North America.

Florida is also biologically diverse in terms of the number of recognized plant communities. The Florida Natural Areas Inventory (1990) describes 81 natural communities that occur in Florida, 13 of which are endemic (Muller et al. 1989). Examples of rare or endemic Florida communities are coastal strand, mangrove swamp, tropical hardwood hammock, pine rocklands, scrub, sandhill, and coral reef (Muller et al. 1989). Human activities have caused all of these communities to decline or to become significantly degraded in quality, and, just as several plants and animals are in jeopardy of extinction in Florida, so too are these native communities at risk of disappearing forever.

The importance of maintaining the varied elements that make up Florida's biological diversity can be measured along many scales. Norse et al. (1986) proposed that protecting natural diversity is important because: (1) foods, medicines, and other products from living organisms are essential to human existence; (2) human welfare requires basic ecosystem services such as clean soil, water, and air; flood control; water purification; and amelioration of climatic conditions; (3) plants, animals, and natural landscapes have beneficial effects on human health and well-being; and (4) humans are ethically bound to provide responsible stewardship over the planet they dominate.

The potential for future discoveries from native species cannot be overstated, though it is often overlooked and always undervalued economically. Approximately 1,500 new compounds are discovered each year from wild plants, and about 300 of these have potential use in medicine. A relative of the rare Florida yew, for example, produces a special group of compounds that offers the greatest hope of any new discovery in the treatment of certain cancers (Land Acquisition Advisory Council 1991). The Lake Placid scrub mint, an endangered plant found only in a small area of the Lake Wales Ridge in Polk and Highlands counties, was recently found to have a previously unknown compound with potent insect repellant properties (Eisner et al. 1990). Blood of the endangered West Indian manatee has poor clotting capabilities, which may aid in research on hemophilia (Wilson 1988).

A diverse natural environment also plays an important economic role that can be portrayed in terms that are perhaps more easily grasped. More than 67% of Florida's residents participated in "nonconsumptive" natural resource activities such as bird watching, nature study, canoeing, and hiking in 1985. Each participant spent an average of $221 on food, lodging, transportation, field guides, binoculars, bird seed, and other items. Combining these figures, nature enthusiasts contributed $1.3 billion to Florida's economy while enjoying the state's natural diversity (U.S. Fish and Wildlife Service 1987a). Likewise, Florida residents participating in "consumptive" activities (e.g., hunting and fishing) contributed about $3.8 billion to the state's economy in 1985. If consumptive and nonconsumptive activities are combined, recreational activities associated with Florida's diverse natural heritage contributed $5.2 billion to the state's economy in 1985. At the time, this was the second largest "industry" in Florida, and every indication is that this "industry" has expanded considerably in the years since 1985 (Duda 1987). Continued recreational opportunities such as these rely on a well functioning environment made up of myriad diverse elements.

Widespread support for protecting Florida's environment has been documented repeatedly in various opinion polls (Duda 1987). About 80% of the state's residents believe that development in fragile areas containing rare species should be prohibited (Duda 1987), and at least 60% of Floridians believe that spending on the environment should be increased. Quoting from a report by deHaven-Smith and Gatlin (1985):

> "Overall, the Florida public is strongly supportive of the state's efforts to protect the environment and quality of life. The majority of respondents say that the natural environment is deteriorating and that land-use regulations should be strengthened. Respondents overwhelmingly support stronger laws to prevent pollution and protect fish and wildlife ..."

Such statements help to describe the sentiments of Floridians in quantitative terms, but perhaps the most important reason for maintaining native wildlife and natural habitats rests along a dimension that has no price tag. The conservation of natural areas and wildlife populations provides us with many unparalleled experiences: the sight of a bald eagle soaring above rivers and lakes; the mysterious night sounds of barred owls and limpkins that slip from swamps and sloughs; the pursuit of fish and game in remote wilderness areas; the fresh, clean smell of pinewoods on a spring morning or the sharp, pungent aroma of a rosemary scrub. These and other experiences found only in the natural world quench a deep-seated human thirst for natural aesthetics and renew our links with the world around us. Although it is difficult to quantify the extreme importance of these natural experiences, especially to future generations, a loss of such opportunities will likely entail a very dear price.

SECTION 1.2. FACTORS CONTRIBUTING TO THE LOSS OF BIOLOGICAL DIVERSITY

Florida is a bustling urban and agricultural state with a human population fast approaching 14 million (Duda 1987). The unspoiled splendor discovered by early Europeans exists only in scattered patches, and evidence of people can be found at every turn. In addition to our resident population, Florida's sandy beaches, sparkling waters, and subtropical climate attract 39 million visitors each year (Duda 1987). These visitors use airports, roads, shopping centers, restaurants, and many other facilities that displace natural areas. The growth of Florida's resident and tourist populations has led to a dramatic destruction of forest and wetland areas. According to data available from the U.S. Forest Service (Kautz 1993), today's Floridian sees a landscape that is 30% agricultural, 13% urban, and only about 57% in some type of forested or "seminatural" land cover (Kautz 1993). However, only a portion of this latter category might be considered "natural" since most of our remaining forest and prairie lands are subjected to some form of human disturbance.

Human habitation has taken its toll on several natural communities and wildlife populations that were not very common to begin with in Florida. Coastal strand (Figure 5), a community dominated by herbaceous vegetation growing on and amid sand dunes, originally occurred as a narrow, continuous strip along the high energy shorelines of both coasts. Johnson and Barbour (1990) estimate that coastal development and other factors have reduced the coverage of this community type by more than 50%, leaving only about 5,260 ha (13,000 acres) statewide (Kautz et al. 1993). Pine rocklands (Figure 6) are a rare association of slash pines and tropical

Figure 5. The coastal strand community associated with high-energy beaches has been eliminated from 50% of its range.

Figure 6. About 21,000 acres of the rare Pine Rockland community remain in southern Florida.

plants found on limestone outcrops in Broward, Dade, and Monroe counties. This community formerly covered about 154,650 ha (382,000 acres) (Davis 1967), but development has reduced the total area to fewer than 8,500 ha (21,000 acres) today. Tropical hardwood hammock (Figure 7), another rare community found on limestone outcrops in extreme South Florida, is presently estimated to cover only 6,070 ha (15,000 acres) (Kautz et al. 1993). This community contains some of the rarest plants and animals found in all of the United States (Layne 1974, Snyder et al. 1990).

Great concern has developed over the future of the once common scrub communities of Florida. These communities (Figure 8) are nearly endemic to Florida and occur on ancient sand dunes found along Florida's central ridges and just inland of both coasts (Myers 1990). Scrub communities support some of Florida's rarest and most distinctive plants and animals. Whereas scrub formerly covered approximately 417,000 ha (1.03 million acres) of Florida (Davis 1967), only 170,850 ha (422,000 acres) remain today (Kautz et al. 1993). More than 82% of the scrub habitat found along Florida's central ridge—the heartland of biodiversity for this community type—has been lost to residential and agricultural development (J. Fitzpatrick, pers. comm.).

Perhaps even more disturbing is the fate of formerly common forest types such as those dominated by longleaf pine (Figure 9). The longleaf pine forest known as a "sandhill" community once covered much of the panhandle and the northern two-thirds of the peninsula (Davis 1967). Sandhill communities support a rich vertebrate fauna that includes species such as gopher tortoise, red-cockaded woodpecker, fox squirrel, pocket gopher, pine snake, and gopher frog. Sandhill communities once occupied 2.78 million ha (6.89 million acres) or 20% of the original Florida landscape (Davis 1967). Today only 344,530 ha (851,000 acres) of sandhill remain in all of Florida (Kautz et al. 1993), and only about 38% of this acreage is found in current public land. Perhaps the most decisive figure that demonstrates the widespread loss of natural areas is that our once common sandhill communities have been reduced to several disparate patches covering less than 10% of their former area.

As the foregoing discussion suggests, the primary problem confronting Florida's varied wildlife and plant communities is a precipitous loss of habitat. Due to the unparalleled growth of the state's human population, we now face a situation where only a few thousand acres remain of several important natural communities. If we are to maintain the current diversity of plant and animal life found in Florida, our system of conservation areas must be capable of supporting thousands of species on only a fraction of the original land base.

In addition to outright habitat loss, other problems stem from the fragmentation of our remaining patches of natural habitat. Habitat fragmentation refers to the tendency for remaining patches of habitat to become reduced in size and

Figure 7. About 15,000 acres of the rare Tropical Hardwood Hammock community remain in southern Florida.

increasingly isolated from one another as land is cleared. This creates problems since some species range widely and require large tracts of habitat to survive. As patch sizes fall below the minimum area needed to sustain a breeding pair, a species will likely disappear in areas that otherwise have appropriate vegetative conditions. Red-cockaded woodpeckers, for example, require 80-160 ha (200-400 acres) of older growth pine forests to support breeding pairs; isolated patches of old-growth pine forests much smaller than 80 ha (200 acres) will rarely contain red-cockaded woodpeckers.

Yet another effect of habitat fragmentation stems from the fact that as habitat is lost, the remaining patches tend to become increasingly distant from one another. If patches of appropriate habitat are sufficiently large to support a breeding pair yet are so far apart that individuals cannot move easily from one patch to another and intermix with other members of the species, then the presence of the species across all remaining patches becomes increasingly unlikely. A breeding group of red-cockaded woodpeckers requires 80-160 ha (200-400 acres) of habitat, but sustainable populations of red-cockaded woodpeckers require at least 20-30 territories in close proximity to one another. Isolated patches of red-cockaded habitat that are much smaller than 1,210-3,240 ha (3,000-8,000 acres) may not support populations for extended lengths of time (see Baker 1983).

Small habitat fragments also tend to have a greater percentage of "edge habitat" when compared with larger habitat fragments (see Shafer 1990). Some of the deleterious features commonly associated with edge habitats near urban and residential areas are decreased survival and reproduction owing to increased predation, collisions with vehicles, and nest parasitism (Ambuel and Temple 1983, Harris 1984), as well as fundamental changes in habitat owing to changes in species composition (Janzen 1983) and habitat management procedures (Doren et al. 1987).

Another problem affecting Florida's biodiversity is land management practices on the remaining areas with forest cover. About 35% of Florida's remaining forest cover (including wetland forests) is in short rotation, commercial pine plantations (Bechtold et al. 1990). While this management practice is still suitable for some wildlife species, it also eliminates many plant and animal species that are normally associated with natural pine forests (Harris et al. 1974, Umber and Harris 1974, Repenning and Labisky 1985, McComb et al. 1986).

Similarly, vast expanses of Florida's remnant natural wetlands have radically altered hydroperiods owing to past draining or flood-control practices, particularly in the Everglades and the Upper St. Johns River. Wading birds have abandoned many of their former breeding sites within these large wetland systems (Runde et al. 1991). Other natural wetlands have been altered by polluted runoff originating from intensively developed urban and agricultural lands. Still other natural habitats in Florida have been invaded by exotic plants (e.g., melaleuca, Australian pine, Brazilian pepper, water hyacinth, and hydrilla) that often force out native plant species and eliminate appropriate habitat conditions for many native animal species (Dalrymple 1988).

Although present conditions may seem grim, the future will be much worse unless we engage in a renewed commitment to the conservation, management, and restoration of habitat areas. Within the foreseeable future, we may be left with only a few thousand disparate acres of some of the world's rarest community types. If we are to maintain Florida's diverse biological richness in the face of the sweeping changes taking place, our system of public lands and conservation areas must be capable of supporting at least 4,000 known species of plants and animals, and hundreds or thousands of little known invertebrates. In this report, we identify some of the most valuable tracts of wildlife habitat that remain in Florida, and we propose methods for protecting these important areas.

Figure 8. Some of Florida's rarest plants and animals are associated with the endemic oak scrub (pictured here) and sand pine scrub communities.

Figure 9. Sandhill communities once occupied nearly 7 million acres in Florida. Today only 0.8 million acres remain.

SECTION 2. PROJECT ABSTRACT AND BRIEF DESCRIPTIONS OF REPORT SECTIONS

SECTION 2.1. OBJECTIVES AND GENERAL APPROACH

The objective of this report is to identify lands in Florida that, at a minimum, must be conserved and managed in order to ensure the long-term survival of key components of Florida's biological diversity. This objective was pursued by (1) identifying habitat areas that are essential to the survival of rare and declining species not adequately protected by the current system of conservation areas; (2) identifying areas important to several globally endangered species of plants and rare animal and plant communities; and (3) identifying regional areas of high biological diversity ("hot spots") to assist in local land-use planning.

The analyses are framed by three fundamental assumptions:

1. Although some private land owners may be excellent land stewards, private ownership cannot guarantee that important natural resources will be maintained even to the next generation. Therefore, some degree of public management of important habitat areas is required to ensure that meaningful protection is provided the biological resources found within those areas. The level of public management may be complete (as would result through acquisition of the area), or it may be limited (as would result from securing conservation easements or other land-use agreements).

2. Selecting new lands for public management will depend on the extent to which the various components of biodiversity are protected by the current system of conservation areas. Conservation efforts should target those components that currently are least adequately protected.

3. The areas identified as requiring some level of protection must be sufficiently large, must be well distributed across a broad geographic area, and must possess other acceptable landscape and habitat characteristics so as to provide species and communities with acceptable chances of survival over very long periods of time.

Given the tremendous variety of species and natural communities that occurs in Florida, the task of assembling information on all components of biological diversity is impossible. To accomplish as much as possible in a reasonably short time frame, our analyses proceeded in the following manner:

1. We identified a set of 44 focal species to serve as "umbrella" or "indicator" species of biological diversity in Florida and assembled as much information as possible on the locations of these key species.

2. We assessed the level of security provided these focal species by the current system of conservation areas, and we proposed Strategic Habitat Conservation Areas for 30 species lacking adequate representation in current conservation areas. The proposed conservation areas outlined for each species were based on the most recent information available on conservation area planning. We also considered how protection of an area for a single species might also protect larger communities and multi-species assemblages.

3. In addition to the 44 focal species, we assembled as much information as possible on the locations of other key components of biological diversity, including rare plants, invertebrates, and natural communities. We used this information to identify additional Strategic Habitat Conservation Areas to add to the minimum conservation measures outlined for focal species.

4. We developed regional maps displaying information on the distribution of rare plants, animals, and natural communities. These maps highlight many additional areas of potential importance and can be used to expand upon the minimum habitat conservation recommendations proposed as Strategic Habitat Conservation Areas.

Of course, the focal species selected for detailed analyses are not perfect indicators of the minimum conservation areas needed by all species and all communities in Florida (Ryti 1992, Mills et al. 1993). Furthermore, the collection of as much information as we could find does not ensure that we have all the information we need. Many species exist whose basic taxonomy, distributions, and life-history requirements have not yet been determined. Nevertheless, we believe that our data-driven approach has identified lands that, if conserved, will meet the minimum long-term conservation needs of a majority of Florida's rare species and natural communities.

SECTION 2.2. OVERVIEW OF DATA SETS

This project involved the use of many types of geographically referenced data to derive a final set of maps of important lands in Florida. The computerized mapping capability of Geographic Information Systems (GIS) technology was the only tool capable of handling these data efficiently. GIS was used to manipulate and analyze three principle data sets: (1) land cover and vegetation data, (2) public land boundaries, and (3) documented occurrences of species and communities.

The presence or absence of most species is closely related to land cover, vegetation type, and soil conditions. A map of land cover and vegetation was created using 1985-1989 Landsat Thematic Mapper imagery, and information on soils was obtained from the U.S. Department of Agriculture (1991). Public land boundaries either were digitized by hand from available paper maps or were obtained in digital form from other sources. Occurrence records for rare species and communities were obtained from the Florida Natural Areas Inventory, the Florida Nongame Wildlife Program, the Florida breeding bird atlas project (Kale et al. 1992), species experts, the scientific literature, and several other sources.

SECTION 2.3. POPULATION VIABILITY ANALYSIS

We considered the threats of environmental variability, catastrophic events, and, to a lesser extent, inbreeding depression in determining the security offered wildlife species by the current system of conservation areas. An analysis of

population viability led to the conclusion that 10 populations, each consisting of at least 200 individuals, would provide a minimally acceptable level of security (i.e., be "viable") against the threats posed by a fluctuating environment and inbreeding depression. This minimal level of security also requires that the 10 populations be distributed over a broad geographic area to protect against catastrophic events that can decimate entire populations restricted to a single area.

SECTION 2.4. FOCAL SPECIES ANALYSIS AND DESIGNATION OF STRATEGIC HABITAT CONSERVATION AREAS

Of the 542 taxa of terrestrial vertebrates listed by Millsap et al. (1990) as occurring regularly in Florida, 44 were selected for in-depth analyses (Table 1). Another 120 vertebrate taxa were analyzed either as part of multi-species assemblages or as part of a "gap" analysis described in Section 6.3. The 44 "focal species" were selected based on their utility as indicators of natural communities or because they require suitable habitat conditions covering large areas. Statewide habitat and distribution maps were created for each of the 44 focal species using data on known locations of occurrence, information on the land cover and vegetation types used by each species, and published or well documented information on the life-history requirements of the species.

Of the 44 species analyzed as focal species, only 40 were considered suitable candidates for an assessment of the current level of security provided by existing conservation areas. The four species whose security could not be assessed were American oystercatcher, Florida burrowing owl, piping plover, and Wilson's plover. Habitat distributions or population requirements for these species could not be accurately determined (although some general recommendations are offered). The three shorebirds were included later in a separate analysis of important coastal areas (Section 6.3.3).

For the 40 species whose security could be assessed, security was estimated using the species' habitat and distribution maps, public land boundaries, and literature-based density estimates. Focal species estimated as having fewer than 10 protected populations consisting of at least 200 individuals were considered to lack an adequate base of habitat in the current system of conservation areas in Florida. Of the 40 focal species subjected to this analysis, 30 were found not to have this minimum level of protection on public lands. The 30 species lacking adequate representation were subjected to detailed analyses to identify new lands that must be conserved to satisfy their long-term conservation requirements. The individual maps of under-represented species were then merged into a single statewide map showing those areas of greatest concern (Figure 1).

Several other important aspects of biological diversity were also added to the statewide map (Table 1). Conservation areas were identified for rare communities (e.g., scrub, tropical hardwood hammocks, pine rocklands), rare plants, wading birds, and bat caves. Areas important to the conservation of

Table 1. List of focal species and other components of biological diversity used to identify important habitat areas remaining in Florida. Strategic Habitat Conservation Areas were developed for the taxa shown in bold. Scientific names appear in Appendix 1.

FOCAL SPECIES

Amphibians and Reptiles

American crocodile
Bog frog
Florida scrub lizard
Gopher tortoise
Pine barrens treefrog
Salt marsh snake
- **Atlantic salt marsh snake**
- **Gulf salt marsh snake**

Birds

American oystercatcher
American swallow-tailed kite
Audubon's crested caracara
Black-whiskered vireo
Cuban snowy plover
Florida burrowing owl
Florida grasshopper sparrow
Florida sandhill crane
Florida scrub jay
Limpkin
Mangrove cuckoo
Mottled duck
Piping plover
Red-cockaded woodpecker
Seaside sparrows
- Cape Sable seaside sparrow
- **Louisiana seaside sparrow**
- **Smyrna seaside sparrow**
- **Scott's seaside sparrow**
- **Wakulla seaside sparrow**

Short-tailed hawk
Snail kite
Southeastern American kestrel
Southern bald eagle
White-crowned pigeon
Wild turkey
Wilson's plover

Mammals

Beach mice
- **Anastasia Island beach mouse**
- **Choctawhatchee beach mouse**
- Perdido Key beach mouse
- Santa Rosa beach mouse
- **Southeastern beach mouse**

Bobcat
Florida black bear
Florida panther
Fox squirrel
- **Big Cypress fox squirrel**
- Sherman's fox squirrel
- Southeastern fox squirrel

OTHER COMPONENTS OF BIOLOGICAL DIVERSITY

Analysis of 105 globally rare plant species
Bat maternity and winter roosting caves
- **Southeastern bat**
- **Gray bat**

Coastal communities
Gap analysis of 120 species
Pine rocklands
Prairie bird communities
Sandhill communities
Scrub communities
Tropical hardwood hammock communi -ties
Wetlands important to wading birds
- **Great egret**
- **Little blue heron**
- **Reddish egret**
- **Roseate spoonbill**
- **Snowy egret**
- **Tricolored heron**
- **White ibis**
- **Wood stork**

these components of biological diversity are also shown as Strategic Habitat Conservation Areas in Figure 1.

SECTION 2.5. REGIONAL MAPS OF HOT SPOTS OF BIODIVERSITY

The data sets incorporated into the GIS used in this project provide valuable information on the distribution of natural resources throughout Florida. Such information would be of significant value to local land-use planning and in efforts to expand upon the minimum conservation requirements outlined here. However, since many private and public entities lack the computer equipment needed to process and store geographic data sets in a meaningful manner, we created regional maps showing three important features stored in the GIS. First, the individual habitat maps created for 44 focal species and rare natural communities were added together to highlight areas within each region where potential habitat conditions for many species occurred. Second, records processed by the Florida Natural Areas Inventory, the Florida Game and Fresh Water Fish Commission, and other sources were displayed to provide information on the location of other natural resources in each region. Third, boundaries of public lands were displayed to show the relationship between natural resources in each region and the distribution of existing public ownerships. Although these regional maps may appear to be complex, they portray much of the information stored in the GIS in a manageable fashion.

SECTION 2.6. USES OF PROJECT MAPS

Project maps are intended to help guide land acquisition, land conservation, land-use planning, and regulatory programs at many levels. The maps represent our best estimate of those Florida lands that require some form of conservation to ensure that biodiversity is maintained for future generations.

The reader should be aware that the maps represent only a snapshot of Florida's conservation needs at one point in time. The data on which the maps are based are already outdated, and they will become increasingly out of date as time goes by. For example, the satellite imagery used for vegetation mapping and habitat modeling was collected between 1985 and 1989. Undoubtedly, some natural areas we identified as needing protection have been destroyed during the time it has taken to collect and analyze the data and publish the results.

The temporal nature of the maps has two effects. First, because some areas identified as needing protection may no longer support the habitat features or species expected to occur there, these maps should not be incorporated into law or rule as inviolate zones in which no development may occur. Rather, the maps should be used as a layer of information in the making of decisions concerning land acquisition, land-use planning, and development regulation. Second, as time goes by, new parcels of land come into public ownership, new data become available on the locations of rare species, and the character of the Florida landscape changes. As a result, project maps are continually being updated with new information, and the latest version of the maps actually resides in the computer at the Office of Environmental Services. Therefore, before using the maps in this report for detailed management decisions, users should contact the Office of Environmental Services at the address below for the latest information on lands currently recommended for protection.

SECTION 2.7. AVAILABILITY OF MAPS

In addition to the maps presented in this report, project results are available as hard copy maps at a variety of scales and in digital formats for use in computer mapping packages. For more information on the availability of data sets, contact the Office of Environmental Services, Florida Game and Fresh Water Fish Commission, 620 S. Meridian St., Tallahassee, FL, 32399-1600.

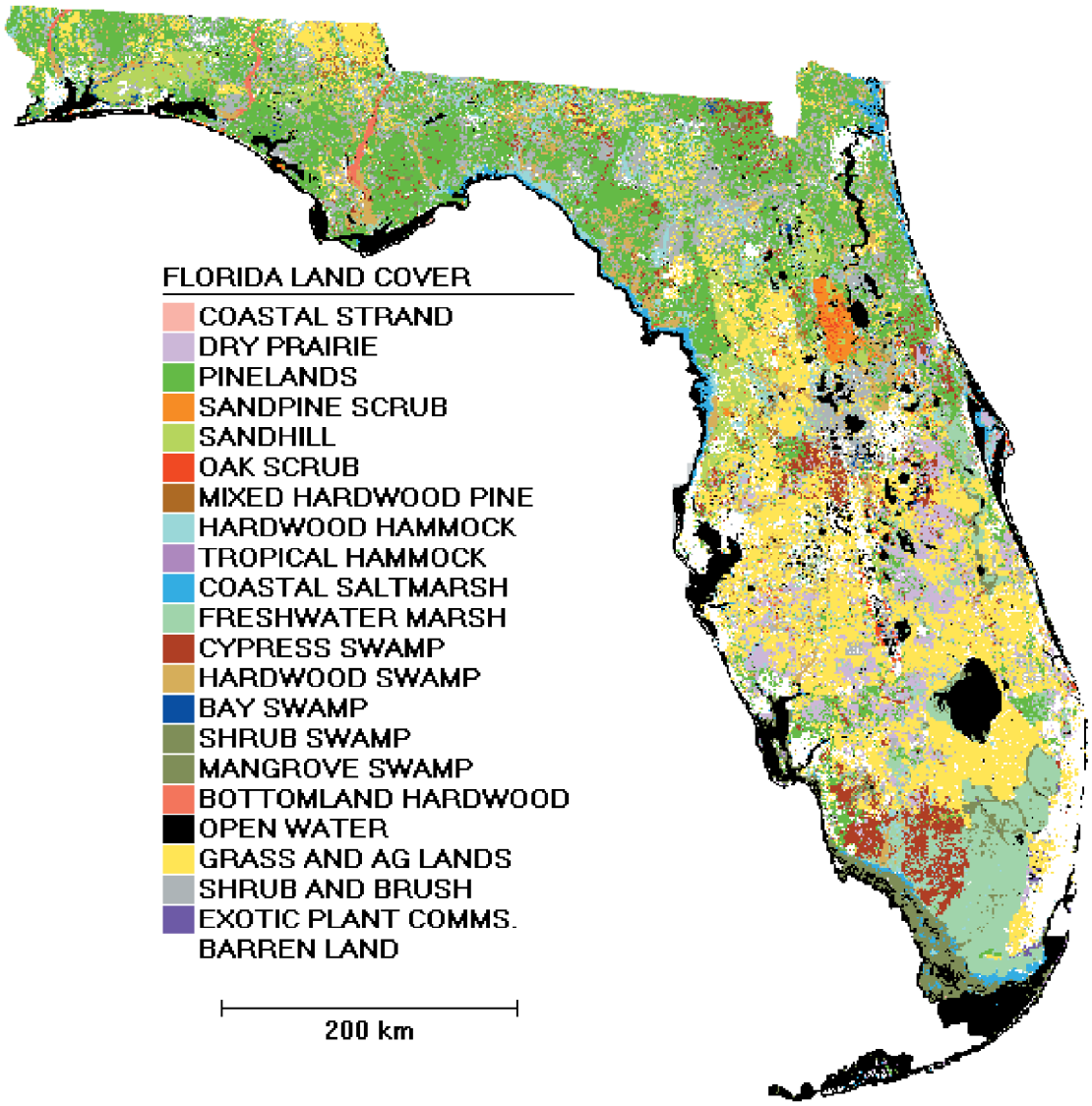


Figure 10. A land-cover map of Florida developed from Landsat Thematic Mapper data.

Table 2. Cover types mapped for Florida based on Landsat Thematic Mapper data collected from 1985-89.

COVER TYPE	ACREAGE	COVER TYPE	ACREAGE
Natural Upland Communities		Cypress Swamp	1,636,808
		Hardwood Swamp	1,908,891
Coastal Strand	13,280	Bay Swamp	157,216
Dry Prairie	1,385,952	Shrub Swamp	672,789
Pineland	6,542,570	Mangrove Swamp	546,416
Sand Pine Scrub	239,728	Bottomland Hardwood Forest	89,744
Sandhill	850,859		
Xeric Oak Scrub	182,170	*Disturbed Land Cover*	
Mixed Hardwood-Pine	549,672		
Upland Hardwood Forest	2,302,249	Grass and Agriculture	6,266,804
Tropical Hardwood Hammock	15,253	Shrub and Brush	4,078,013
		Barren and Urban	4,146,322
Natural Wetland Communities		Exotic Plant	40,266
Coastal Salt Marsh	485,320	Open Water	4,279,763
Freshwater Marsh	2,706,786		

SECTION 3. DEVELOPMENT OF GEOGRAPHIC INFORMATION SYSTEM DATA SETS

SECTION 3.1. A STATEWIDE LAND-COVER MAP

This project relied on data and computer technology capable of conducting fine-scale geographic analysis. One of the primary geographic data sets utilized was an up-to-date map of land cover (Kautz et al. 1993). The land-cover map (Figure 10) was developed from Landsat satellite data collected from 1985-1989. A brief description of techniques used to construct this map is presented here; more detailed information is found in Kautz et al. (1993).

Landsat satellite imagery was chosen because of the large area to be covered and the speed with which satellite imagery could be obtained and processed. Landsat Thematic Mapper (TM) data are collected using a predefined grid work of "pixels" (or picture elements). Each pixel is 30 m square. These 0.09-ha (0.25-acre) cells represent the theoretical limits of resolution of Landsat TM data, but the true limits of resolution are somewhat larger.

A total of 22 land-cover types was processed for these analyses. These cover types (Table 2) correspond to other land-cover classifications developed for Florida (e.g., Davis 1967, Hartman 1978, Soil Conservation Service (undated), Florida Natural Areas Inventory 1990) and allow for high levels of accuracy. The cover types include 17 "natural" vegetation types, 1 class for water, and 4 additional classes that are most often associated with "disturbed" areas. We use quotation marks when referring to the "natural" and "disturbed" cover types presented in Table 2. Some "natural" cover types (e.g., commercial pine forests) may be heavily disturbed, while some "disturbed" areas occur naturally (e.g., sand beaches may be classified as barren land). More thorough descriptions of each land-cover type appear in Appendix 2.

Landsat TM data were processed using ATLAS Remote Imaging System (Version 1.13) software, developed by Delta Data Systems, Inc. (131 Third St., Picayune, MS 39466). The Florida Department of Transportation performed these analyses under contract to the Florida Game and Fresh Water Fish Commission. Raw satellite data were obtained from the Florida Department of Natural Resources. Because of the complexity of the analyses and the tremendous size of the data sets, Landsat TM data were processed by multi-county regions over a 3.5-year period. All or portions of 17 separate Landsat scenes were used with dates ranging from 1985 for the Florida Keys to 1989 for portions of the panhandle (Kautz et al. 1993). Landsat imagery was georeferenced to the Universal Transverse Mercator coordinate system for use as a data layer in the GIS.

Landsat imagery for each region was divided into smaller subscenes, and an unsupervised classification routine was performed for each subscene (Kautz et al. 1993). This classification was compared with aerial photography and ancillary data from a variety of sources to produce a preliminary land-cover map for each area. A total of 454 areas covering 1.10 million ha (2.72 million acres, or 8% of the land area of Florida) was inspected using a helicopter equipped with a Loran-C unit. Inaccuracies observed in these field inspections were corrected in the production of a final land-cover map for each subscene, and then each subscene was compared with neighboring subscenes to correct errors occurring across subscene boundaries.

Kautz et al. (1993) did not formally analyze the accuracy of the land-cover map, but, based on field reports received since the map was last edited, overall accuracy appears to be around 80-90%. However, the accuracy varies by cover type. Oak scrub land cover, for example, proved difficult to distinguish from the shrub and brush land cover, and sand pine scrub was sometimes confused with pineland cover. The accuracy of scrub identification was improved by digitizing scrub sites surveyed by Christman (1988), and comments from map users indicate that most inaccuracies that remain are largely errors of omission (i.e., the scrub class contains scrub, but not all patches of scrub were detected). Accurately mapping sandhill cover also presented problems. Sandhill sites with open stands of longleaf pine, minimal understory vegetation, and dense ground cover were readily identified with satellite imagery. Other areas that might be classified as sandhill contained denser understories of oaks or densely stocked pine plantations growing on sandhill sites. Many such areas were classified as mixed pine-hardwood or pineland land cover. Bay swamp was also difficult to distinguish from mixed hardwood swamp. We have not received extensive comments concerning the accuracy of the sandhill and bay swamp classes, but most errors are probably errors of omission.

A tally of all cover types mapped (Table 2) shows that vegetated uplands covered 4.89 million ha (12.1 million acres, or 35%), wetlands covered 3.32 million ha (8.2 million acres, or 24%), and "disturbed" cover types covered 5.88 million ha (14.54 million acres, or 42%) of Florida around 1985-1989. Pinelands were the most abundant upland vegetation type, covering 2.65 million ha (6.54 million acres, or 19%) and distributed primarily in the northern third of the peninsula and throughout the panhandle (Figure 10). Freshwater marsh and wet prairies were the most abundant wetland vegetation type, covering 1.10 million ha (2.72 million acres, or 8%) and occurring mostly in south Florida.

SECTION 3.2. A STATEWIDE MAP OF CONSERVATION LANDS

Public lands capable of providing long-term protection for rare species include national parks, forests, wildlife refuges, and portions of military lands; state preserves, reserves, parks, and forests; state-owned wildlife management areas; water management district lands; county-owned nature preserves; and certain private lands owned by groups such as The Nature Conservancy, National Audubon Society, Florida Audubon Society, and other conservation entities. Our definition of "conservation lands" includes these various public and private lands, but it does not include lands owned by native Americans. While lands owned by native Americans may contain important wildlife resources, there are few legally binding agreements through which the important resources might be protected.

At the time that these analyses were initiated, there was no comprehensive set of conservation land boundaries available for Florida. We developed our map of conservation lands using four major sources: Florida Atlas and Gazetteer (DeLorme Mapping Company 1989), Florida Department of Transportation county highway maps, county plat maps

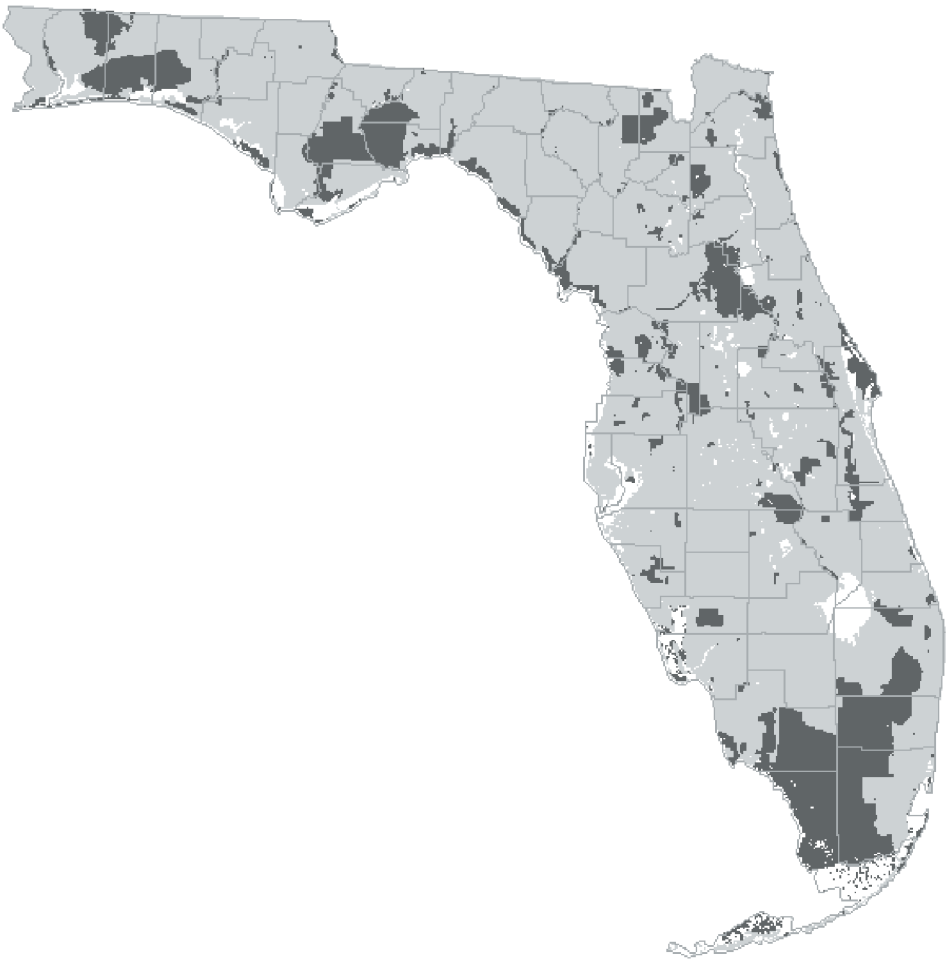


Figure 11. The distribution of current conservation areas in Florida.

(dated 1987-1990, Florida Plats, 1289 Bowan Blvd., Clermont, Florida), and boundaries processed by the Florida Natural Areas Inventory. The DeLorme and Florida Department of Transportation county highway maps depict boundaries of many public lands at scales of 1:150,000 and 1:126,720, respectively. Plat maps depict property ownerships referenced to the township-range-section system used for property descriptions. Plat maps were obtained for 54 Florida counties, and the boundaries of additional lands shown to be in public ownership were transferred by hand to county highway maps and then digitized. Boundaries obtained from the Florida Natural Areas Inventory were digitized from 1:24,000 topographic maps.

Our map of conservation lands (Figure 11) includes 1,210 parcels ranging in size from about 1 ha (2.5 acres) to 453,490 ha (1,120,120 acres). Staying abreast of recent land purchases and obtaining accurate boundary maps are daunting tasks that preclude all conservation areas from appearing in the data set. We estimate that the map of public land boundaries includes > 98% of the area in conservation lands in Florida.

The mean size of the conservation areas is 5,835 ha (16,217 acres), but the median size is only 170 ha (524 acres). The size distribution of protected areas is shown in Figure 12. The total area of conservation lands included in our map is 2.81 million ha (6.95 million acres), excluding large water bodies, or roughly 20% of the land area of the state. The largest conservation areas in Florida are owned and managed by the federal government and include Everglades National Park, Big Cypress National Preserve, Ocala National Forest, Osceola National Forest, Apalachicola National Forest, Avon Park Air Force Range, and Eglin Air Force Base. The largest state-owned parcels are the Everglades Water Conservation Areas, Blackwater State Forest, Withlacoochee State Forest, Camp Blanding Military Reservation, Cecil Webb Wildlife Management Area, Fakahatchee Strand State Preserve, and J. W. Corbett Wildlife Management Area. Table 3 shows the distribution of acreage on conservation areas by several broad groups of ownership. Federal lands cover nearly twice as much area as state-owned lands, and the average size of federal parcels is about 13-times as large as the average size of state-owned parcels.

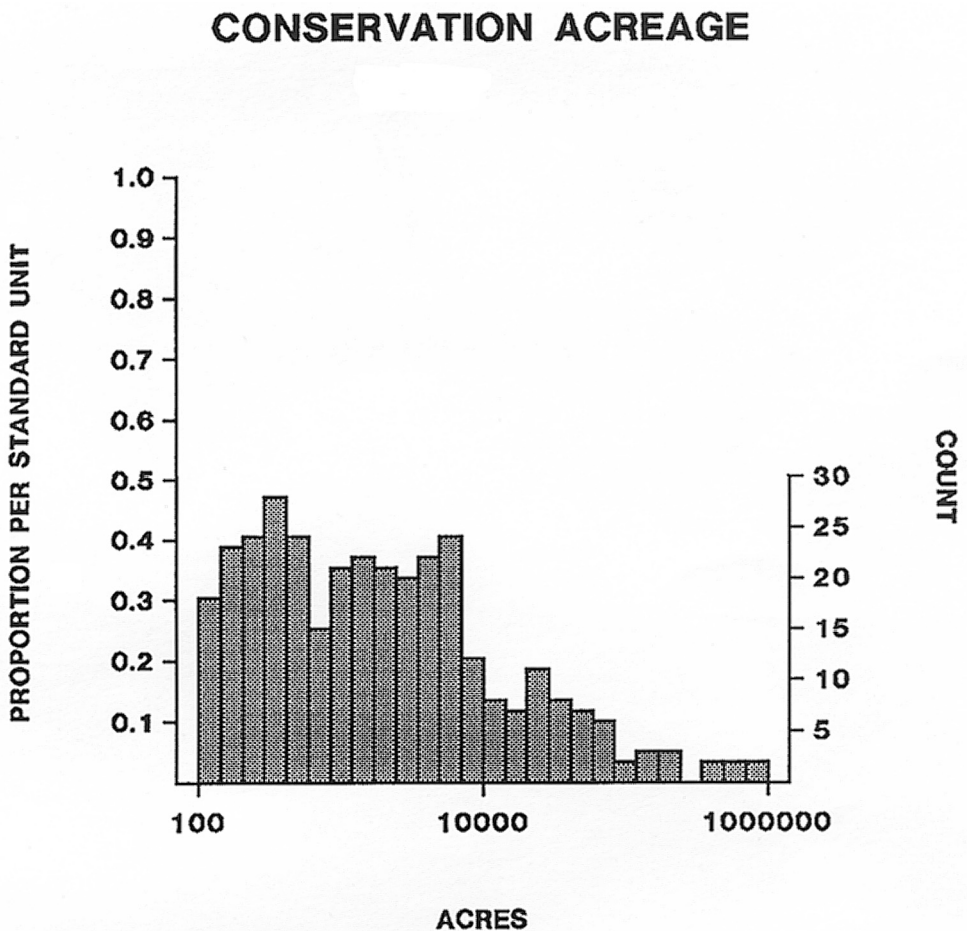


Figure 12. Size distribution of current conservation areas in Florida. The right-hand column ("Count") provides the number of managed areas within each size category. The left-hand column ("Proportion per Standard Unit") shows the proportion of classes falling in each bar divided by sample standard deviation. This axis enables easier comparisons to other histograms based on different scales.

Table 3. Comparison of the areas of existing conservation lands by various ownership categories. The mean and median for each category were calculated based on all areas presented in Figure 11.

	PARCEL SIZE (ha)		
	MEAN	MEDIAN	SUM
Federal	41,830	1,620	1,854,110
State	3,023	240	927,607
Private/local	484	17	33,252
All Lands	5,835	170	2,814,969

Table 4. Percentages of existing conservation lands by individual Florida counties. Counties are arranged in ascending order.

COUNTY NAME	PERCENT CONSERVATION LAND	COUNTY NAME	PERCENT CONSERVATION LAND
Desoto	0.1%	Highland	9.4%
Hardee	0.1%	Pasco	10.4%
Hendry	0.2%	Volusia	10.6%
Glades	0.2%	Taylor	10.9%
Lafayette	0.5%	Orange	11.2%
Flagler	0.6%	Sarasota	11.6%
Gilchrist	0.6%	Levy	11.8%
Calhoun	0.8%	Dixie	12.3%
Suwannee	1.2%	Duval	13.4%
St. Lucie	1.4%	Franklin	14.9%
Nassau	1.4%	Lake	15.4%
Madison	1.7%	Columbia	16.6%
Hamilton	1.8%	Lee	17.1%
Pinellas	1.9%	Clay	18.4%
Okeechobee	2.6%	Indian River	19.3%
Jackson	2.9%	Citrus	19.9%
Escambia	3.3%	Sumter	21.8%
Seminole	3.4%	Hernando	21.9%
Holmes	3.5%	Palm Beach	23.4%
Hillsborough	3.5%	Charlotte	23.6%
Manatee	3.7%	Walton	24.7%
St. Johns	3.8%	Santa Rosa	26.8%
Gadsden	3.8%	Brevard	27.0%
Martin	4.3%	Baker	28.1%
Washington	4.6%	Leon	30.0%
Union	5.3%	Marion	30.5%
Alachua	5.4%	Collier	46.1%
Bay	6.4%	Okaloosa	48.7%
Jefferson	7.6%	Dade	56.2%
Polk	8.2%	Liberty	59.0%
Gulf	8.4%	Broward	63.1%
Bradford	8.4%	Wakulla	65.5%
Putnam	8.6%	Monroe	79.1%
Osceola	8.8%		

The distribution of conservation areas among counties is very uneven. Eight counties (DeSoto, Hardee, Hendry, Glades, Lafayette, Flagler, Gilchrist, and Calhoun) have < 1% of their total land area in some type of conservation area (Table 4). About half of the counties in Florida have < 10% of their total acreage in conservation areas, while the statewide average is 15.2%. In sharp contrast, 5 counties (Monroe, Wakulla, Broward, Liberty, and Dade) have > 50% of their total area in conservation areas. The statewide median for the proportion of conservation lands within individual counties is 8.6%. Figure 13 shows Florida counties categorized by the proportional acreage of conservation area that they contain.

An overlay of conservation land boundaries on the Landsat cover map produces an estimate of the area of various plant communities currently protected in Florida (Table 5). At present, conservation lands hold 46.2% of Florida's remaining wetlands, but only 19.6% of Florida's remaining "natural" upland plant communities. Only 4.2% of the area on conservation lands falls into one of the "disturbed" cover types.

Based on percentages, the best represented upland cover type on conservation lands is sand pine scrub with about 75% of its remaining acreage within conservation lands (primarily on the Ocala National Forest). Of Florida's remaining xeric communities, only 38.2% of the sandhill land cover and 41.3% of the xeric oak scrub land cover are in public ownership. However, the quality of these protected xeric communities varies widely. Over half of the coastal strand and tropical hardwood hammock mapped by Kautz et al. (1993) occurs on conservation lands. Forests dominated by hardwoods (i.e., the upland hardwood forest and mixed pine-hardwood classes) appear to be among the least represented in comparison to their acreage statewide (Table 5). In addition, only 16.6% of the 561,113 ha (1,385,950 acres) of dry prairie remaining in Florida is found in current conservation lands.

Among wetland cover types, mangrove swamps are the best represented in current conservation areas (79% of statewide total). Also well represented are freshwater marshes (62.3%), coastal salt marshes (60.0%), and shrub swamps (58.5%). The quality of many of these protected wetlands varies widely (Bildstein et al. 1991). The least represented wetland types are forested wetlands such as mixed hardwood

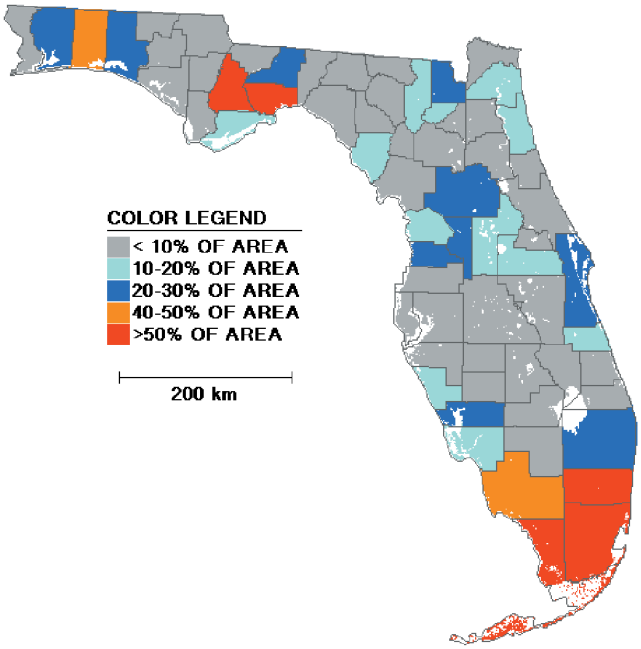


Figure 13. Florida counties categorized by the proportional acreage of conservation areas that they contain.

Table 5. Quantities and percentages of land-cover types found on conservation areas in Florida. The map of land-cover types was developed from Landsat Thematic Mapper satellite imagery.

LAND COVER TYPE	CONSERVATION AREAS (ha)	TOTAL AREA (ha)	PERCENT IN CONSERVATION LANDS
Upland Plant Communities			
Pinelands	440,220	2,648,814	15.9
Upland Hardwood Forests	178,960	932,085	19.2
Dry Prairie	93,145	561,114	16.6
Sandhill	150,650	344,477	38.2
Mixed Hardwood-Pine Forests	26,482	222,539	11.9
Sand Pine Scrub	72,792	97,056	75.0
Xeric Oak Scrub	30,460	73,753	41.3
Tropical Hardwood Hammock	3,088	6,175	50.0
Coastal Strand	2,699	5,377	50.2
Uplands Subtotal	998,496	4,891,390	19.6
Wetland Plant Communities			
Freshwater Marsh	701,783	1,095,865	62.3
Mixed Hardwood Swamp	168,477	772,830	21.8
Cypress Swamp	198,140	662,675	29.9
Shrub Swamp	159,345	272,384	58.5
Mangrove Swamp	193,602	221,221	78.9
Coastal Salt Marsh	117,892	196,486	60.0
Bay Swamp	14,894	63,650	23.4
Bottomland Hardwood Forest	17,549	36,334	48.3
Wetlands Subtotal	1,533,564	3,321,445	46.2
Plant Community Subtotal	2,493,941	8,212,835	30.4
Disturbed Land Cover			
Grassland & Agriculture	53,281	2,537,160	2.1
Barren & Urban Land	77,219	1,678,673	4.6
Shrub & Brush Land	112,269	1,651,017	6.8
Exotic Plant Communities	2,021	16,302	12.4
Disturbed Land Subtotal	244,790	5,883,160	4.2
Natural and Disturbed Subtotal	2,814,969	14,074,845	20.1
Open Water	471,294	1,732,697	27.2
Totals	3,286,263	15,807,542	20.7

swamp and cypress swamp, which have only 21.8% and 29.9% of their remaining acreage, respectively, on conservation lands.

The relatively poor representation of upland cover types on conservation lands in comparison to wetland cover types stems from many factors. Uplands certainly provide better areas for residential and agricultural development and are thus the first areas to be developed, but there has also been an emphasis historically on wetland protection through both land acquisition and regulation.

SECTION 3.3. OTHER GEOGRAPHIC DATA SETS

County boundaries used in all GIS analyses were digitized from 1:24,000 scale U.S. Geological Survey 7.5-minute quadrangle maps. A comparison of land-cover types by county and conservation areas within counties is provided in Appendix 3. Various types of socioeconomic information were also linked to county boundary files using data from the Florida Statistical Abstract (Shermyen et al. 1991). These data include estimated population sizes, estimated number of occupied homes, median income, etc. (Shermyen et al. 1991).

A digital copy of the STATSGO generalized soils map (Figure 14) of Florida (U.S. Department of Agriculture 1991) was used to refine some of the land-cover classes and assist in estimating important habitat areas. The pineland land-cover class, for example, simply represents lands dominated by pines regardless of the species or soil type present. When soils from the STATSGO map are combined with the pineland cover type, the pineland cover type can be reclassified into more specific categories based on whether the underlying soil conditions are relatively mesophytic or xerophytic (Figure 15).

Vector files depicting federal, state, and county roads maintained by the Florida Department of Transportation were obtained (Figure 16). The Florida Department of Transportation digitized these files from 1:126,720 county highway maps. The road network files aid in the identification of specific localities more precisely, and we also used the road information in our analyses of suitable habitat areas for selected species. For example, Figure 17 shows a classification of the areas defined by roads based on their size. Preventing future transportation projects from further subdividing some of the larger roadless areas shown in Figure 17 may be

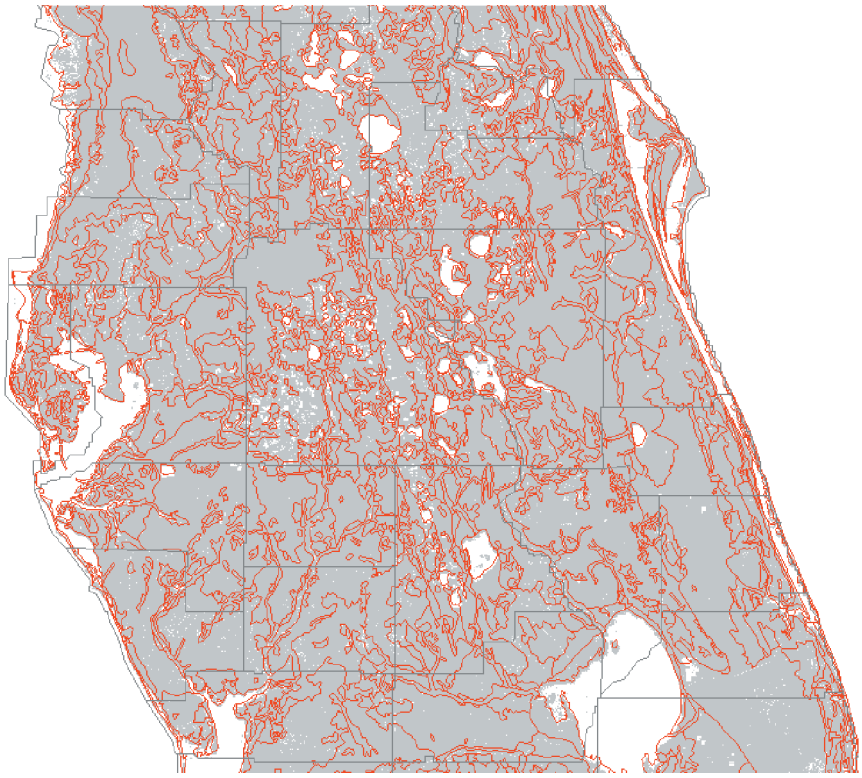


Figure 14. Polygons for the STATSGO generalized soils map (U.S. Department of Agriculture 1991).

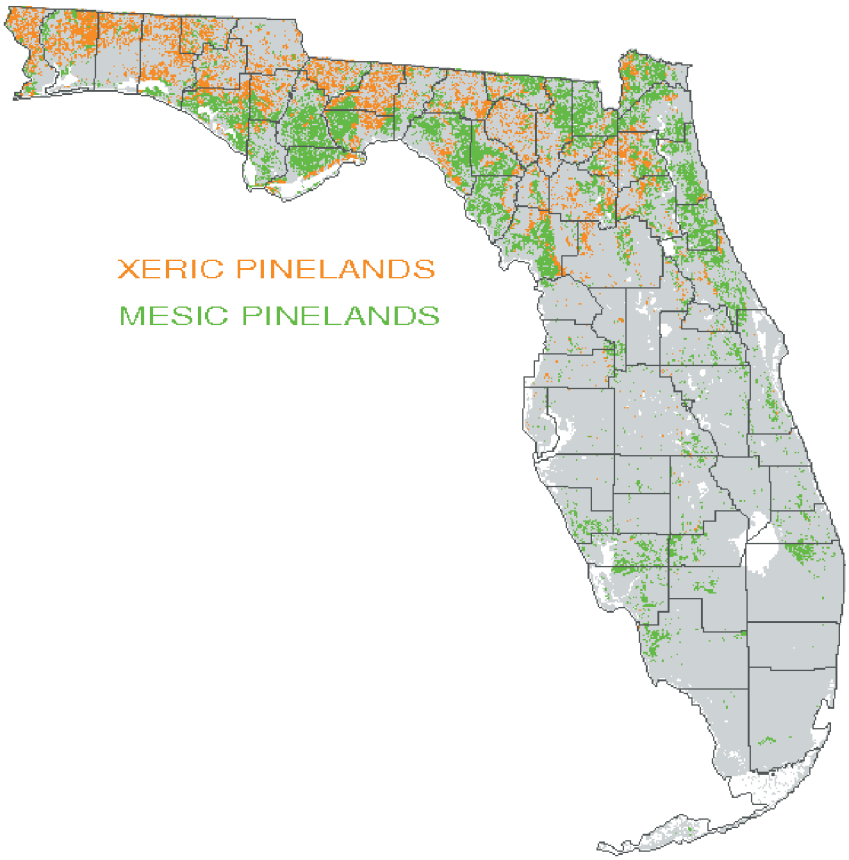


Figure 15. Pineland land cover reclassified based on xeric and mesic soil types.

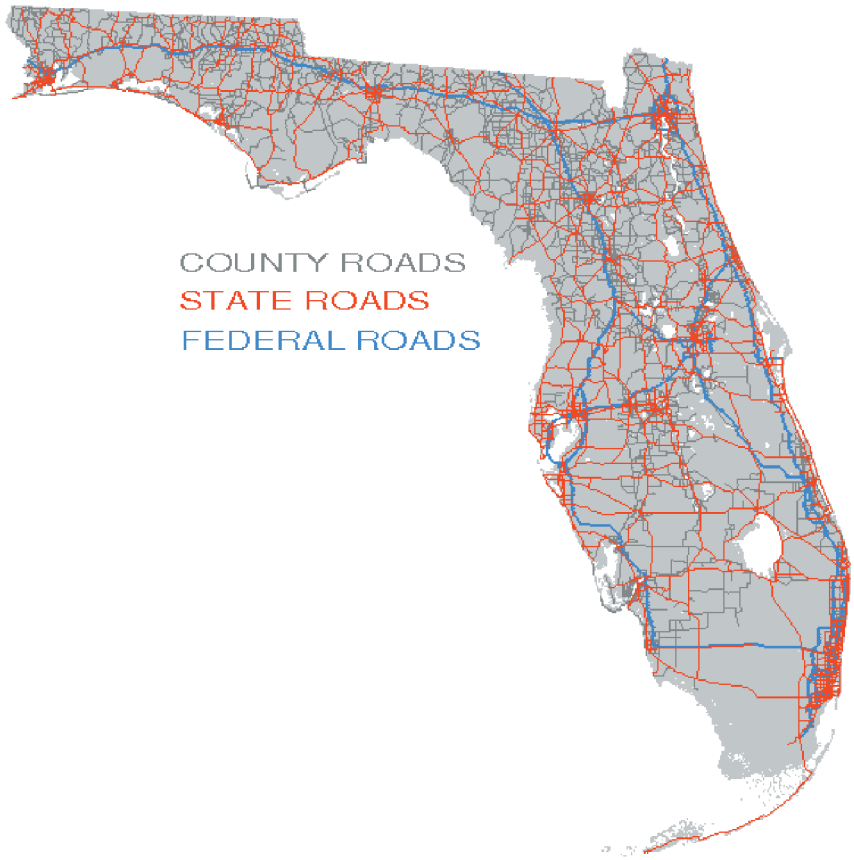


Figure 16. Vectors depicting federal, state, and county roads maintained by the Florida Department of Transportation.

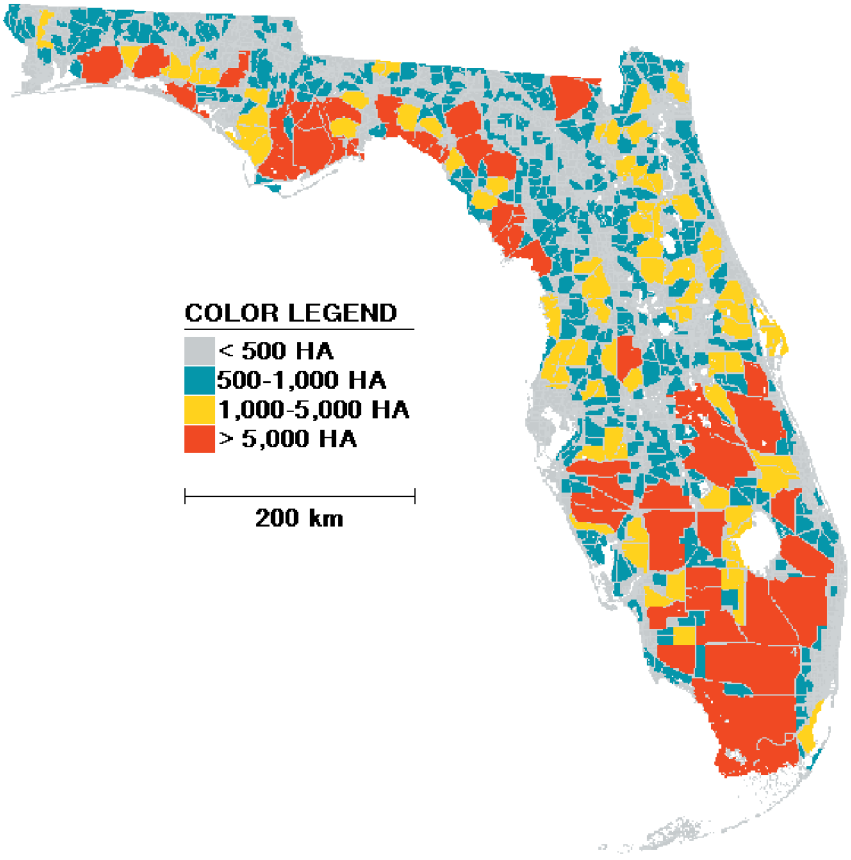


Figure 17. Polygons bounded by roads (Figure 16) were reclassified based on the land area they contained.

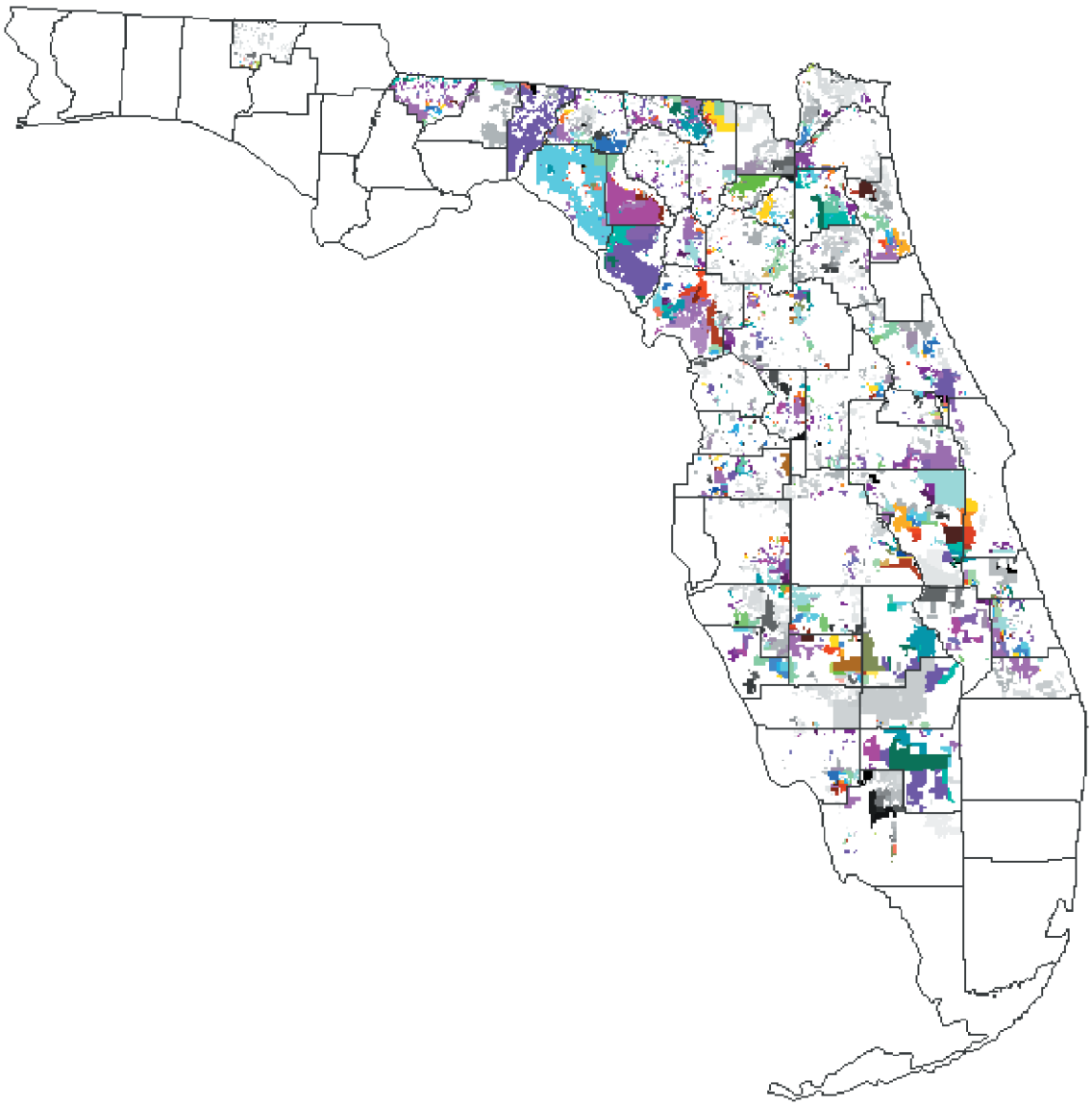


Figure 18. Private land parcels larger than 130 ha (320 acres) were digitized for all but 18 counties using plat directories.

important to the conservation and management of some of the rare species analyzed here.

We created a map of privately owned parcels larger than 130 ha (320 acres) using plat directories dated 1987-1990 (Florida Plats, 1289 Bowan Blvd., Clermont, Florida). The boundaries of individual parcels were transferred onto 1:126,720 scale county road maps prepared by the Florida Department of Transportation and digitized for all but 18 counties (for which no plat maps have been published). The resulting map (Figure 18) is helpful in identifying lands that might be more easily conserved through one of a variety of land-conservation techniques.

SECTION 4. DEVELOPMENT OF INFORMATION ON WILDLIFE SPECIES

SECTION 4.1. SELECTION OF SPECIES FOR ANALYSIS

Forty-four vertebrate taxa (Table 6) were selected for our most detailed analyses. The term "focal species" is used to describe this group. Soulé and Simberloff (1986) and Noss (1991) discuss the importance of focussing on the autecology of rare species when developing conservation strategies. However, a narrow focus on focal species will obviously overlook habitat needed by other species (Ryti 1992).

While the inclusion of additional taxa as "focal species" would be desirable and future analyses are planned, it is impossible to analyze all 542 terrestrial and wetland vertebrate species found in Florida in a meaningful manner. In fact, such a herculean task is largely unnecessary since many species are not declining or currently at risk of extinction. In addition, if focal species are carefully selected, they may umbrella the habitat needs of many other species.

Table 6. List of Focal Species used in analyses and their status in Florida (E=endangered, T=threatened, SSC=species of special concern, D=declining, G=game, F=furbearer). Scientific names appear in Appendix 1.

SPECIES	WIDE-RANGING	STATUS	HABITAT INDICATOR
Amphibians and Reptiles			
American crocodile	Yes	E	Mangrove
Bog frog		SSC	Seepage bogs
Florida scrub lizard		D	Scrub
Gopher tortoise		SSC	Sandhill, scrub
Pine barrens treefrog		SSC	Seepage bogs
Atlantic salt marsh snake		T	Coastal salt marsh
Gulf salt marsh snake		D	Coastal salt marsh
Birds			
American oystercatcher		SSC	
American swallow-tailed kite	Yes	D	Forested wetlands
Audubon's crested caracara	Yes	T	
Black-whiskered vireo		D	Mangrove and hammock
Cape Sable seaside sparrow		E	Coastal and freshwater marshes
Cuban snowy plover		T	
Florida burrowing owl		SSC	Dry prairie
Florida grasshopper sparrow		E	Dry prairie
Florida sandhill crane	Yes	T	Freshwater marsh
Florida scrub jay		T	Oak scrub
Limpkin		SSC	Wetlands
Louisiana seaside sparrow		D	Coastal marshes
Mangrove cuckoo			Mangrove
Mottled duck		G/D	Wetlands
Piping plover		T	
Red-cockaded woodpecker		T	Old growth pine
Scott's seaside sparrow		SSC	Coastal marshes
Short-tailed hawk	Yes	D	Forested wetlands
Snail kite	Yes	E	Freshwater marshes
Smyrna seaside sparrow			Coastal marshes
Southeastern American kestrel		T	Sandhill
Southern bald eagle	Yes	T	
White-crowned pigeon	Yes	T	Mangrove, tr. hammock
Wakulla seaside sparrow		SSC	Coastal marshes
Wild turkey	Yes	G	
Wilson's plover		D	
Mammals			
Anastasia Island beach mouse		E	Coastal strand
Bobcat	Yes	F	
Big Cypress fox squirrel		T	
Choctawhatchee beach mouse		E	Coastal strand
Florida panther	Yes	E	
Florida black bear	Yes	T	
Perdido Key beach mouse		E	Coastal strand
Santa Rosa beach mouse			Coastal strand
Sherman's fox squirrel		SSC	Sandhill and open pinelands
Southeastern fox squirrel			Sandhill and open pinelands
Southeastern beach mouse		T	Coastal strand

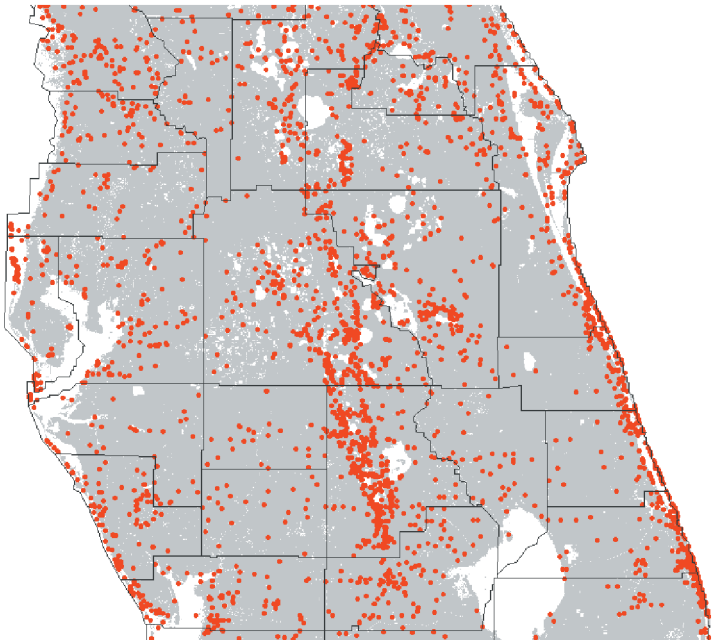


Figure 19. Occurrence records processed by the Florida Natural Areas Inventory.

Several criteria were used to select focal species. A primary consideration was whether habitat requirements for the species could be described using the land-cover map and other geographic data sets. In many cases, the land-cover map is simply too coarse to use for identifying lands that constitute appropriate habitat for certain species. However, when combined with information from field surveys, published occurrence records, and maps of soils, roads, and other geographic features, the land-cover map provides a much better description of potential habitat.

A second consideration was whether a species exhibited large home-range requirements and might be susceptible to increasing fragmentation of contiguous forest tracts (Juday 1983). Focal species selected for these reasons included Florida panther, Florida black bear, bobcat, and wild turkey. Protection provided for these species could also benefit other species with smaller home range sizes and similar habitat requirements.

A third consideration was whether a species was closely tied to a specific rare plant community so that conservation plans for a focal species might provide greater protection for rare communities. Focal species selected for this reason included Florida scrub jay and scrub lizard (scrub communities), red-cockaded woodpecker (old-growth pine forests), gopher tortoise and fox squirrel (sandhill communities), white-crowned pigeon (tropical hardwood hammocks), mangrove cuckoo and black-whiskered vireo (mangrove communities), snail kite, sandhill crane, Florida grasshopper sparrow, and burrowing owl (prairies and freshwater marshes), and seaside sparrows and salt marsh snakes (coastal marshes).

A final group of birds was also included as focal species because they are listed as endangered or threatened in Florida (Wood 1992), exhibited declining populations or special habitat requirements, or, most importantly, were the subject of special studies that resulted in precise data on known occurrences. This group included southern bald eagle, short-tailed hawk, Audubon's crested caracara, southeastern American kestrel, Cuban snowy plover, Wilson's plover, American swallow-tailed kite, and American oystercatcher. The relatively larger proportion of birds chosen as focal species reflects a greater knowledge of the distributions and habitat requirements of this group. Birds are also useful in identifying habitat features important to other species (Scott et al. 1993).

SECTION 4.2. DEVELOPMENT OF DISTRIBUTION INFORMATION

Data documenting the known occurrences of focal species came from several sources. The Florida Natural Areas Inventory maintains a database of over 16,000 geographically referenced points that document the occurrences of 387 species of plants, 467 species of animals, and 81 natural communities. A copy of the Florida Natural Areas Inventory database (Figure 19) was obtained in 1992 and last updated in January 1993. The Florida Game and Freshwater Fish Commission's Nongame Wildlife Program maintains a species observation database that includes geographically referenced points documenting the occurrences of a variety of wildlife species, including wading bird rookeries, southern bald eagle nests, short-tailed hawk territories, crested caracara territories, and shorebird nesting colonies. A copy of this database (Figure 20) was obtained in January 1992. Various researchers were also contacted for occurrence information on selected species. Location data (in the form of georeferenced points) were obtained for snail kite (J. Rodgers), American swallow-tailed kite (Meyer and Collopy 1990), grasshopper sparrow (M. Delany, R. DeLotelle), red-cockaded woodpecker (J. Beever, R. DeLotelle, K. Dryden, T. Engstrom, J. Garrison, D. Jansen, C. Smith), Florida panther (D. Maehr), white-crowned pigeon (T. Bancroft), Florida scrub jay (J. Beever, K. Dryden), black bear (J. Wooding), and sandhill crane (J. Beever, K. Dryden, N. Dwyer).

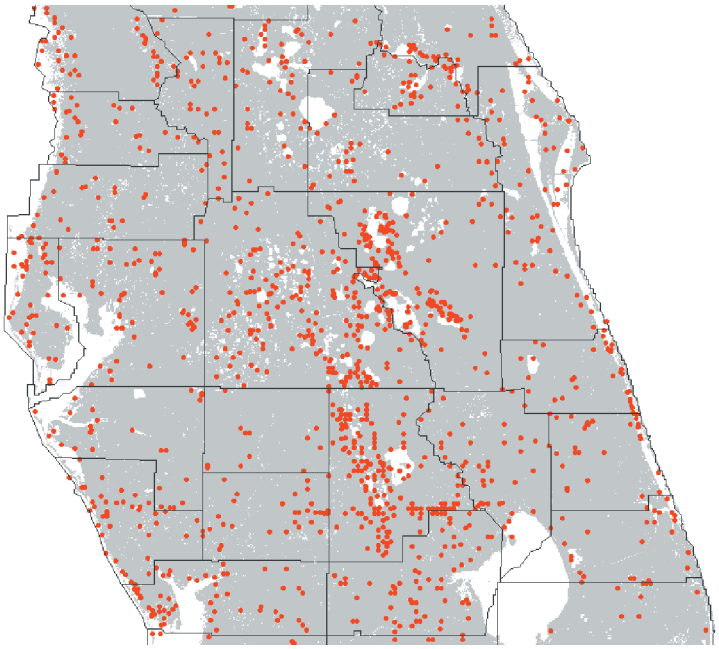


Figure 20. Occurrence records processed by the Florida Game and Fresh Water Fish Commission.

The occurrence data described above are stored in a "point" format whereby the records consist of latitude and longitude coordinates for known occurrence records. Point data help to describe species' distributions and identify specific areas of potential concern, but they provide little information on the surrounding habitat features important to the animals in question. Points also do not describe slight changes in the location of a feature over time (e.g., relocation of a nest within a larger territory).

To compensate for these deficiencies, we generated circles of a given radius around many of the point data sets. For example, bald eagles forage within a 3-km or larger area around nests (U.S. Fish and Wildlife Service 1987b). By extending a 3-km zone around all eagle nest sites and then isolating the open water and wetland areas found within this zone, we identify the actual habitat features that might be important to maintaining bald eagles in an area.

Information on specific territory size and foraging areas was not available for some of the species considered here. Where information was lacking, we used "small" and "large" radii to help identify some of the habitat features surrounding occurrence records that might be important to the species in question. A small radius was arbitrarily set at 250 m (covers 20 ha or 48 acres), and a large radius was arbitrarily set at 1 km (covers 314 ha or 775 acres). The use of either a small or large radius is described in the accounts of individual species (Section 6.2).

Another treatment of point data delineated areas with concentrations of points. Voronoi tessellation (TYDAC 1991) creates polygons around individual points where the borders of all polygons are equidistant from the nearest neighboring points. A Voronoi tessellation of the Florida Natural Areas Inventory data set is shown in Figure 21. Since polygons surrounding points with distant neighboring points have a larger area, the

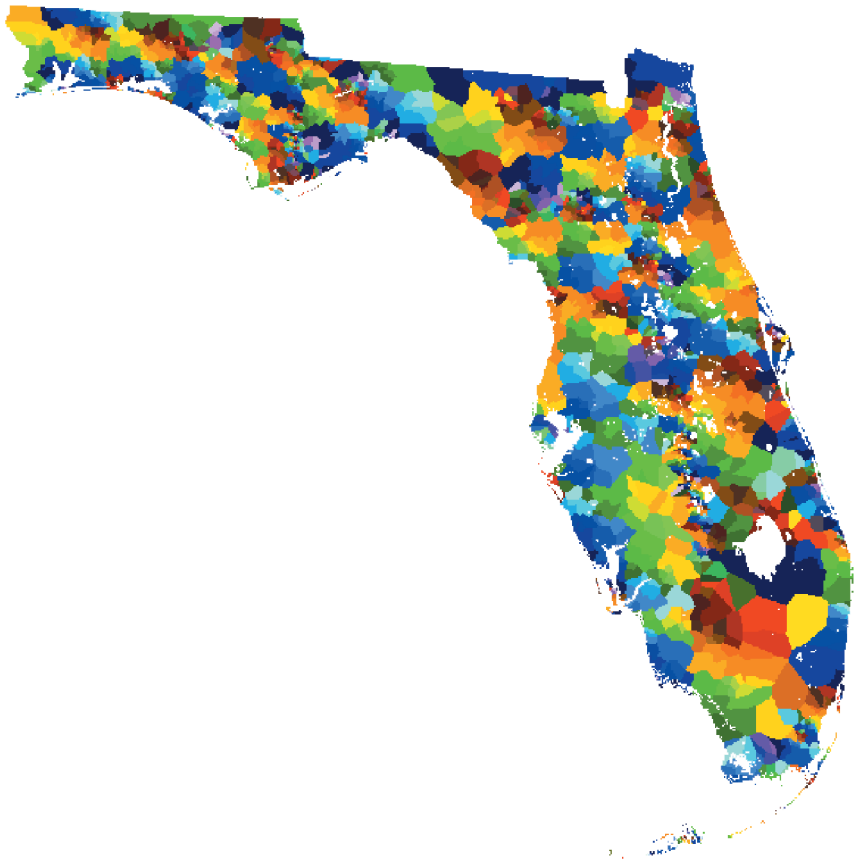


Figure 21. Tessellation of occurrence records processed by the Florida Natural Areas Inventory.

individual polygons may then be reclassified based on the area that they cover. Figure 22, for example, shows the previous figure reclassified into 3 categories based on the size (or area) of the polygons defined by the Voronoi tessellation. This technique shows where concentrations of Florida Natural Areas Inventory data points occur based on a repeatable, quantitative technique.

We used records provided in the Atlas of Florida Breeding Birds (Kale et al. 1992) as another type of occurrence record. Atlas data reference breeding locations for different birds to blocks that cover one-sixth of a 7.5-minute quadrangle map, an area of about 3,080 ha (7,600 acres). By isolating specific land-cover types within atlas blocks where a species was recorded, we can refine our maps showing potential habitat for the species. Atlas data are used primarily for wide-ranging species that might move over an area as large as an atlas block, or for species that can be tied to specific land-cover types within atlas blocks. Figure 23, for example, shows the boundaries of atlas blocks in which American swallow-tailed kites nested in an area of the panhandle (including portions of Leon, Wakulla, and Jefferson counties). Within each block, we highlighted the mixed hardwood swamp, cypress swamp, hardwood hammocks, and other cover types commonly used by this species for nesting and foraging (Meyer and Collopy 1990). This technique provides a much more accurate habitat distribution map than would be possible using either the land-cover map or atlas blocks alone.

P. Moler (unpubl.) transcribed museum records (which often include location information) for many species of amphibians and reptiles. This database was obtained in January 1993. The township, section, and range information included in this database was used to restrict habitat models for many amphibians and reptiles to the 260 ha (640 acre) area defined by a section.

Focal species such as Florida panther and Florida black bear require large areas of land for survival and cannot be conveniently represented by points and blocks. Potential habitat maps were developed for these and other selected species using habitat models within areas where the species was known to occur. Data used to establish the geographic limits within which models were performed are described below for individual species. Habitat models generally involved identifying broad regions where species occur, highlighting cover types that the species uses, and considering other geographic variables of potential importance (e.g., habitat patch sizes, proximity to known population centers, and the density of roads and urban areas).

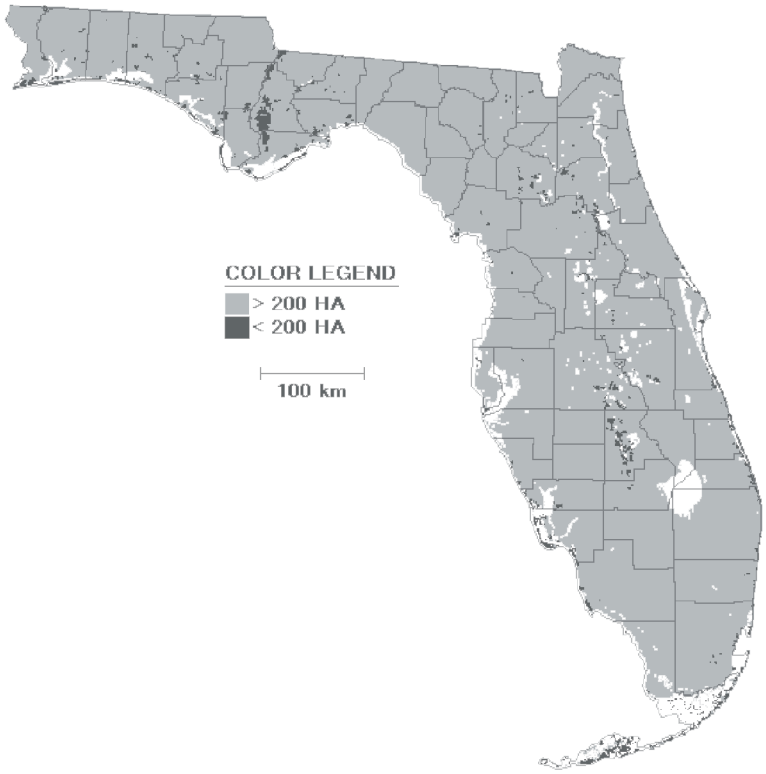


Figure 22. Reclassification of the polygons created in Figure 21 based on area.

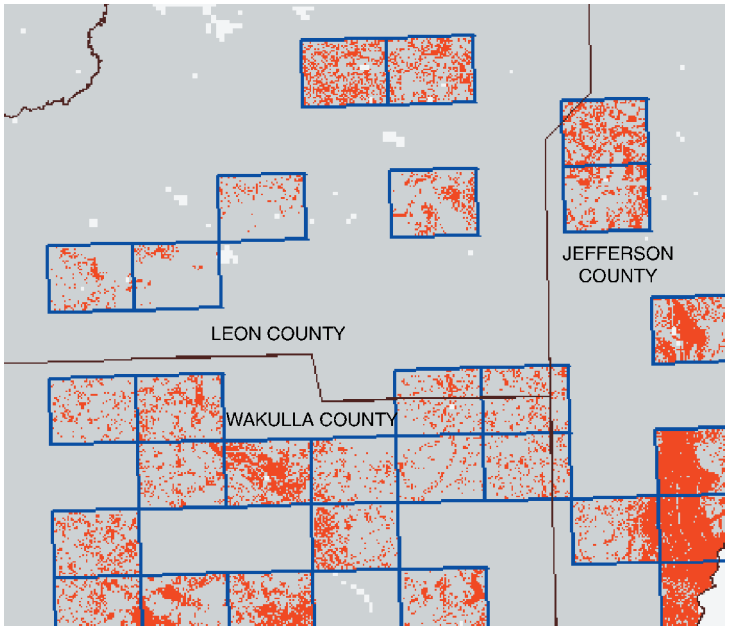


Figure 23. Boundaries of breeding bird atlas blocks in which American swallow-tailed kites nested in Leon, Wakulla, and Jefferson counties. The mixed hardwood swamp, cypress swamp, upland hardwood hammock, and other appropriate land-cover types are highlighted within each atlas block.

SECTION 5. ASSESSING POPULATION VIABILITY

Minimizing the threat of extinction is the primary concern in conservation planning and rare species management. Although populations may go extinct for several reasons (Soulé and Simberloff 1986), environmental variability (including catastrophic events) and inbreeding depression are usually listed as the primary threats to vertebrate populations (Shaffer 1987). Although most recent evaluations (Lande and Barrowclough 1987, Lande 1988) conclude that environmental variability poses the more immediate threat, the popular conservation literature tends to stress inbreeding prob-lems. Thus, we believe that some discussion of inbreeding and genetics is important in order to explain why we treat it as a secondary problem. In addition, the fact that environmental variability represents the primary threat to small populations does not mean that genetical problems should be totally ignored over the very long time periods envisioned for most conservation goals. Genetic composition has an influence on the survival and productivity of individuals in a population (Ralls et al. 1979, O'Brien and Evermann 1988).

SECTION 5.1. ENVIRONMENTAL VARIABILITY

The variation in fecundity and survival that occurs over time poses a significant threat to small populations. The chance occurrence of several "bad" environmental years in quick succession, or a catastrophic event such as a major disease or storm, can drive even fairly large populations to the point that they have little chance of recovery. Variation in demographic parameters such as sex ratios and age distributions may also affect the persistence of extremely small populations.

We used computer simulations (Shaffer 1987) to evaluate the influence of environmental variability on population persistence in 11 focal species. A computer model (Appendix 4) was constructed that followed females over time and simulated year-to-year changes in fecundity and survival over a 200-year period. The specific values of survival and fecundity experienced by individuals in a population in a given year were drawn at random from a pseudo-normal distribution. The simulations also included an infrequent "catastrophic" year where survival and/or reproduction were markedly lowered for all individuals in the population. Catastrophic events appeared with a frequency of 15-25 years (depending on the species in question) and were determined by drawing from a uniform distribution. The specific values used, and whether a catastrophe influenced survival, fecundity, or both, varied among species (Appendix 4).

Population sizes ranging from 10-350 individuals were used to initiate simulations, and 200 trials were conducted for each set of unique conditions (Harris et al. 1987). The distribution of extinction times resulting from this model was approximately log-normal, which precludes an informative use of means and standard deviations. We therefore report population viability as the proportion of the 200 trials where the population persisted for at least 200 years (Goodman 1987a). A population was considered effectively "extinct" when only 1 female remained.

Sufficient demographic data were found for 11 species (Appendix 4) for use in our generalized population model. Since there was variation in many of the population parameters obtained from literature searches, we used a range of "unfavorable," "moderate," and "favorable" parameters to assess how such variation affected estimates of population persistence. "Unfavorable" parameters approached the lower range of estimated values for survival and fecundity found in literature searches, while "favorable" parameters approached the higher levels of fecundity and survival. "Moderate" parameters fell somewhere in between. Appendix 4 contains the range of values used for these abbreviated sensitivity analyses.

Figures 24a-k show the relationships between initial total population size (converted to include males) and the pseudo probability of extinction. For example, model populations of red-cockaded woodpeckers (Figure 24a) appear to have very good chances of persisting for 200 years under favorable conditions given an initial population size of roughly 200 individuals. Even at lower levels of fecundity and survival (the "unfavorable" model), model populations with about 200 individuals have > 75% chances of persisting for 200 years. Species with relatively high minimum thresholds for persistence are fox squirrel, Cuban snowy plover, red-cockaded woodpecker, and gopher tortoise. Under favorable environmental conditions, these species require populations of about 200-300 to provide good chances of long-term survival. Florida panther, black bear, bobcat, wild turkey, southern bald eagle, and sandhill crane, on the other hand, appear to have lower minimum thresholds. Smaller populations (e.g, 100-150) of these species facing favorable environmental conditions appear to have good chances of long-term survival.

The general relationship between population size and population persistence (Figures 24a-k) is nonlinear, which indicates that substantial increases in population size may produce only slight increases in estimated persistence times. A model population of 200 red-cockaded woodpeckers appears to have almost as good a chance of surviving as a population of 300 red-cockaded woodpeckers under moderate conditions. This result, which is characteristic of other models (e.g., Goodman 1987a, 1987b, Shaffer 1987), stems from the roles that catastrophes and environmental calamities play in determining population persistence. The impacts of catastrophic events will of course depend on the autecology of the species in question and the nature of the catastrophe. When Hurricane Hugo struck the South Carolina coast in 1989, it destroyed habitat for red-cockaded woodpeckers across a large area, but the storm probably had less of an impact on bobcat habitat in the same area. The effects of epidemics may also vary depending on whether the species is spatially clustered (e.g., Florida scrub jay) or spatially dispersed (e.g., Florida black bear). Shaffer (1987) and Beier (1993) provide additional discussions on how catastrophic and environmental perturbations vary among species.

As indicated in Figures 24a-k, population models are very sensitive to the specific population parameters used. If one were to define a viable population of fox squirrels (Figure 24g) as a population having > 90% chances of surviving for 200 years, then the requisite number of individuals needed to satisfy this condition ranges from 200-400+ depending on the demographic values used. This result provides a very strong indication of the importance of

Figure 24 (a-k). Relationships between initial population size and the chances of persisting for 200 years for model populations of 11 focal species (Model 1 = favorable environmental conditions; Model 2 = moderate environmental conditions; Model 3 = unfavorable environmental conditions).

Figure 24a.

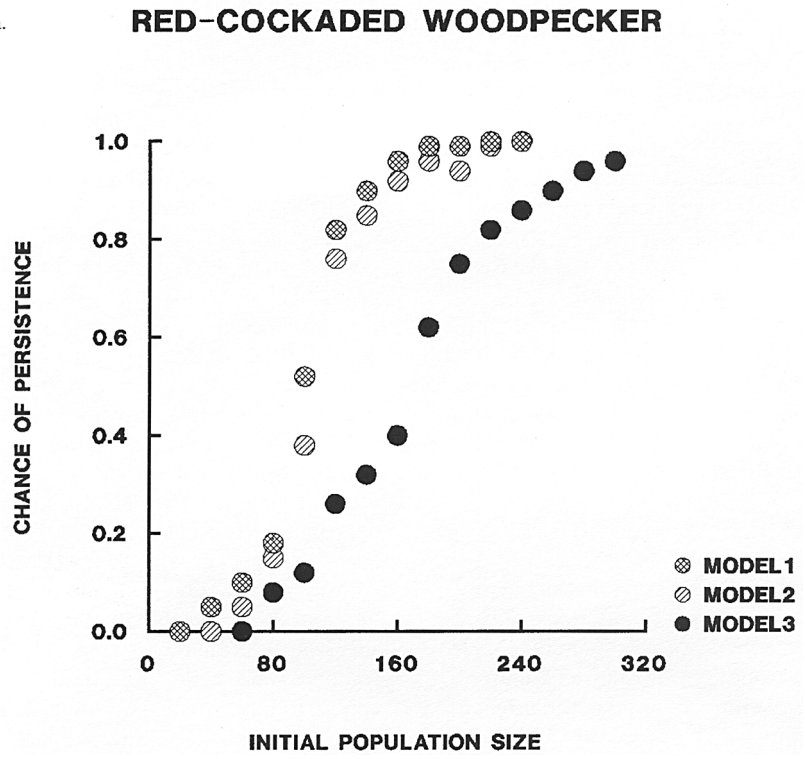


Figure 24b.

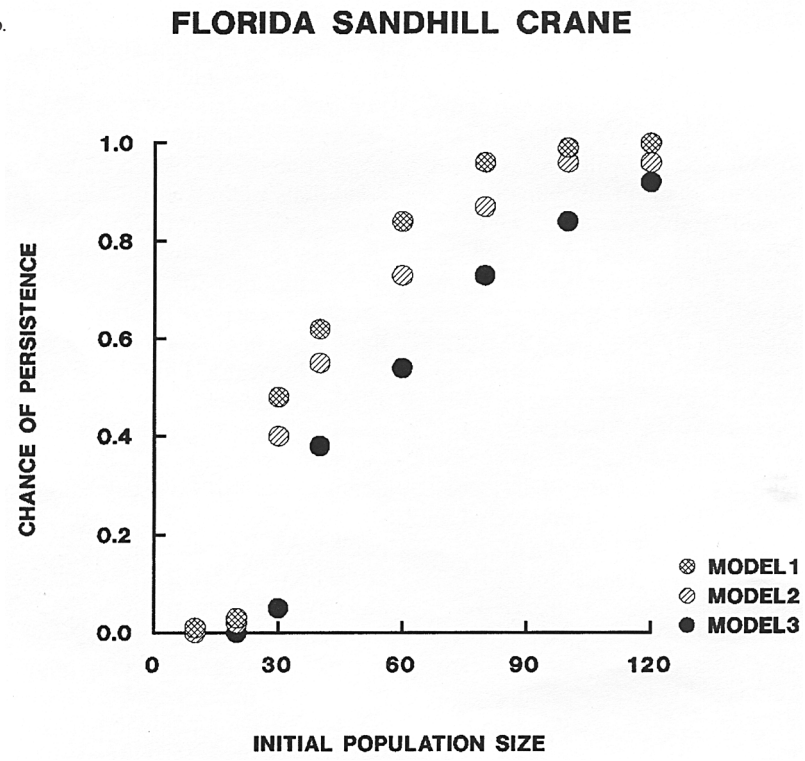


Figure 24 (a-k). Relationships between initial population size and the chances of persisting for 200 years for model populations of 11 focal species (Model 1 = favorable environmental conditions; Model 2 = moderate environmental conditions; Model 3 = unfavorable environmental conditions).

Figure 24c.

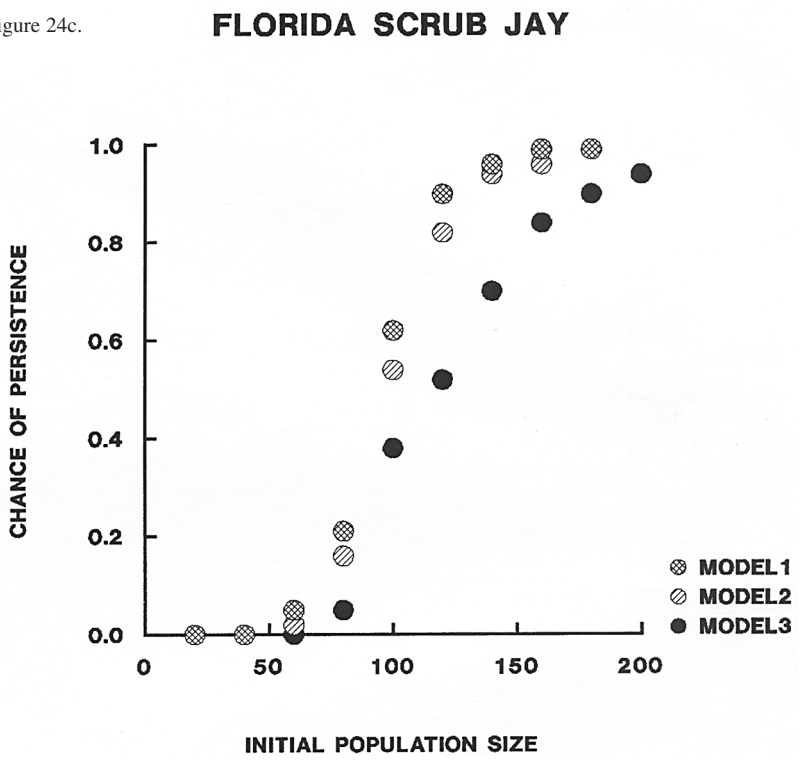


Figure 24d.

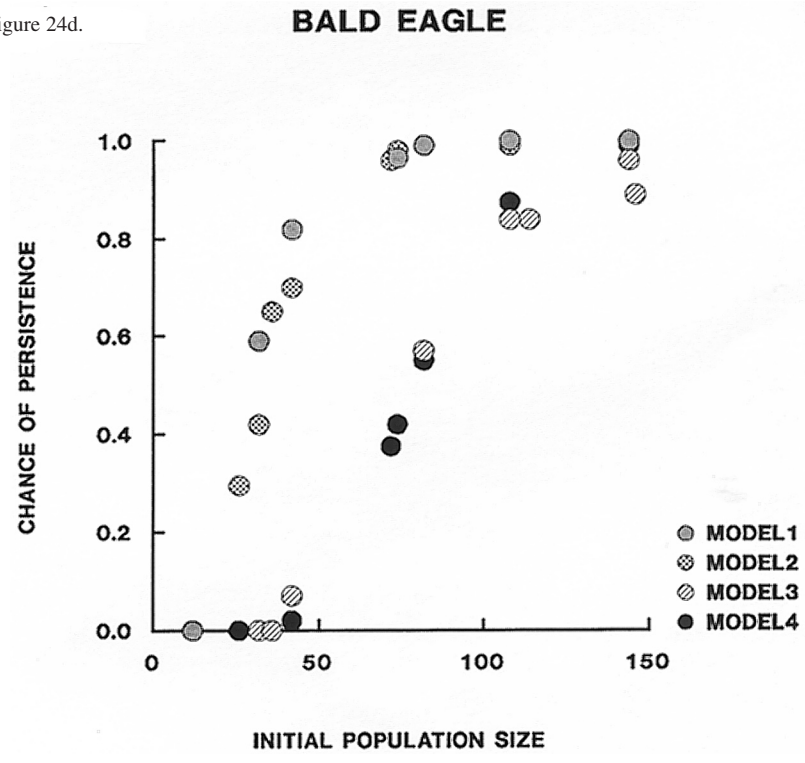


Figure 24 (a-k). Relationships between initial population size and the chances of persisting for 200 years for model populations of 11 focal species (Model 1 = favorable environmental conditions; Model 2 = moderate environmental conditions; Model 3 = unfavorable environmental conditions).

Figure 24e.

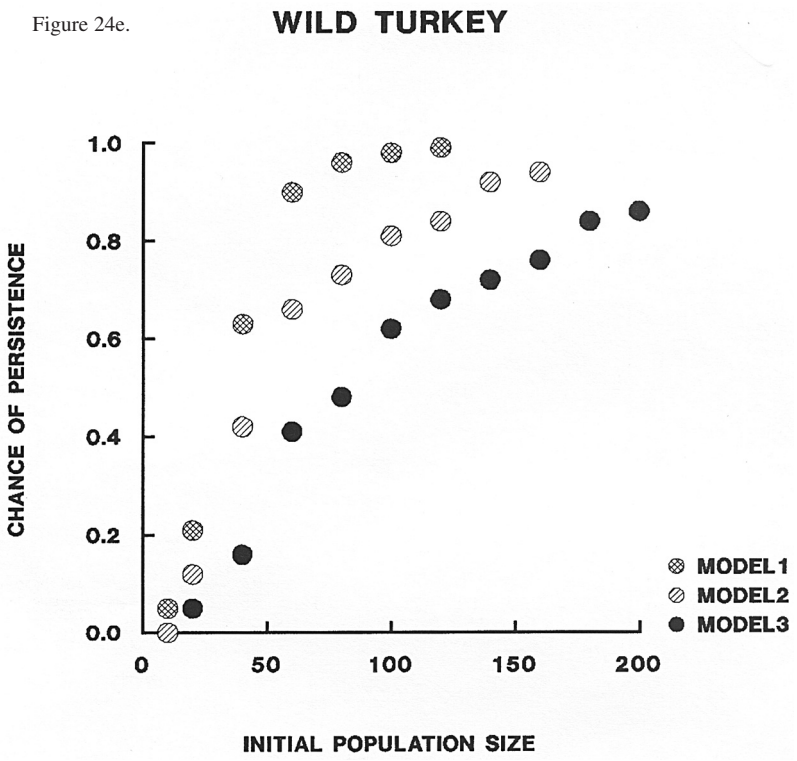


Figure 24f.

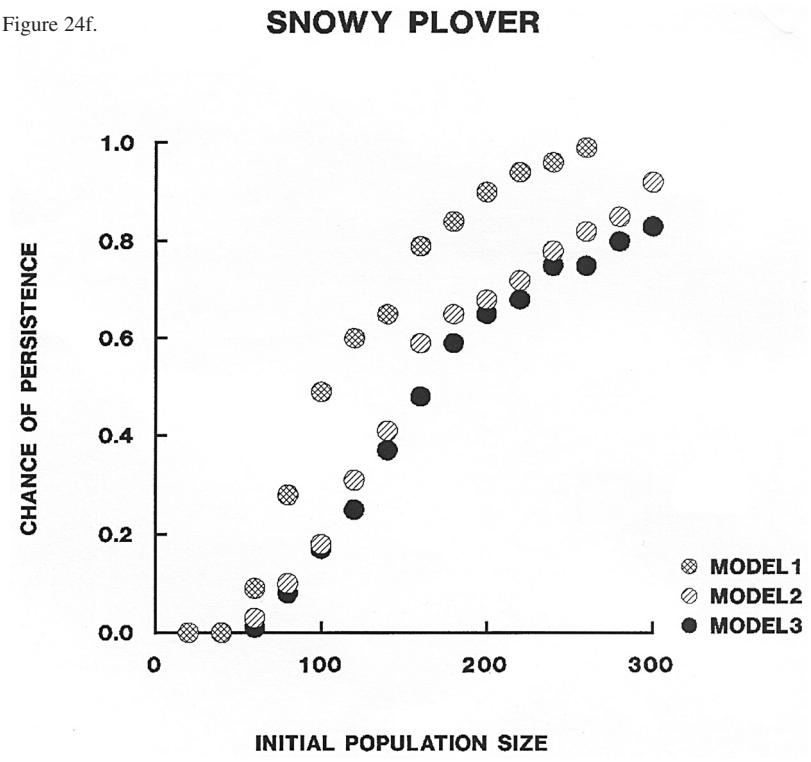


Figure 24 (a-k). Relationships between initial population size and the chances of persisting for 200 years for model populations of 11 focal species (Model 1 = favorable environmental conditions; Model 2 = moderate environmental conditions; Model 3 = unfavorable environmental conditions).

Figure 24g.

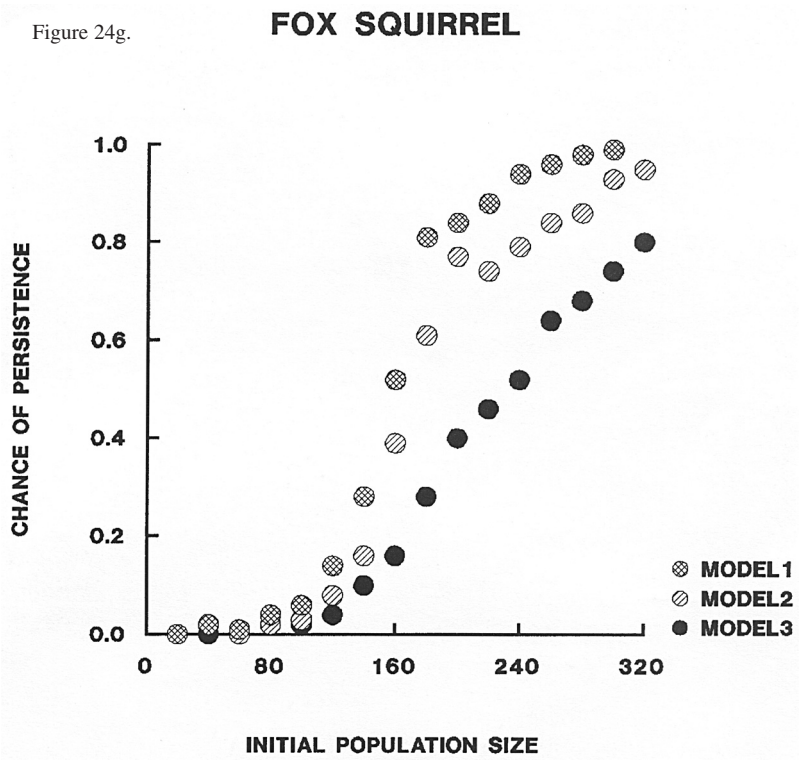


Figure 24h.

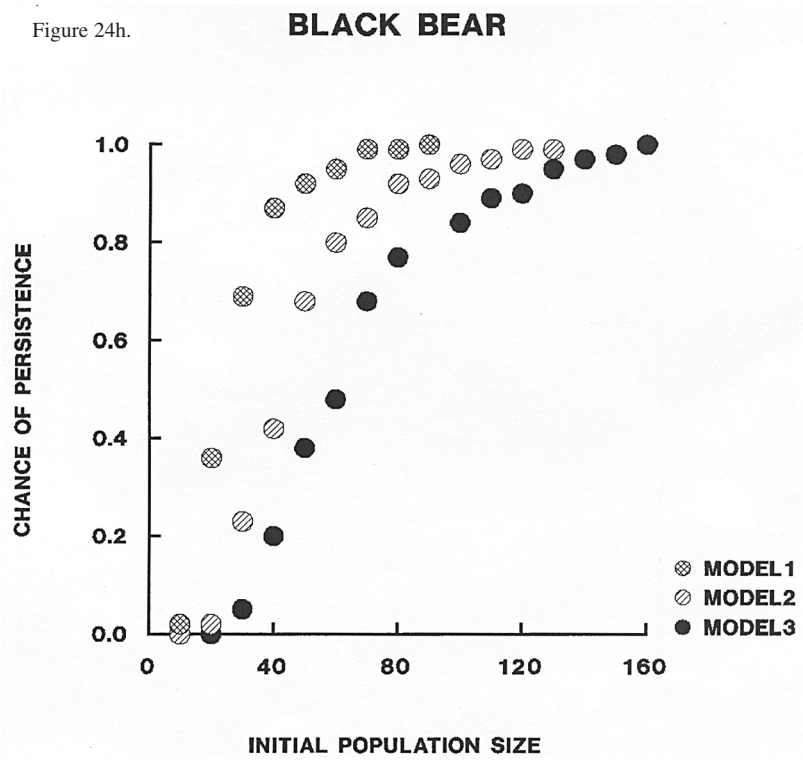


Figure 24 (a-k). Relationships between initial population size and the chances of persisting for 200 years for model populations of 11 focal species (Model 1 = favorable environmental conditions; Model 2 = moderate environmental conditions; Model 3 = unfavorable environmental conditions).

Figure 24i.

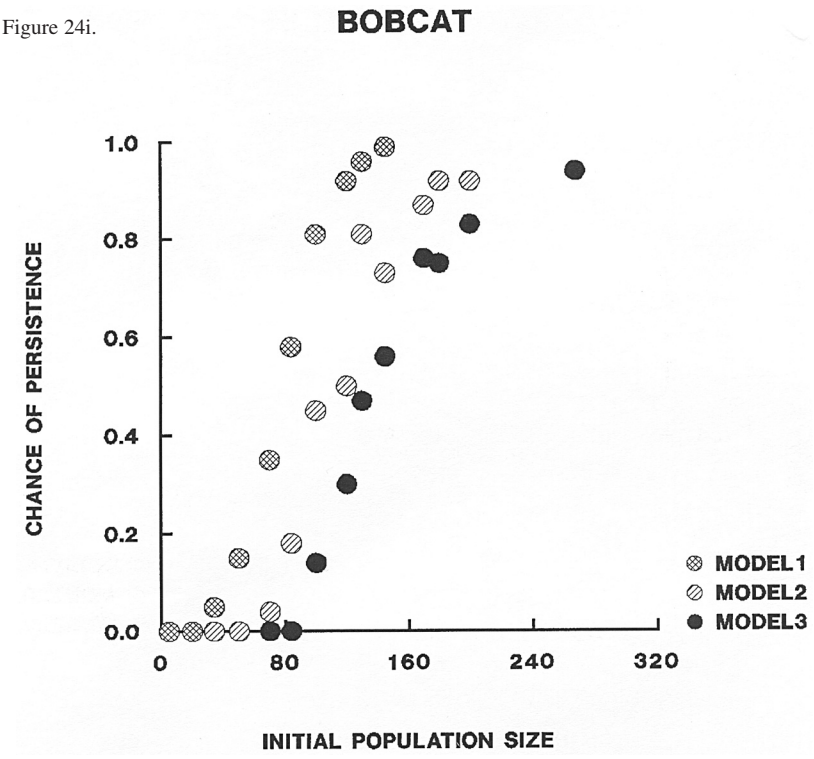


Figure 24j.

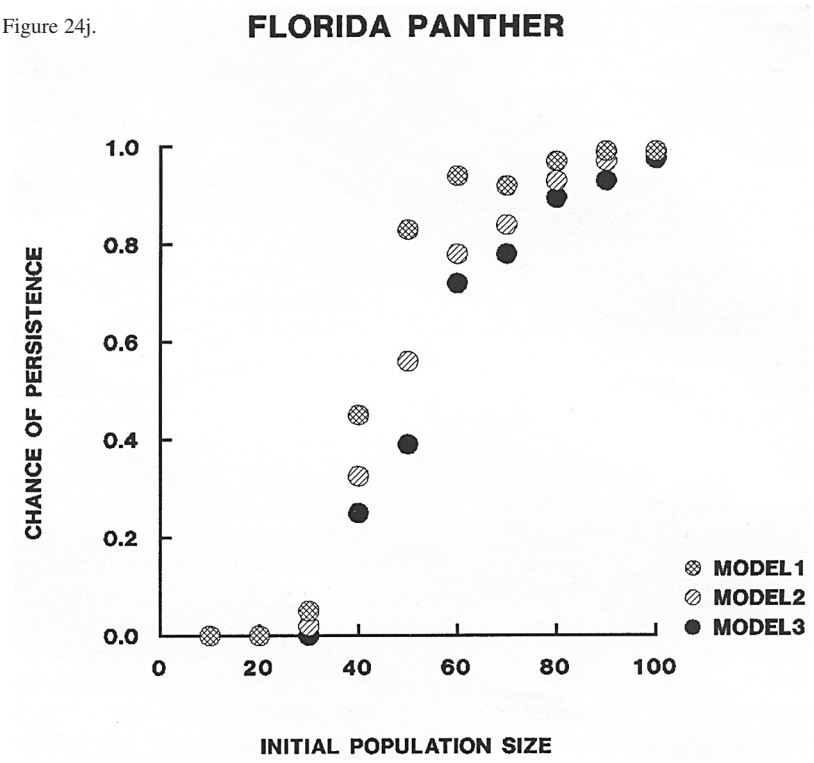
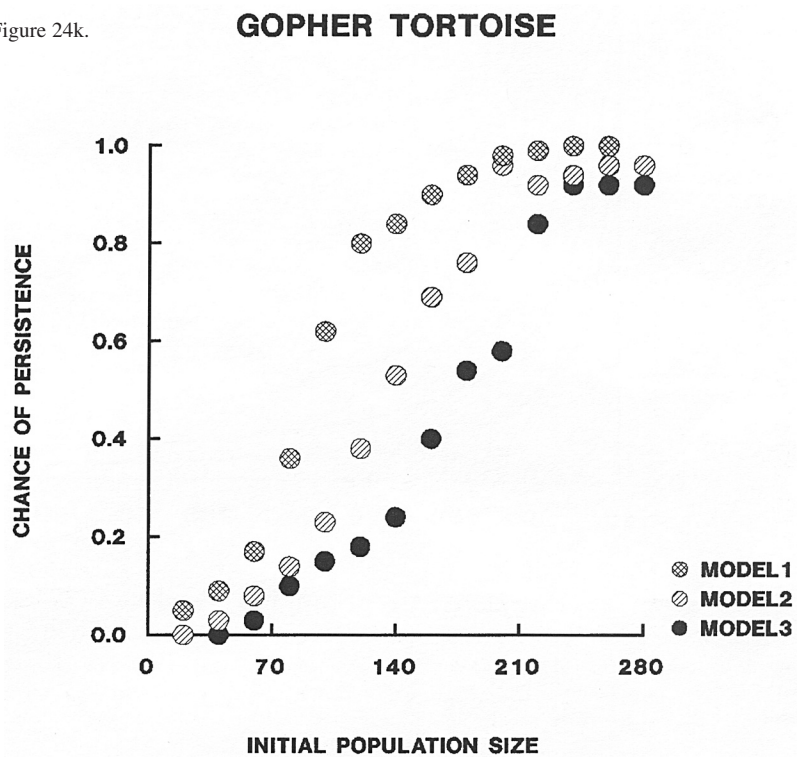


Figure 24 (a-k). Relationships between initial population size and the chances of persisting for 200 years for model populations of 11 focal species (Model 1 = favorable environmental conditions; Model 2 = moderate environmental conditions; Model 3 = unfavorable environmental conditions).

Figure 24k.



appropriate population and habitat management in preserving rare species. Populations of 200 or 400 fox squirrels facing poor management conditions (i.e., lowered survival and fecundity) have about equal likelihoods of becoming extinct. The population of 400 requires a much larger patch of habitat, but protection of even a very large patch **does not guarantee** greater security. On the other hand, a population of 200 fox squirrels placed under favorable management conditions (i.e., higher survival and fecundity) has a much better chance of persistence and requires roughly half the habitat base needed to support a population of 400 under unfavorable conditions. In simple terms, there is no guarantee that conservation efforts emphasizing the protection of very large populations and habitat areas will be effective if populations are not provided with appropriate management after habitat areas are protected. An investment in population and habitat management thus may sometimes outweigh an investment in protecting additional land.

SECTION 5.2. INBREEDING AND INBREEDING DEPRESSION

The term inbreeding has developed a bad connotation in the popular conservation literature in recent years. Inbreeding occurs in all populations, and low levels of inbreeding are actually correlated with higher productivity in at least one population of birds (van Noordwijk and Scharloo 1981). The concern in wildlife conservation and management is thus not whether inbreeding occurs, but whether it reaches such levels that it significantly lowers survival and reproduction, which, in turn, could reduce the chances of population survival. The term inbreeding depression is used to distinguish between inbreeding and the deleterious effects that might arise from high levels of inbreeding. Unfortunately, the level of inbreeding required to induce inbreeding depression varies tremendously among species (Ballou and Ralls 1982), and the data needed to estimate such effects accurately may take several decades to collect (Koenig 1988). Indeed, some species appear to tolerate fairly high levels of inbreeding very well (Walter 1990).

The genetic size of all vertebrate populations (i.e., the diversity of alleles in the population) is very different from the censused size of populations (i.e., the number of individuals that can be counted). For example, since juveniles in many long-lived species do not breed, simply counting all the individuals that make up a population does not provide a good estimate for the size of the breeding population that actually contributes genes to the next cohort of young. As a result of the social structure of populations and dispersal characteristics, the size of genetic populations may also be spatially restricted to a degree that may seem surprising. For example, the white-footed mouse occurs in a variety of habitat types and is common throughout much of North America, but the size of genetic subpopulations is estimated at 80-110 individuals occupying only a few score acres (Howard 1949). The size of genetic subpopulations of Florida scrub jays may be only 20-40 individuals (J. Fitzpatrick, pers. comm.).

Calculations of effective population size and effective neighborhood size (Wright 1969, Crow and Kimura 1970) are needed to translate estimates of censused population size into estimates of the genetical population size and extent. Such calculations adjust for the variation in age, survival, and

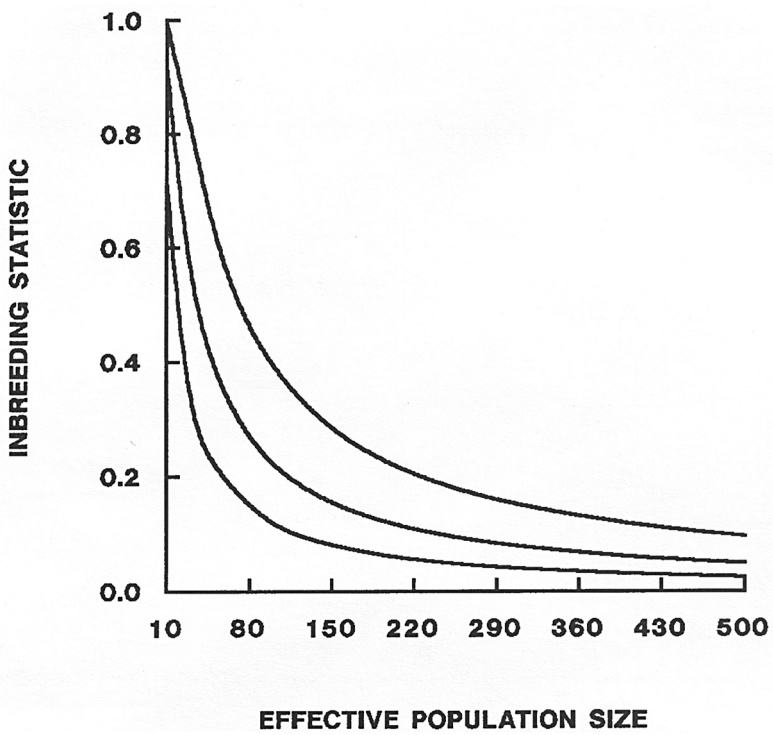


Figure 25. Relationship between the level of inbreeding and effective population size for three lengths of time (as measured by the number of generations). The upper line is the inbreeding statistic over 50 generations; the middle line is the inbreeding statistic over 100 generations; and the bottom line is the inbreeding statistic over 200 generations. Different generation lengths are shown because the level of inbreeding is influenced by both the size of a population and the time period of concern.

fecundity of individuals that make up a population, as well as the fact that the distance between the site of birth and the site(s) of reproduction is always limited.

As a result of the various population characteristics incorporated into estimates of effective population and effective neighborhood sizes, the rate at which inbreeding decreases in relation to effective population size is nonlinear and flattens out sharply approaching larger effective population sizes (Figure 25). For example, if a protected population has an effective population size of 150, it may take a doubling of the population size to reduce the rate of inbreeding by only 10%. The importance of slight changes in the rate of inbreeding to the survival of populations is poorly known (Ralls et al. 1979, Ralls et al. 1988), and simply enlarging populations to guard against inbreeding may not actually alter the level of inbreeding appreciably.

Franklin (1980) recommended that an effective population size of 50 individuals would have acceptably low levels of inbreeding over the course of many generations. This estimate was based on the observations of stock breeders, but it is only a ballpark figure that should not be strictly applied (Lande and Barrowclough 1987). It is difficult to estimate effective population sizes in wild populations accurately in the absence of long-term studies (Futuyma 1979, Koenig 1988), and even when long-term data exist the specific techniques used to estimate effective population sizes may produce very different results. The proposition that conservation efforts should focus on protecting effective populations of about 50 individuals has been widely used (Cox et al. 1987, Reed et al. 1988, Hellgren and Vaughn 1989), but it would be wrong to suggest that effective populations smaller than 50 individuals are doomed to extinction.

Recommendations for protecting effective population sizes much larger than 50 have also been proposed (Franklin 1980, Lande and Barrowclough 1987), but there are additional problems associated with these recommendations (Lande and Barrowclough 1987, Simberloff 1988). Lande and Barrowclough (1987) conclude that effective population sizes totalling "several hundred" should be the goal of conservation efforts, but they also conclude that this large population can be effectively managed on a system of multiple preserves. The general effect of maintaining populations on multiple preserves is to increase the genetic variation across all populations at the possible expense of lowered genetic variation within subpopulations (Lande and Barrowclough 1987, Leberg 1991).

We conclude that effective population sizes in the range of 50 individuals are sufficiently large to withstand genetic deterioration for extended periods and represent a reasonable goal for conservation of a single population. Populations of this general size satisfy many of the minimum sizes proposed to offset the potentially deleterious effects of inbreeding depression (Franklin 1980, Lande and Barrowclough 1987), and if several preserves containing effective population sizes of around 50 are established, as discussed below, the level of genetic diversity preserved throughout all populations becomes extremely high (Chesser 1981, Chesser and Ryman 1986, Lacy 1987, Lande and Barrowclough 1987).

However, due to the over-riding importance of environmental variability in determining population persistence, any genetics-based recommendations should serve only as a very general guideline and must not be blindly followed. Populations with effective population sizes smaller than 50 often play a very crucial role in safe-guarding against certain

Table 7. Demographic parameters and effective population size estimations for selected species. Survival and reproduction ranges were determined from literature searches (see Appendix 5). Variation in estimated parameters was used to assess the sensitivity of the estimates to imprecise demographic data. Approximate generation length estimates (in years) are also provided. The effective equivalent represents the number of breeding individuals needed to establish an effective population size of approximately 50.

SPECIES	ANNUAL SURVIVAL	ANNUAL FECUNDITY	GENERATION LENGTH (yr)	EQUIVALENT POPULATION SIZE
Black Bear	0.87±	0.9	10±	75-130
Fox Squirrel	0.73±	2.3	3	105-150
Sandhill Crane	0.90±	0.5	8	100-135
Bobcat	0.68±	2.3±	4	160-190
Gopher Tortoise*	0.90±	6.0±	20	90±
Red-cockaded Woodpecker*	0.75±	0.9±	4–5	110±
Scrub Jay*	0.80±	2.0±	7–8	110±
Cuban Snowy Plover	0.73±	1.5±	3–4	130-170
Florida Panther*	0.86±	1.5±	3–4	100-150
Bald Eagle	0.90±	0.8±	3–4	100-150

* Estimations based on data published in Woolfenden and Fitzpatrick (1984), Cox et al. (1987), Reed et al. (1988), and Seal et al. 1989).

environmental threats. In addition, populations with effective populations smaller than 50 will persist for long periods of time (Walter 1990), and management activities can offset the loss of genetic variation that might occur in extremely small populations (Chesser 1981, Chesser and Ryman 1986, Lande and Barrowclough 1987, Leberg 1991).

Estimates for breeding population sizes that correspond to effective population sizes of 50 are presented in Table 7 for several species considered here. These estimates are based on the technique described in Reed et al. (1988) and demographic data presented in Appendix 4. The estimated effective population sizes range from 20-45% of the censused population sizes (Table 7) and are within the range of values presented for other vertebrate species (Ralls et al. 1988, Harris and Allendorf 1989). For other vertebrates not analyzed here, an effective population size of 50 translates into a censused population of about 100-250 individuals (Ballou et al. 1989).

SECTION 5.3. GUIDELINES FOR ESTABLISHING MINIMUM LEVELS OF SECURITY

As might be expected, the foregoing analyses of population viability point to some uncertainties and inconclusive results. There are simply no equations or models that can generate a convenient number that guarantees the continued existence of wildlife populations. Indeed, rarely are there sufficient data to drive the few crude models that exist, much less more elaborate models that take into account even more complex features of natural populations. Thus, to declare certain populations "viable" and other populations "nonviable" could be a serious mistake.

Our evaluation of the threat of extinction lead us to propose some general guidelines for evaluating the relative security of certain rare species. For many of the species analyzed here, we propose three very broad categories of viability for individual populations:

Imperiled Population: census population size estimated to be smaller than 100. Single populations of this size face a risk of extinction even under favorable management conditions. Populations of this size also may lose a significant portion of their genetic variability over the course of several generations.

Insecure Population: census population size estimated to be 100-200. Single populations of this size may be susceptible to annual environmental perturbations over an extended period and may lose a portion of their genetic variability over many generations. The prosperity of populations of this size will rely heavily on appropriate management regimes.

Potentially Secure Population: census population size estimated to be larger than 200. If habitat and population management are appropriate, the security of populations of this size will likely depend on the frequency and nature of catastrophic events rather than other environmental and genetical threats.

We will use these guidelines (in part) in Section 6 to estimate the level of protection offered to different species by the current system of conservation areas in Florida. We also recognize the fundamental importance of establishing multiple copies of protected populations to prevent "bad" environmental conditions or infrequent catastrophic events from affecting all protected populations simultaneously. The establishment of multiple populations might also preserve a large portion of the genetic variation that occurs across a broad landscape. Several articles discuss the importance of establishing multi-

ple populations (Soulé and Simberloff 1986, Goodman 1987b, Shaffer 1987, Lande and Barrowclough 1987, Harrison and Quinn 1989), but in simple terms multiplicity is analogous to placing your eggs in several different baskets.

To satisfy requirements for multiplicity, we propose that the presence of 10 potentially secure populations also be used to evaluate the relative security of populations of rare species. Even if the chances of persistence for a single population are around 30% rather than 80%, the establishment of 10 independent populations could provide a > 90% chance of at least one (Figure 26) of the populations persisting (Quinn and Hastings 1987). The conservation of 10 potentially secure populations will also satisfy the recommendations developed by Lande and Barrowclough (1987) of protecting effective populations sizes totalling in the hundreds. This protective strategy will conserve > 95% of the extant genetic variation across all populations over the course of scores of generations (Ballou et al. 1989). This protective strategy may also enable a portion of the genetic variation to be maintained within individual populations (e.g., Manlove et al. 1979, Chesser et al. 1982, Osterhoff et al. 1983). The presence of 10 populations of 200 individuals represents a sound conservation strategy where a minimum goal of protecting a viable collection of wild populations is sought within an increasingly humanized landscape.

These general guidelines must not be applied blindly to all species. For example, the interaction of large numbers of individuals at many different breeding sites may be an important feature of the population biology of species such as wading birds (Bildstein et al. 1991), and such features preclude the use of the proposed guideline. However, we believe the guideline represents a legitimate goal for several species, especially since it seems unlikely that more accurate estimates of acceptable security will be developed by the next generation of research, except perhaps on a species-by-species basis. On the other hand, there are definite consequences in delaying conservation efforts until new procedures or better estimates become available. As human populations continue to grow, many of the larger blocks of habitat remaining in Florida will likely be eliminated within the next few years.

Proper habitat and population management is critical to guaranteeing that this or any other type of conservation strategy will work. Beneficial management techniques increase average survival and fecundity within populations, and even slight increases in survival and fecundity will greatly enhance the chances that populations persist over time. The fate of all protected populations ultimately rests on how well they are managed, and an investment in the management of protected populations may sometimes outweigh an investment in the conservation of additional habitat.

The general guidelines may also be modified in certain cases based on more precise estimates of population viability or the amount of habitat available, or that can be restored, outside of existing conservation areas. Populations smaller than the minimum standards set forth here are certainly "viable" over extremely long periods of time (Walter 1990). However, their viability will require much more careful monitoring, greater habitat and population management, and, ultimately, more luck than if the manageable populations were larger and more numerous. The minimum desired goal of 10 populations of at least 200 reflects a careful weighing of the information available on population viability and the various costs and constraints facing all conservation efforts.

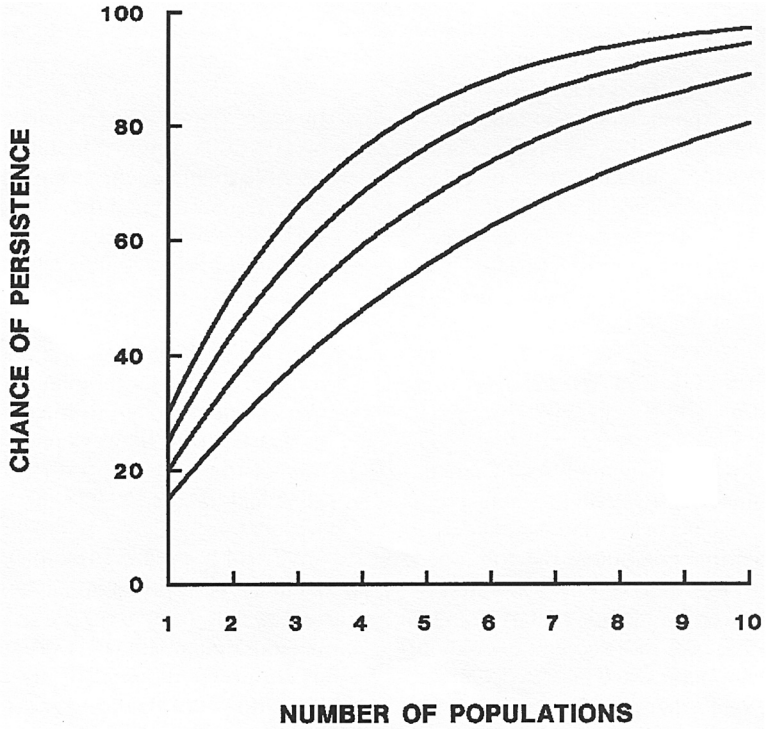


Figure 26. Relationship between the number of managed populations and population persistence. Several different values for estimated chances of persistence are shown. For example, the lowest curve represents the situation where each population has a 15% chance of survival. Two such populations would have about a 28% chance of at least one population surviving, and 10 populations would have >80% chance of at least one population surviving. The starting point on the Y axis indicates the estimated chance of survival for a single population (e.g., 15%, 20%, 25%, and 30%).

SECTION 6. IDENTIFICATION OF GAPS IN FLORIDA'S WILDLIFE CONSERVATION SYSTEMS

General guidelines for population sizes and numbers needed to provide security against extinction (Section 5) allow us to evaluate the effectiveness of current conservation areas in providing adequate protection for Florida's many rare species. Of interest, based on our stated targets, is whether a minimum of 10 conservation areas exists with sufficient habitat to support potentially secure populations of 200 or more individuals. We use this evaluation as a filter to help determine which species are in the greatest need of additional habitat conservation measures. As stated in Section 2.1, one of our primary assumptions is that habitat conservation efforts should focus on those species that are least adequately protected by the current system of conservation areas. Also important is the distribution of protected populations across the known range of the taxon in question and locations of patches of potential habitat outside of current conservation areas.

No comprehensive surveys exist for most species of wildlife on conservation areas throughout the state, much less on private lands. In fact, species such as Florida black bear and Florida panther can be very difficult to census over very large areas. Thus, we are forced to estimate population sizes in current conservation areas indirectly using two pieces of information: (1) an estimate of the amount of habitat available within conservation areas, and (2) an estimate of the density of individuals in relation to appropriate habitat conditions. Samson et al. (1985) proposed the term "habitat capacity" be used to describe this type of estimate since it makes assumptions about densities of species in relation to potential habitat maps. Although there are some drawbacks to this approach (Samson et al. 1985, Verner et al. 1986), such an analysis is needed to help determine how to allocate the limited monetary resources available for land conservation in Florida.

When estimating population sizes based on indirect measures, it is important to rely on known occurrences rather than completely unreferenced estimations of suitable habitat (Verner et al. 1986). Point and polygonal data documenting known occurrences were used in conjunction with habitat models to estimate the distribution of available habitat. The use of documented occurrence information restricted the area over which models were applied but greatly improved their accuracy. The specific combinations of data sets and GIS operations are discussed separately for each species.

SECTION 6.1. THEORY PERTINENT TO THE IDENTIFICATION AND DESIGN OF CONSERVATION AREAS

When the potential habitat within existing conservation areas fell short of the amount needed to support 10 populations of roughly 200 individuals, conservation plans were developed to increase the habitat that effectively could be managed for the species in question. Development of such plans leads to an area of conservation biology with conflicting opinions. Is it best to establish a single large or several small preserves? When and where will corridors be needed to help facilitate population interchange? We outline our planning philosophy below. The habitat conservation plans developed in this section focus on the autecology of each species and on attaining acceptable levels of security using the habitat available. Foremost in our considerations in developing minimum habitat conservation recommendations was the need to maintain existing populations and the various ecological processes most important to these populations. Protecting every individual within a population may not be a primary concern (except in the case of extremely rare species), nor is it critically important at this stage to consider habitat areas well outside the region where core population functions are played out.

Our approach of designing conservation plans that favor the protection of core populations at the expense of some individuals can perhaps be demonstrated by an extreme example. When a green-tailed towhee showed up in Florida in 1989 (Florida Ornithological Society 1992), the event did not lead to a call to establish a new conservation area for this very rare bird (from a Florida perspective). Nobody proposed a network of corridors or stepping-stone preserves so that other green-tailed towhees could find their way to Florida in the future. The circumstances that led to the arrival of this individual in Florida constituted an extreme "outlier." Attempts to separate unusual dispersal events and occurrence records from those events that are more essential to population persistence may be difficult because the biological literature often highlights the unusual (Endler 1972). However, we attempt to stress the processes most important to core population dynamics throughout this section by considering the dispersal capabilities of individual species and concentrations of occurrence records and potential habitat.

One of the most important reasons for focussing on core population areas is the potential monetary cost behind all conservation efforts. As Harris (1985) notes, we can never buy and protect everything. Land-acquisition spending in Florida may amount to $3.2 billion over the next decade. Based on the average cost of around $2,919 per ha (2.47 acres) expended by the Conservation and Recreation Lands Program prior to 1992 (Anon. 1992), we might expect these land-acquisition efforts to secure an additional 1,096,200 ha (2.7 million acres). While this may seem like a significant amount of land, it will increase the acreage of conservation lands in Florida by only about 28%, taking the statewide total from about 2.8 million ha (7.0 million acres) to 4.0 million ha (10.0 million acres). If we are to conserve and manage 4,000+ species on a habitat base of about 4.0 million ha, land conservation efforts must efficiently, as well as meaningfully, enhance the chances of population persistence.

Some researchers focus conservation efforts towards species rich areas (Scott et al. 1993), and a criticism that might be leveled at the focal species habitat conservation plans developed below is that the plans may not adequately treat communities, ecosystems, or higher-level aggregates of species (Noss 1991, Ryti 1992). We attempt to address this criticism in three ways. First, most of the species selected for analysis have large home range requirements. Habitat protection strategies developed for these species may umbrella the habitat requirements of other species with narrow habitat requirements and smaller home range sizes (Eisenberg 1980, East 1981; but see Gilbert 1980, Ryti 1991). Second, a num-

ber of protective options is presented for each focal species lacking adequate habitat in current conservation areas. We then stress habitat conservation options that benefit other species or features. That is, habitat conservation strategies proposed for each species are developed in relation to other species and information in our database, and, as shown in various tables presented in the discussions of individual focal species, the habitat conservation plans developed here may provide benefits to a much larger group of species. Third, in Section 6.3 we discuss and incorporate information developed for several rare community types (e.g., tropical hardwood hammocks, sandhill, pine rocklands, coastal areas, and xeric oak scrub), rare plant species, and higher-level assemblages of rare wildlife species.

We also point out that conservation strategies based on ecosystems, communities, and species richness (e.g., Scott et al. 1993) are not without their own sets of serious problems (Simberloff and Abele 1976, Graves and Gotelli 1983, Zimmerman and Bierregaard 1986). For example, a widely distributed archipelago of 50 patches of sandhill habitat, each about 100 acres in size, might effectively protect 95% of the species that make up this community. However, this preserve strategy will not adequately protect viable populations of species such as indigo snake, red-cockaded woodpecker, or fox squirrel since individual conservation areas for these species must be a minimum of several thousand acres before they will be very effective over long periods of time.

Wildlife corridors, preserves arranged as stepping stones, and other strategies that emphasize the geographical placement of conservation areas have become increasingly popular tools in efforts to combat habitat fragmentation (Harris 1984, Harris 1985, Noss and Harris 1986). Assessing the effectiveness of such geographical arrangements is more complex than sometimes realized (Simberloff and Cox 1987, Soulé and Gilpin 1991, Simberloff et al. 1992), and the benefits provided by corridors or stepping stone preserves, independent of habitat, may also be provided by large preserves (Soulé and Gilpin 1991, Simberloff et al. 1992). Soulé and Gilpin (1991) analyzed corridor capability and suggested that "corridors, regardless of how effective they may be, can never replace large reserves for the protection of ecosystems and species."

A few examples provide some indication of the complicated assessments that corridor placement may entail. Corridors of appropriate habitat have been shown to be important in several instances. Maehr (1990) described the use of a corridor by Florida panthers in southwest Florida, while Beier (1993) described the importance of panther corridors in southern California in allowing immigration to occur into an area supporting a small population. J. Wooding (pers. comm.) described movement of black bears through a potential corridor in northeast Florida. A large block of black bear habitat in Volusia, St. Johns, and Flagler counties lies in close proximity to the large block of black bear habitat found on the Ocala National Forest. In 1989, two black bears were recorded moving between these two large blocks of habitat using an area near Crescent Lake.

In other cases, the value of corridors has not been firmly established. Thomas et al. (1990) found that dispersing spotted owls did not frequently use the corridors left behind after logging. More importantly, forest corridors were surrounded by large open spaces, which provided suitable habitat conditions for great horned owls, a predator of spotted owls. Mortality among dispersing spotted owls was very high in areas where thin corridors were provided. The fact that corridors may enhance populations of certain predators and produce high rates of mortality has been noted in several studies (Soulé and Gilpin 1991, Simberloff et al. 1992).

Noon (1992) tested corridor use by small vertebrates and found that < 30% of the individuals used the corridors under study. The remaining individuals dispersed into the hostile surrounding habitats and died. This raises a question: if corridors provided safe conduit for only 30% of the dispersing individuals, is there another conservation strategy that might protect 50% of the dispersing individuals and be of potentially higher value? The conservation of large blocks of habitat surrounding an area may in some cases provide better protection for whole populations.

We take steps to maximize the benefits from geographical placement of proposed conservation areas and minimize the potential drawbacks. First, we stipulate that conservation areas designed to foster movement must lie within frequently reported dispersal distances for the species in question. We compiled information on dispersal distances from published reports, and we selected the minimum distances that would encompass approximately 70% of the published dispersal distances for each species. For example, the observation of a single juvenile black bear moving 120 km (Maehr et al. 1988) does not mean that a 120-km habitat corridor will permit bears to move frequently between patches of habitat. Fewer than 5% of the reported dispersal events for black bears are > 100 km, and most (ca. 70%) are < 60 km (Alt 1979, Rogers 1987, Maehr et al. 1988, Wooding and Hardisky 1988). Furthermore, the distances across which a black bear disperses, establishes a territory, and successfully reproduces is certainly much smaller than the distance over which all black bears simply disperse. Dispersal events are often random in direction; individuals dispersing long distances often have lower rates of survival than individuals dispersing shorter distances; and reproduction for dispersing individuals may be lower (Endler 1972).

Second, we also considered the size of the populations when evaluating the potential benefits of the geographical placement of conservation areas. Connecting a larger population to a much smaller population would help to sustain the smaller population (Beier 1993), and connecting two small populations might provide each with higher chances of survival than either population has if isolated (Goodman 1983). However, the benefits of connecting two very small or two very large populations are less clear. In cases where two very small populations are connected by virtue of a corridor or some stepping-stone arrangement of conservation areas, no amount of interchange can totally alleviate the potential problem of inbreeding depression (Chesser 1981). A single large population of 40 will have a slightly lower level of inbreeding than two populations of 20 individuals, but the importance of this lower level of inbreeding may not be significant over many generations. With respect to connecting two large populations, Soulé and Gilpin (1991) note that it may be unnecessary to consider the capabilities of corridors to facilitate movement when the corridor will link two presumably viable populations.

Third, we consider carefully whether a focal species is likely to use conservation areas designed to foster movement based on literature information, where available. Black bears

appear to rely on forested wetlands as they disperse (Weaver et al. 1990), but they may also move without reference to land-cover features once outside of familiar territory (Maehr et al. 1988). Black bears likely require broader habitat areas rather than thin corridors if connecting distant populations is a goal. Florida panthers may use forested habitats that are about 10 km long and only 1 km wide as movement corridors (Maehr 1990). On the other hand, many birds, insects, and mammals may be able to traverse broad areas without corridors or appropriate habitat in the interstitial area.

Finally, we required that corridors, stepping stones, and other types of linkages do more than simply foster movement. Areas that constitute valuable habitat and also facilitate movement among conservation areas represent better investments than those protected simply to help animals move.

Several researchers (Simberloff and Abele 1976, Gilpin 1987, Goodman 1987a) point to the potential benefits of establishing many small preserves rather than a few very large preserves. Our method of incorporating this recommendation is to focus attention on providing a broad geographic distribution and multiple conservation areas that support potentially secure populations. We rely on the analyses of population viability to determine when it might be better to bolster a local population by extending the boundaries of a preserve, or protect nearby patches or corridors of habitat to facilitate movement, versus the importance of enhancing the geographic distribution and number of protected populations with new isolated conservation areas.

Noss (1983) argues that a regional landscape perspective is needed to produce effective conservation strategies, and we agree with this. The external threat posed to protected areas is very real (Janzen 1983, Janzen 1986, Laurance 1991), and changes to surrounding areas in Florida have substantially influenced survival and reproductive characteristics within protected populations (Humphrey and Barbour 1979, Spalding 1991, Dwyer and Tanner 1992). However, we wonder how effective a strictly landscape perspective can be since it is impossible to define the extent of landscape parameters that might influence a managed population or to anticipate all the future changes that might occur. The full range of landscape-level threats includes rising sea levels, climate change, encroachment of exotic species (Loope 1992), mercury contamination (Spalding 1991), altered hydrology (Bildstein et al. 1991), and many others. It also may be difficult to define the landscape requirements of some (possibly many) animal species (Dueser et al. 1988).

SECTION 6.2 ANALYSES OF INDIVIDUAL FOCAL SPECIES AND DEVELOPMENT OF SPECIES CONSERVATION PLANS

This section presents the techniques, data sets, and analyses used to create habitat distribution maps for focal species. These maps were used to assess the quantity of habitat provided each species by the current system of conservation areas in Florida. When the habitat found in current conservation areas fell short of the minimum quantity deemed acceptable (i.e., sufficient habitat to sustain at least 10 populations of 200 or more individuals), the habitat distribution maps were used in combination with other information to identify important habitat areas lying outside of existing conservation areas. In Section 7.1, the important habitat areas identified for individual species are merged with the important habitat areas identified for rare communities and plants to produce a single map showing some of the most important lands outside existing conservation areas in Florida.

The habitat areas identified for each species are called Strategic Habitat Conservation Areas due to their importance in providing some of Florida's rarest species with the base of habitat needed for long-term persistence. However, owing to the constantly changing nature of the Florida landscape, the Strategic Habitat Conservation Areas should be considered as general guidelines for new habitat conservation initiatives. Some of the areas highlighted may have been converted to shopping malls, orange groves, or four-lane highways since the land-cover map was created. Still other areas may have been brought into public ownership since the boundaries of public lands were processed. Further updates are planned.

Section 6.2.1. American Crocodile

The habitat distribution map for the American crocodile was developed by isolating the mangrove, coastal salt marsh, and freshwater marsh cover types within the known breeding range of the species (Moler 1992b). This area includes the mainland shoreline of southern Biscayne Bay (Turkey Point), west to Cape Sable, the bay-side shoreline of North Key Largo, and islands in Florida Bay (Moler 1992b). Records of nesting locations collected by P. Moler and F. Mazzotti and processed by the Florida Natural Areas Inventory were also used to identify important nesting locations more specifically. No recent breeding records exist for either the lower Florida keys or the west Gulf coast area, although crocodiles are occasionally seen in these areas (Moler 1992b).

The population of American crocodiles in Florida consists of fewer than 500 individuals and only approximately 30 breeding females (Moler 1992b). This small population also has an extremely limited geographic distribution, making it vulnerable to catastrophic events. The combination of small population size and limited geographic distribution makes it imperative that no further reduction in habitat quantity or quality be allowed (Moler 1992b). The habitat distribution map developed for this species is shown in Figure 27. All habitat areas that fall outside of current conservation lands are proposed as a Strategic Habitat Conservation Area for this species. The proposed Strategic Habitat Conservation Area consists of wetlands where regulatory provisions could be applied to maintain appropriate habitat.

In addition to conservation of the wetland areas shown in Figure 27, two other management activities could assist in the management of this small population. The greatest known source of mortality is collisions with vehicles along U.S. Highway 1, which runs through the heart of the documented breeding range (Moler 1992b). Steps to correct this problem are desperately needed. Moler (1992b) recommends the construction of box culverts with sufficient clearance to allow for their utilization by crocodiles. Another management recommendation is to reduce human recre-

ational activities in some of the areas inhabited by American crocodiles (Moler 1992b).

Section 6.2.2. American Oystercatcher

The habitat distribution map developed for the American oystercatcher was based on nesting areas recorded by the Nongame Wildlife Program and the Florida Natural Areas Inventory, and records collected for the Atlas of Florida Breeding Birds (Kale et al. 1992). These data were used to restrict the area within which additional habitat analyses were performed using the land-cover map. Habitat analyses were performed for all atlas blocks where oystercatchers were reported as "probable" or "confirmed" breeders. For the two point data sets (see Section 3.3), we radiated out 500 m to estimate a larger area within which oystercatchers might find appropriate habitat conditions. Within these narrowly defined areas, we isolated the coastal strand and coastal salt marsh cover types and then radiated out a distance of 60 m (2 pixels) from the edges of these cover types. The barren land cover and coastal salt marsh that fell within this area was combined with all the coastal strand cover type as an estimate of appropriate habitat areas. The choice of a 60 m distance was somewhat arbitrary, but this procedure was deemed necessary to help identify open sand beaches and the fringes of salt marshes that might constitute appropriate habitat for this species.

The potential habitat areas produced through these procedures are difficult to see at a statewide scale. Figure 28 thus shows the data sets used to construct the map of potential habitat. There are three population centers for American oystercatchers along the Gulf coast of Florida and a more or less sparse but continuous distribution of occurrence records along the Atlantic coast. The coastal strand, salt marsh fringe, and barren land (i.e., beaches) in and around Apalachicola Bay, Ochlockonee Bay, Tampa Bay, and Charlotte Harbor appear to be important centers for the Gulf coast populations. Large concentrations of oystercatchers also occur around Levy, Dixie, and Citrus counties in late summer (J. Cox, pers. obs.), but there is little information on the breeding population of this area. As many as 100 individuals may be found in specific areas in these counties.

Estimating the security of oystercatcher populations in current conservation areas was difficult due to a lack of density

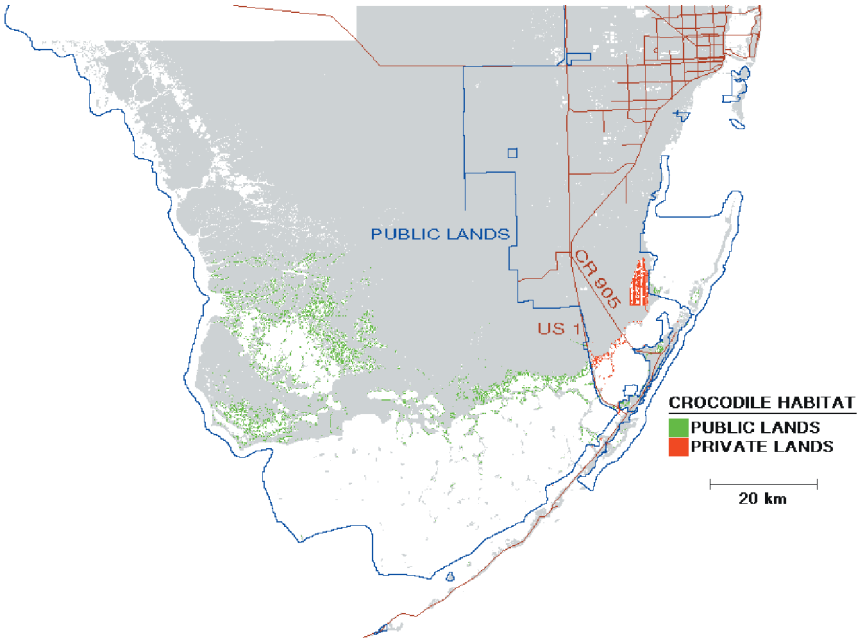


Figure 27. Habitat distribution map and Strategic Habitat Conservation Areas for the American crocodile.

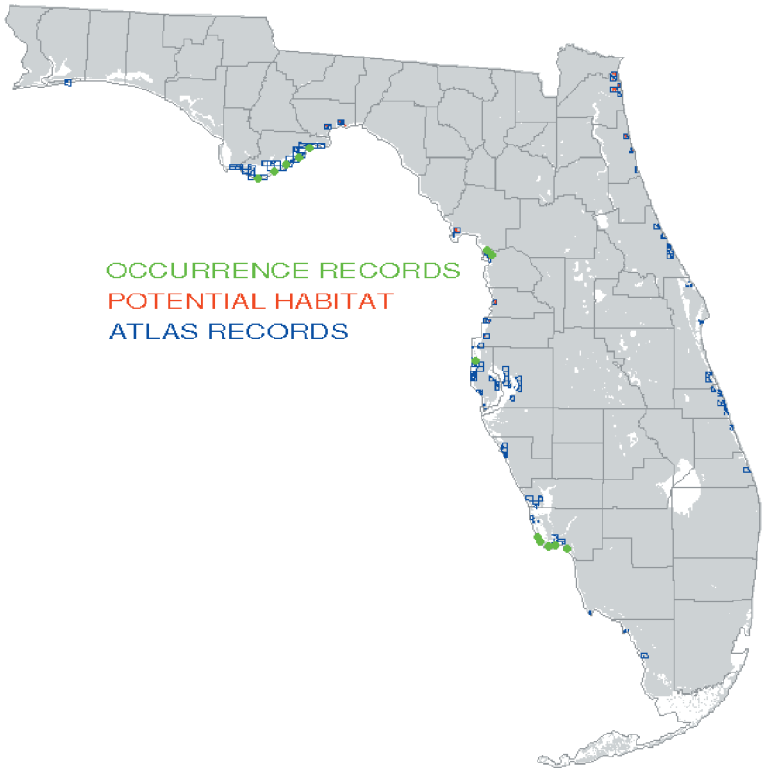


Figure 28. Habitat distribution map and occurrence data for the American oystercatcher.

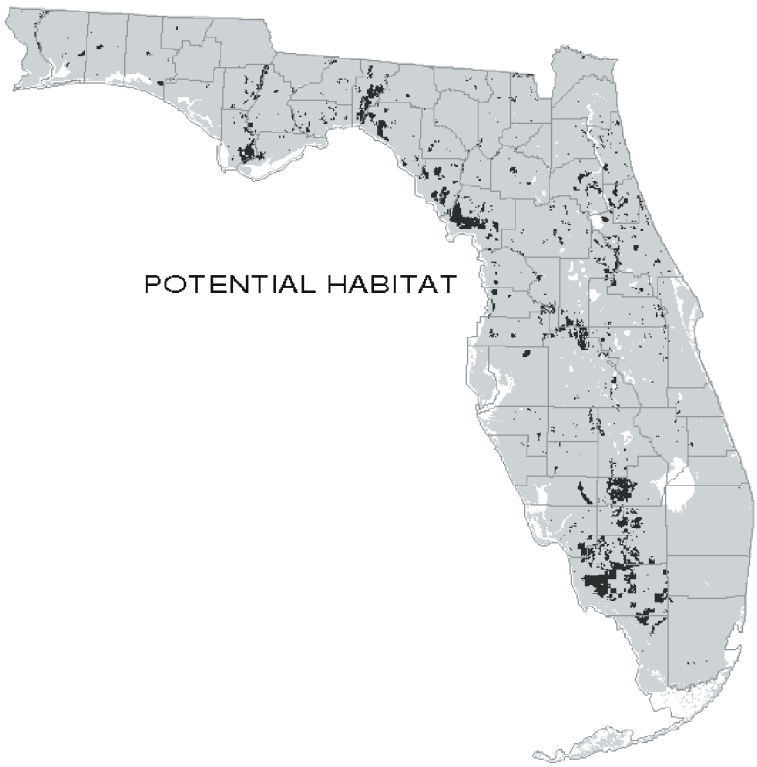


Figure 29. Habitat distribution map for the American swallow-tailed kite.

estimations. Paul and Below (1991) provide the following estimates of population size for specific regions of the State: 50 at Apalachicola Bay, 60 at Citrus County, 125 at Tampa Bay, and 60 at Indian River Lagoon and Mosquito Lagoon. Population sizes for other areas are not known.

Despite the limited knowledge of statewide population sizes, we conclude that the American oystercatcher lacks the habitat base needed for long-term security, and we offer some general recommendations. The proportion of habitat estimated to occur within conservation lands is 45% of the total habitat estimated to occur statewide. Given the declines reported for populations throughout the state (DeGrange 1978, Millsap et al. 1990), protection of additional habitat areas seems warranted. The panhandle coast has the highest percentage (65%) of habitat within current conservation areas when various regions of the state are compared. Tampa Bay and coastal Pinellas and Manatee counties, Indian River and southern Brevard counties, and central and northern Volusia County appear to have substantially smaller percentages (< 20%) of the available habitat base in some type of formal conservation status. Habitat conservation efforts may be needed to maintain oystercatcher populations in these regions, but more specific survey information is needed before specific conservation plans can be developed. Many of the oystercatchers found south of approximately Cedar Key nest on spoil islands (Paul and Below 1991), and appropriate nesting conditions on these islands could not be identified using the land-cover map. Maintenance of suitable habitat conditions (Landin 1991) on these areas is important in perpetuating the broad geographic distribution of the species in Florida.

Section 6.2.3. American Swallow-tailed Kite

The habitat distribution map for the American swallow-tailed kite was created using a variety of data sets. Precise nesting locations were obtained from Meyer and Collopy (1990) and more recent inventories performed in southwest Florida by K. Meyer (pers. comm.). We created a large-radius 1-km zone (Meyer and Collopy 1990) around nesting locations to delineate core habitat areas. Forested wetlands, upland hardwood forests, freshwater marshes, mangrove swamps, dry prairie (containing widely spaced pines), and pine forests within this area were selected as suitable habitat areas. Breeding bird atlas records (Kale et al. 1992) were also used to identify areas where swallow-tailed kites potentially breed and forage. Within atlas blocks, we isolated the forested wetlands, upland hardwood forests, freshwater marshes, and pinelands that might be used as nesting sites. We also obtained information on roost sites (Meyer and Collopy 1990) that support large numbers of swallow-tailed kites during fall migration (Millsap 1987).

Habitat for the American swallow-tailed kite remains widely distributed throughout much of Florida (Figure 29). Hendry, Collier, Lee, Glades, and Charlotte counties in southwest Florida contain several large patches of habitat and represent a core population center for this species in Florida (Meyer and Collopy 1990). The pinelands and prairie land cover in Hendry and Glades counties represent particularly important habitat areas since nests located in pines areas are generally more productive than nests located in other habitats (K. Meyer, pers. comm.). Hammocks and forested wetlands in Levy and Dixie counties near the lower Suwannee River also represent large areas of suitable habitat. Taylor, Wakulla, and Jefferson counties also have several large patches of habitat along forested wetlands associated with the Aucilla, Wacissa, St. Marks, and Econfina rivers. Other potentially important areas occur along the Apalachicola River in Franklin, Calhoun, Gulf, and Liberty counties, and the St. Johns River valley in Flagler, Putnam, and St. Johns counties.

Based on a detailed study of nesting locations throughout Florida, Meyer and Collopy (1990) estimated Florida's breeding population at about 460-900 pairs. We estimate that approximately 7,180 km^2 (1.8 million acres) of potential habitat exist statewide, which implies a density of approximately 0.06-0.12 pairs/km^2. We estimate that 1,984 km^2 of potential habitat exist in current conservation areas, which implies a total population of approximately 113-238 pairs on conservation areas. Therefore, this species is far from having the minimum habitat base recommended for long-term security in Florida. Given the fact that Florida supports the largest extant population of swallow-tailed kites in North America (Meyer and Collopy 1990), conservation of additional habitat areas for the American swallow-tailed kite is especially important to nation-wide efforts to maintain this species.

Meyer and Collopy (1990) identified 12 areas in Florida that are critically important to maintaining core populations of swallow-tailed kites. We digitized the boundaries of these

areas and isolated the suitable habitat features occurring on private lands. These areas form a large portion of the Strategic Habitat Conservation Areas proposed for the American swallow-tailed kite (Figure 30). Another important element in conservation efforts for the American swallow-tailed kite centers on the protection of habitat surrounding known roosting areas. A large portion (ca. 50%) of the North American population of kites may gather at a few key sites in Florida in late summer (Millsap 1987). Major roost sites were identified based on information provided by K. Meyer (Meyer and Collopy 1990). A 3-km radius circle was generated around the largest roost sites containing > 100 individuals and included in the map of Strategic Habitat Conservation Areas developed for this species. American swallow-tailed kites may forage at distances > 20 km from known roost sites (K. Meyer, pers. comm.), and conservation of large habitat areas surrounding the larger roost sites is needed to sustain these important aggregations.

The total habitat area defined by the proposed Strategic Habitat Conservation Areas (Figure 30) for American swallow-tailed kite is 3,544.3 km^2 (875,444 acres). Conservation of these habitat areas will more than double the proportion of kite habitat on conservation areas in Florida. Conservation of appropriate habitat conditions within these zones can include several types of land uses, including some commercial timber operations. Furthermore, most of the areas identified are also part of the Strategic Habitat Conservation Areas identified for Florida black bear, Florida panther, wading birds, and other rare species.

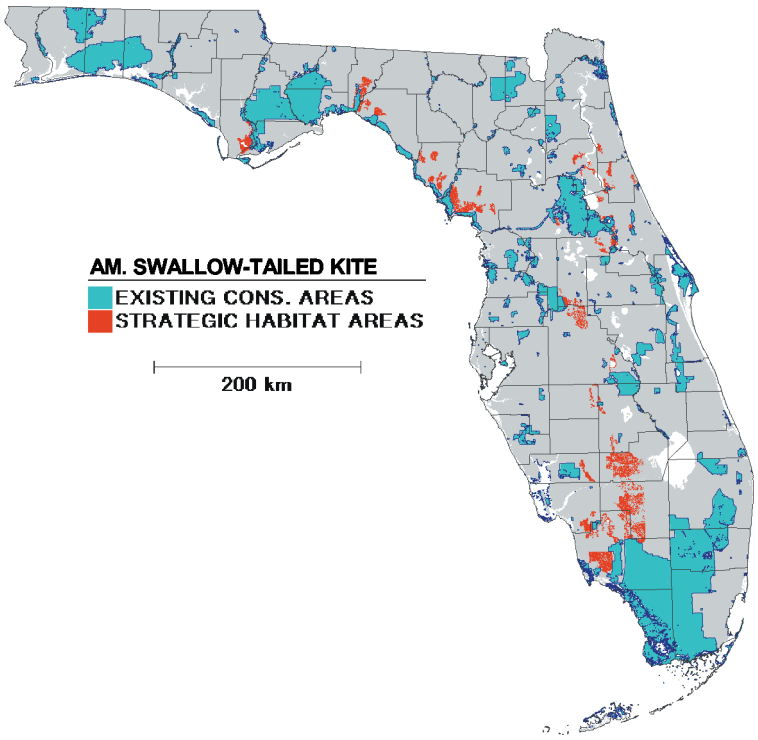


Figure 30. Proposed Strategic Habitat Conservation Areas for the American swallow-tailed kite.

Section 6.2.4. Atlantic Salt Marsh Snake and Gulf Salt Marsh Snake

The Atlantic and Gulf salt marsh snakes are considered "endangere" and "rared," respectively, by the Florida Committee on Rare and Endangered Plants and Animals (Moler 1992a). We estimated the habitat available to each population by isolating the salt marsh and mangrove cover types within the documented distributions of each subspecies. Distributions were determined using point data stored by the Florida Natural Areas Inventory and museum specimens processed by P. Moler. We also created a 150-m zone (5 pixels) around the land-cover types mentioned above and incorporated the freshwater marsh occurring within this zone. The 150-m distance is somewhat arbitrary, but it serves to highlight areas with transitional marshes that

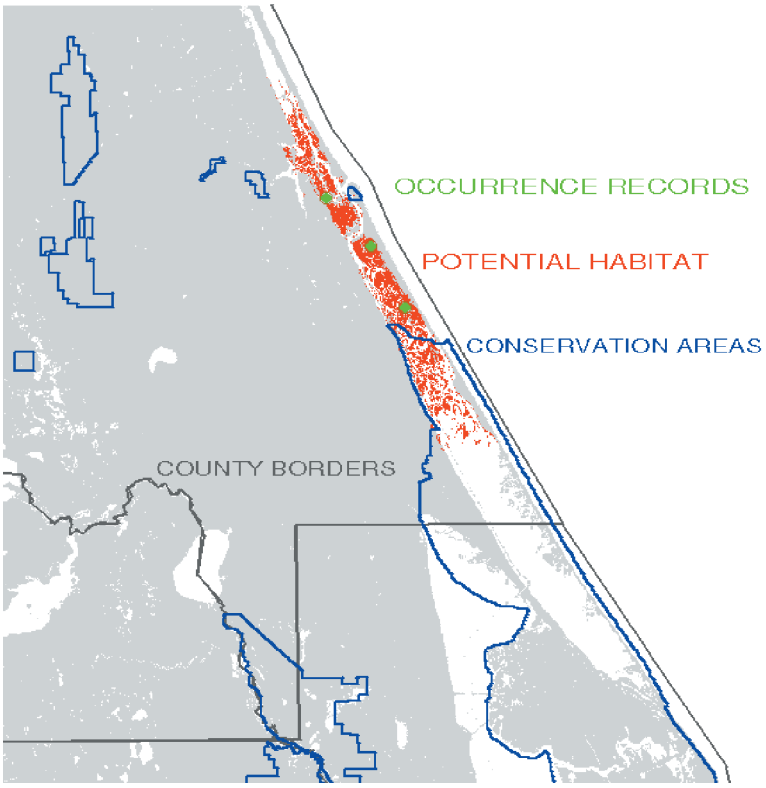


Figure 31. Habitat distribution map for the Atlantic salt marsh snake. The Strategic Habitat Conservation Area proposed for this species consists of all habitat areas outside the boundaries of existing conservation areas.

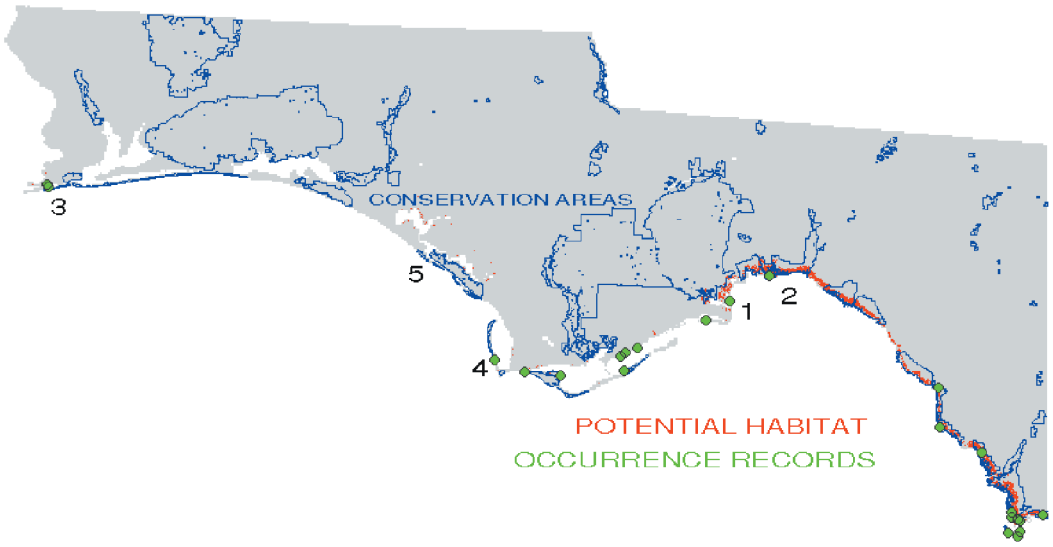


Figure 32. Habitat distribution map for the Gulf salt marsh snake. The Strategic Habitat Conservation Areas proposed for this species consist of the habitat remaining in areas 3 (Pensacola Bay), 4 (St. Joseph Bay), and 5 (St. Andrews Bay).

the land-cover map treats as freshwater marsh. Such transitional marshes may support salt marsh snakes (Kochman and Christman 1992a).

The Atlantic salt marsh snake likely consists of a single population that is limited to a narrow geographic area in Volusia County (Figure 31). We estimate there to be approximately 4,730 ha (11,700 acres) of appropriate habitat within the known range of the taxon. Only 1,400 ha (3,500 acres), or 30% of the available habitat, is within the Canaveral National Seashore. The small quantity of available habitat and narrow geographic distribution make conservation of the remaining habitat of paramount importance. The habitat remaining to the north (as far as Daytona) of current conservation areas was mapped as a Strategic Habitat Conservation Area for this species. Favorable administration of regulations pertaining to these wetlands would provide an adequate measure of conservation without requiring land acquisition. Within mosquito control impoundments, proper management may be critical to maintaining this species (Carlson and Rey 1991).

The Gulf salt marsh snake extends from Corpus Christi to east of Cedar Key (Kochman and Christman 1992b), and habitat for this species is much better represented on conservation lands in Florida than habitat of the Atlantic salt marsh snake. The largest block of potential habitat (Figure 32) found in current conservation areas occurs throughout the Big Bend region stretching from Levy County (Cedar Key) to Gulf County (St. Vincent Island). This broad expanse of habitat includes a diversity of national wildlife refuges, state wildlife management areas, and state park and recreation areas. The largest blocks of unprotected habitat within this area are south of Panacea in Wakulla County (Area 1, Figure 32) and east of the Aucilla River in Taylor and Jefferson counties (Area 2, Figure 32).

Although this broad habitat area supports a large population of the Gulf salt marsh snake in the Big Bend region, several areas in the western panhandle (west of St. Vincent Island) are critical to maintaining a broad geographic distribution of populations. Occupied habitat in the western panhandle occurs near Big Lagoon (Area 3, Figure 32) and St. Joseph Bay (Area 4, Figure 32) and a large block of potential habitat exists near Panama City (Area 5, Figure 32). These disjunct habitat areas in the panhandle are proposed as Strategic Habitat Conservation Areas for this taxon to ensure that the current distribution is maintained. Again, regulations that pertain to these wetlands might provide an adequate measure of conservation without requiring land acquisition.

Section 6.2.5. Audubon's Crested Caracara

The map of potential habitat developed for Audubon's crested caracara relies on the land-cover map, breeding bird atlas records (Kale et al. 1992), a recent survey of caracara territories (Millsap 1991), and data points stored by the Florida Natural Areas Inventory.

We generated a 1-km zone around the territory centers mapped by Millsap (1991) and Florida Natural Areas Inventory. Crested caracaras cover larger areas than the 315 ha (780 acres) defined by this zone, but the circle is intended to define central territory areas, not total territory size. Within these central areas we isolated dry prairie, hardwood hammock, freshwater marsh, shrub and brush, and grass and agriculture land cover that might be used by caracaras (Layne 1978a).

Within breeding bird atlas blocks where crested caracaras were recorded, we isolated dry prairie and freshwater marsh land cover. While improved pasture also constitutes important habitat for Audubon's crested caracara, the land-cover map does not adequately distinguish between vegetable crops, improved pastures, and certain other types of agricultural land uses. The inclusion of the grass and agriculture land-cover data over an area as large as an atlas block over estimates the potential habitat available. Our technique is conservative in that it relies on the identifiable native habitat available within each block. We combined the habitat maps based on territory sites and atlas blocks into a single map of potential caracara habitat.

The map of potential habitat for Audubon's crested caracara (Figure 33) shows several large blocks of potential habitat in south central Florida. The total geographic range covered by this species is very small, however, and is restricted essentially to a 10-county area extending from the southern edge of Lake Okeechobee to approximately the northern edge of Lake Tohopekaliga. The largest blocks of potential habitat occur in Glades, Osceola, and Okeechobee counties.

Layne's (1978a) estimate for the size of Florida's breeding population of Audubon's crested caracaras is fewer than 200 breeding pairs. A comparison of mapped territories with existing conservation lands shows that no existing conservation area currently holds more than four territories, and only 20 territories are known to occur on established conservation areas in Florida. This species obviously lacks adequate representation on Florida's current system of conservation areas.

To develop conservation strategies for this species, we used two valuation indices. First, we identified concentrations of territories mapped by Millsap (1991) and the Florida Natural Areas Inventory by creating a Voronoi diagram from these point data sets. Polygons smaller than 4,050 ha (10,000 acres) were assigned a score of 2 (indicating a higher density of territories) and polygons larger than 4,050 ha (10,000 acres) were assigned a score of 1 (indicating a lower density of territories). The resulting map is shown in Figure 34.

For a second index, we considered the distribution of large landownerships within the known range of crested caracaras. Large landownerships do not necessarily represent caracara "habitat," but large landownerships tend to contain habitat and landscape features sought by caracaras (Layne 1978a). We cross tabulated our initial map of crested caracara habitat by our map of large landownerships throughout central Florida. Private single-ownership parcels with at least 100 ha (250 acres) but not more than 1,000 ha (2,470 acres) of potential habitat, were assigned a score of 1. Private, single-ownership parcels with more than 1,000 ha (2,470 acres) of potential habitat were assigned a score of 2. The resulting map is shown as Figure 35.

When these two maps were overlaid and restricted to the areas of potential habitat (Figure 36), the highest scoring habitat areas were found in Okeechobee, Highlands, and Glades counties. Glades and Highlands counties have the largest

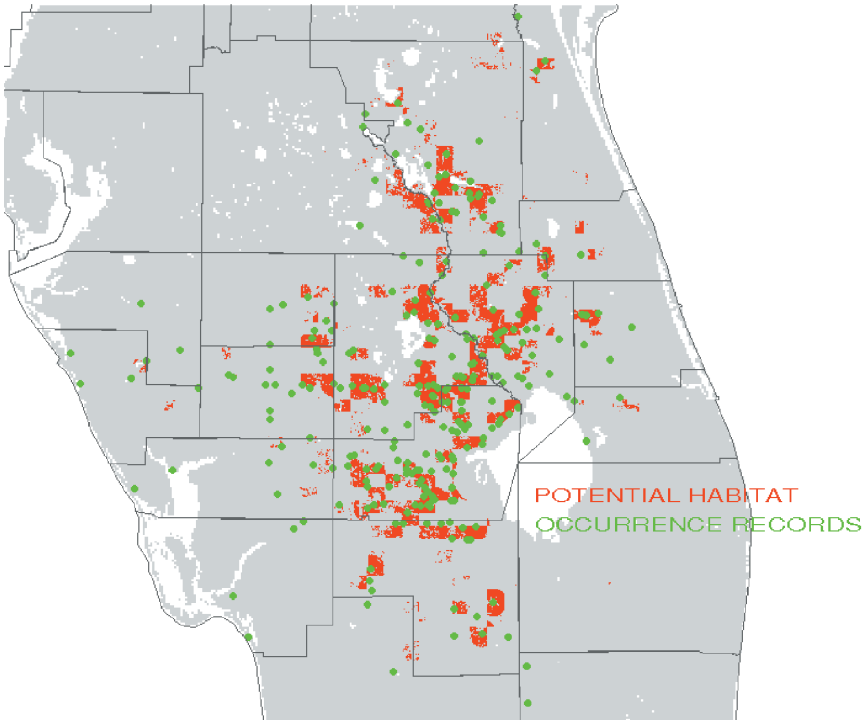


Figure 33. Habitat distribution map for Audubon's crested caracara.

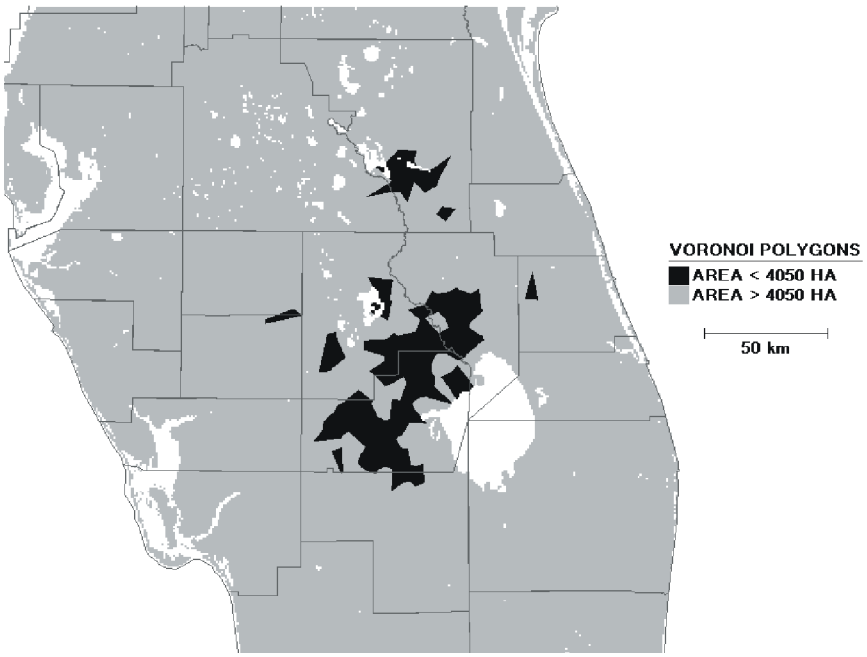


Figure 34. Concentrations of territory centers of Audubon's crested caracara. Concentrations were determined using a Voronoi tessellation.

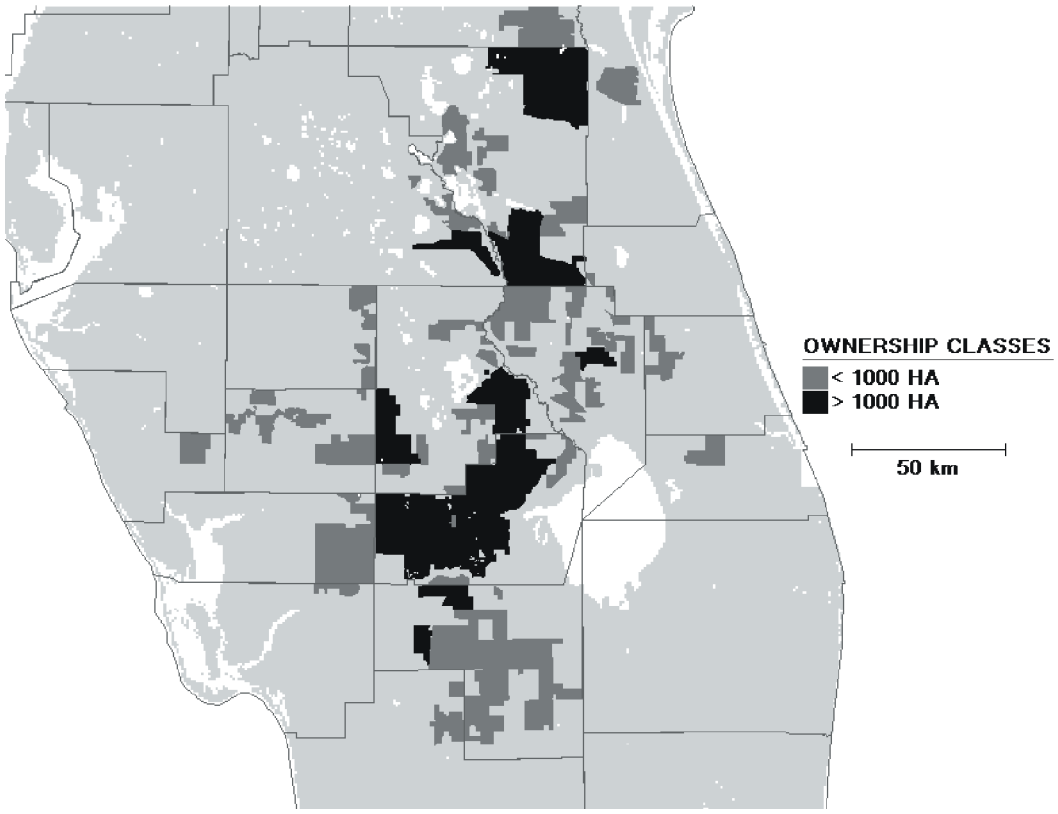


Figure 35. Large landownerships classified by the quantity of caracara habitat. Class 1 lands contain <1,000 ha (2,470 acres); class 2 areas contain >1,000 ha.

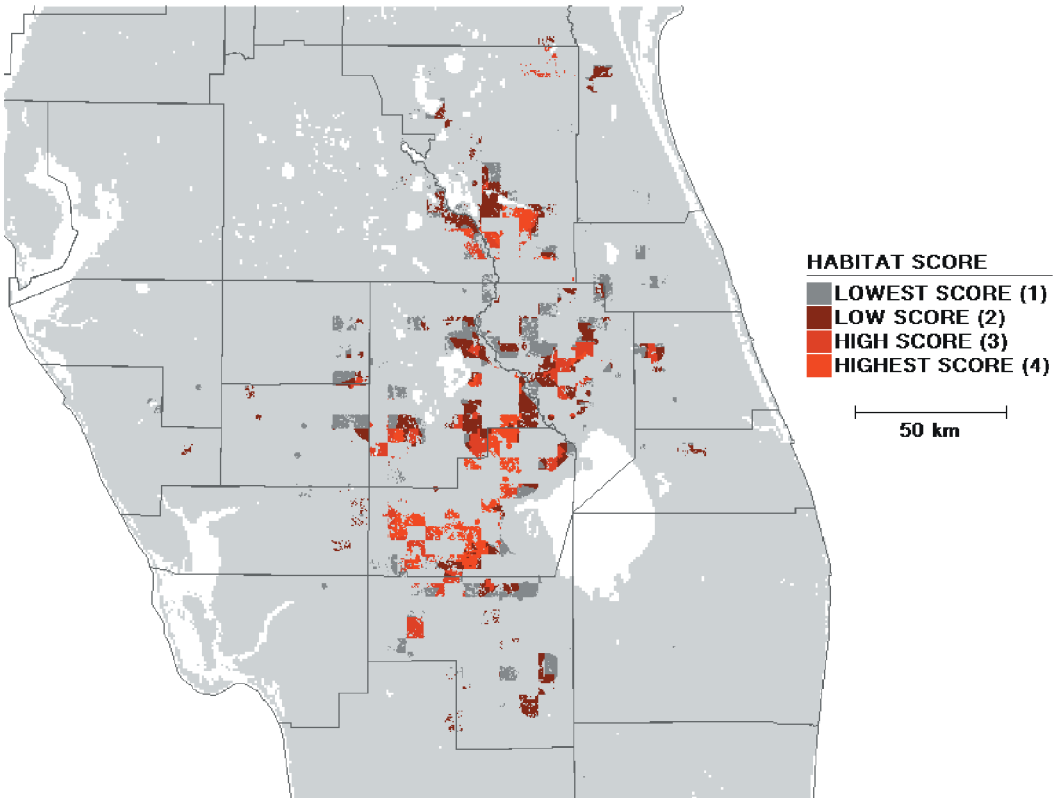


Figure 36. Combination of Figure 34 and Figure 35 to score the potential value of crested caracara habitat.

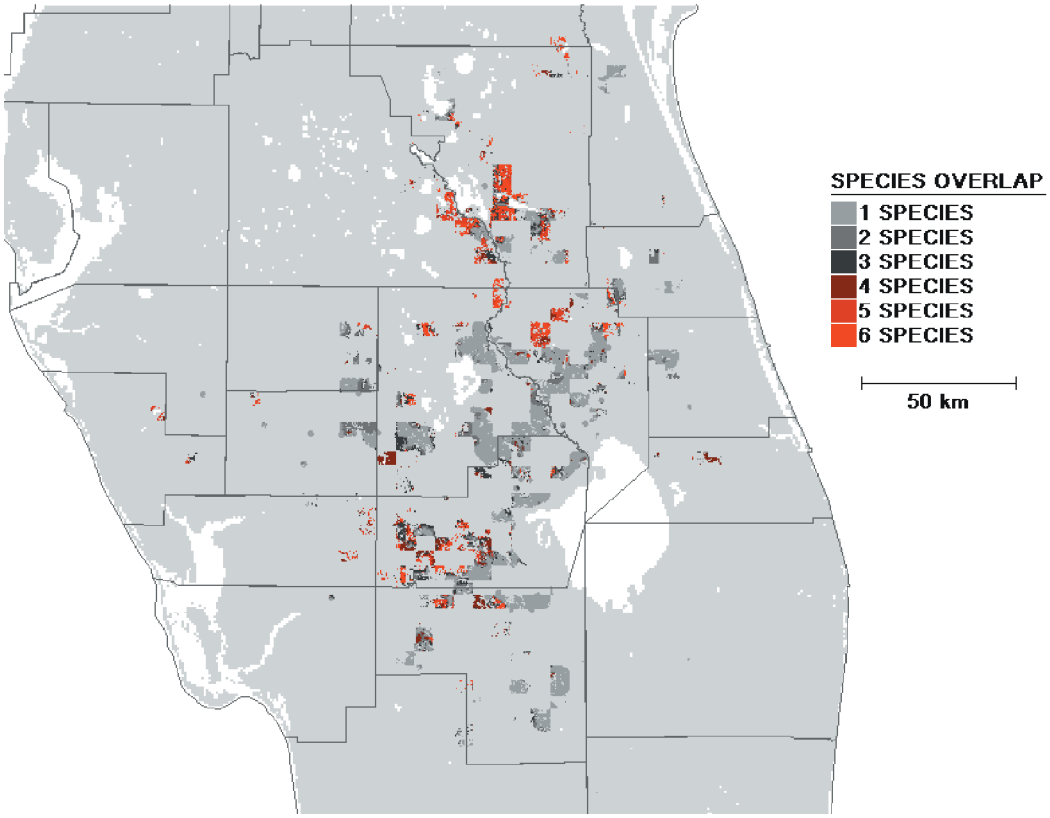


Figure 37. Combined potential habitat maps for other prairie bird species restricted to the potential habitat areas for Audubon's crested caracara.

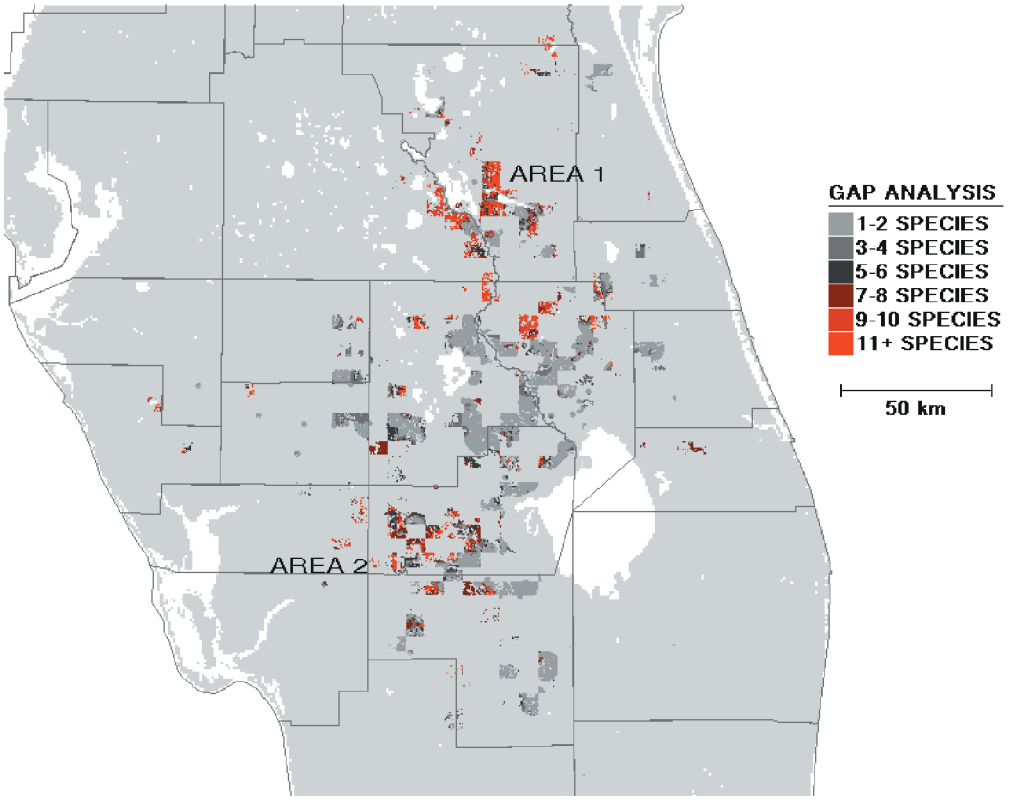


Figure 38. Combined gap analysis maps for 120 species restricted to the potential habitat areas for Audubon's crested caracara (see Section 6.3.4).

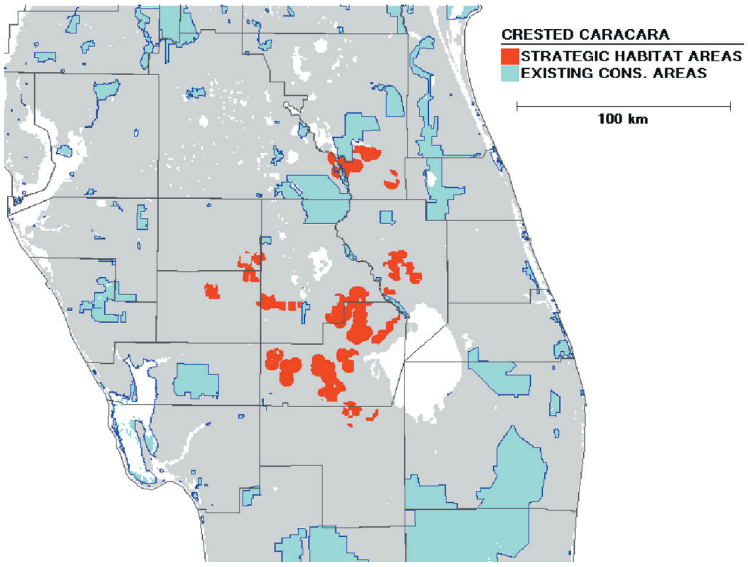


Figure 39. Proposed Strategic Habitat Conservation Areas for Audubon's crested caracara.

Table 8. Rare species recorded within the Strategic Habitat Conservation Areas proposed for Audubon's crested caracara. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

Birds	*Amphibians and Reptiles*
Great egret	Gopher frog
Snowy egret	Gopher tortoise
Little blue heron	Eastern indigo snake
Tricolored heron	South Florida rainbow snake
Wood stork	
Southern bald eagle	*Plants*
Short-tailed hawk	
Crested caracara	Scrub holly
Florida sandhill crane	Florida golden aster
Florida burrowing owl	Florida gay-feather
Florida scrub jay	Carter's warea
Florida grasshopper sparrow	Paper-like nail-wort
	Nodding pinweed
Mammals	Highlands scrub hypericum
	Edison's ascyrum
Sherman's fox squirrel	Scrub bay
	Hairy jointweed
	Britton's bear-grass

contiguous area of estimated high-value habitat for crested caracara. The more valuable areas shown here cover about 311,740 ha (770,000 acres) and are dominated by grass and agricultural land cover (54% of area) with dry prairie and freshwater marsh constituting approximately 16% and 7% of the remaining area, respectively. Important blocks of habitat also exist along the Kissimmee River in Highlands, Polk, Okeechobee, and Osceola counties, and in southern Orange, northern Osceola, and west central Brevard counties.

Another method of evaluating potential caracara conservation areas is to relate habitat areas to other information in our database. The first comparison considers the importance of the habitat areas for crested caracara on private lands to some of the other focal species analyzed here. A composite map of habitat for other bird species that inhabit the open prairies of central Florida was prepared (Section 6.3.6) by adding together the potential habitat maps of individual species (see Section 6.3.6). The highest score created by this overlay process was 8, indicating an overlap of 8 focal bird species. This map was then restricted to the habitat areas for crested caracaras occurring on private lands (Figure 37). Areas highlighted by this evaluation occur in Glades, Highlands, Osceola, and Polk counties, and the technique emphasizes the importance of crested caracara habitat near Lake Kissimmee (Area 1, Figure 37).

Another evaluation was made using a map depicting the distribution of species richness (i.e., gap analysis; see Section 6.3.4) in Florida. When a statewide map of species richness is limited to habitat areas for Audubon's crested caracara, specific areas within central Glades and southern Osceola counties are highlighted (Figure 38). These areas will likely benefit a number of other rare species in addition to providing essential habitat features important to crested caracaras. These areas should be a primary focus of conservation efforts since they will provide multiple benefits.

Lack of demographic data makes it difficult to define precise habitat-conservation goals for Audubon's crested caracara. Analyses performed for other species lead us to believe that a managed population of at least 80-120 territories has a good chance of long-term survival. Based on this recommendation and the analyses of areas important to caracaras and other rare species (Figures 36, 37, and 38), Figure 39 outlines a proposed Strategic Habitat Conservation Area that encompasses 100 territories and contains the important habitat areas on private lands in Glades, Highlands, Osceola, and Polk counties. Other rare species recorded in these areas are listed in Table 8. Whether all of these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

Given the very small size of the caracara population supported by the current system of conservation areas in Florida, new conservation initiatives must move quickly to retain extensive tracts of native prairie and improved rangeland in Glades, Highlands, Okeechobee, Osceola, DeSoto, Charlotte, and Hendry counties. One of the most pressing threats is the conversion of improved rangeland and native prairie lands to citrus production. In just the last few years, permits were granted to develop citrus

groves on over a million acres of land of great importance to the conservation of caracara habitat (see Section 6.2.14).

Section 6.2.6. Beach Mice

Determining the remaining habitat areas important to several taxa of beach mice could not be performed using the land-cover map exclusively. The coastal strand land-cover class coincides with areas where various taxa of beach mice occur, but not all coastal strand constitutes appropriate beach mouse habitat. Other factors such as the presence of exotic species of rodents, damage by recent storms, human recreation, and the presence of feral cats and natural predators may produce inhospitable conditions in areas with appropriate vegetative cover. We relied upon distribution surveys described by Humphrey and Barbour (1979, 1981), Holler and Mason (1987), Robson (1989), U.S. Fish and Wildlife Service (1987c), Frank and Humphrey (1992), Holler (1992a, 1992b), Humphrey and Frank (1992), James (1992), and Gore and Schaefer (1993) to identify appropriate habitat areas. Within the habitat areas described by these reports, the coastal strand land cover was isolated. A 120-m zone was created surrounding this subset of coastal strand land cover, and the xeric oak scrub, dry prairie, and barren land cover within this zone was also incorporated as potential habitat. No effort was made to identify the habitat areas for extinct or extirpated populations (Humphrey 1992a, 1992b).

Figure 40 (a-d). Proposed Strategic Habitat Conservation Areas for subspecies of beach mice.

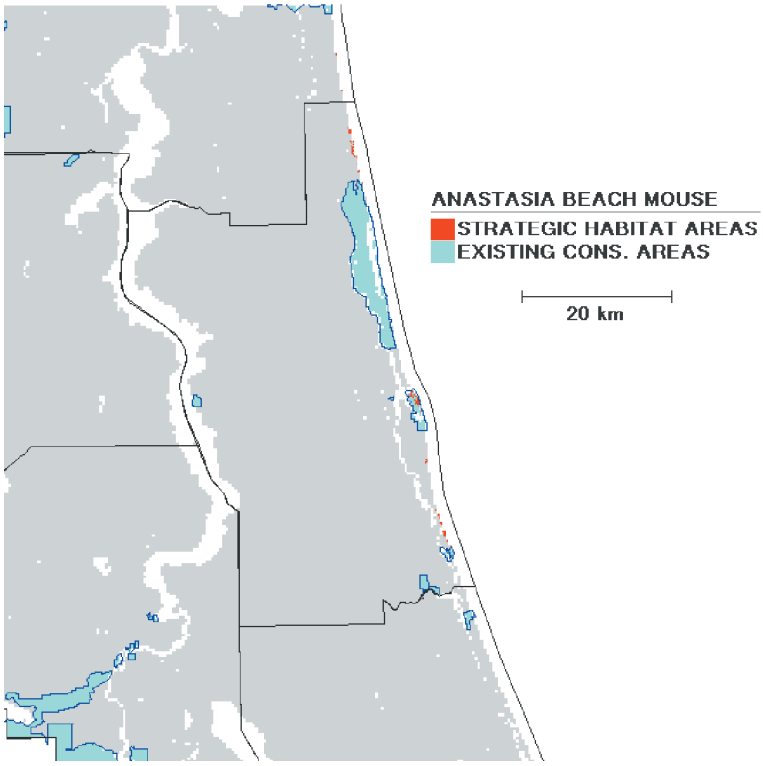


Figure 40a. Anastasia Island beach mouse.

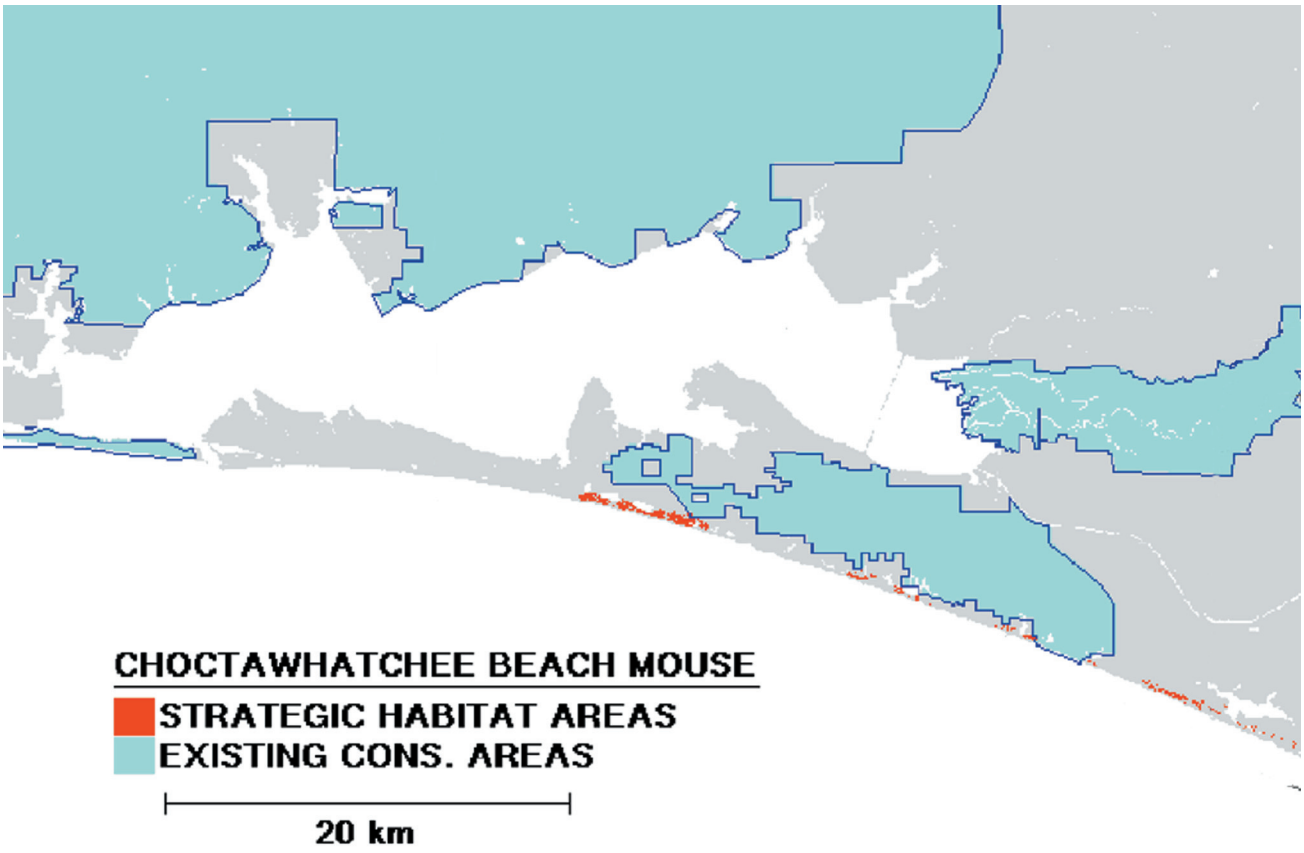


Figure 40b. Choctawhatchee beach mouse.

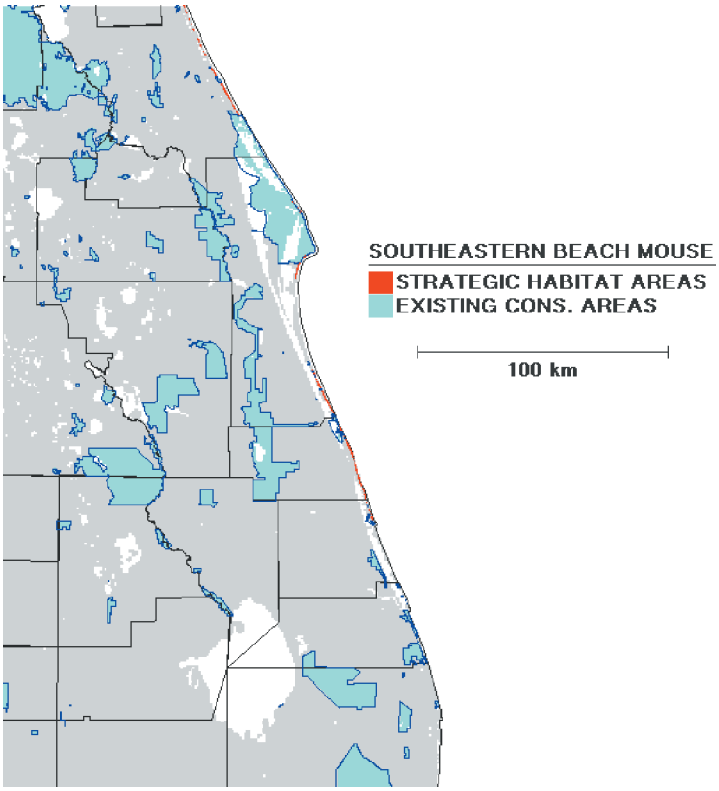


Figure 40c. Southeastern beach mouse.

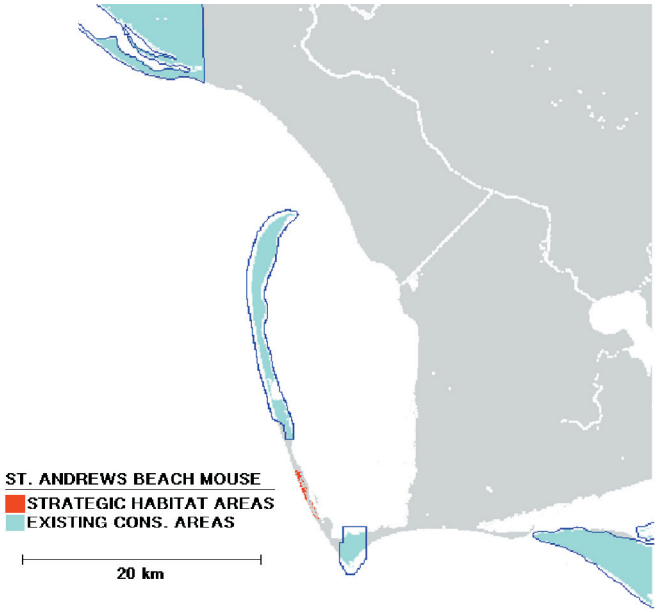


Figure 40d. St. Andrews beach mouse.

Estimates of population size and density exist for several taxa of beach mice, but these estimates vary widely by season and area. Humphrey and Frank (1992) reported densities ranging from 2-90/ha for the Anastasia Island beach mouse. Blair (1951) estimated densities of the Santa Rosa beach mouse to range from 0.8-4.3/ha. Crooked Island East (Bay County) was estimated to contain about 150 St. Andrews beach mice in 1986, while St. Joseph Peninsula State Park was estimated to have a population of about 500 St. Andrews beach mice at approximately the same time (James 1992). Humphrey and Barbour (1979, 1981) provide the following estimates of population sizes for the Choctawhatchee beach mouse: 180 at Topsail Hill (6.5 km of beach), and 360 on Shell Island (9.4 km of beach). Densities of the southeastern beach mouse (Extine and Stout 1987) are reported to range from 8-64 per ha.

Although there is great variation in the estimated sizes and densities of different populations, we estimate that no taxa of beach mouse currently has the minimum quantity of habitat needed for long-term security. The Santa Rosa and southeastern beach mice have the most extensive coverage of potential habitat, but even if population densities are at the upper range of those presented, the habitat available to these taxa on existing conservation areas is not sufficient to support at least 10 populations of 200.

Given the scarcity of beach mouse habitat, more precise estimates for population viability might be useful in devising habitat conservation plans for different taxa. However, viability is difficult to estimate accurately due to a paucity of demographic data and the dramatic population fluctuations characteristic of beach mice populations (Blair 1951, Extine and Stout 1987, Hill 1989). Burke et al. (1991) analyzed population viability in the Stephens' kangaroo rat whose populations undergo fluctuations analogous to those found in beach mice populations (Extine and Stout 1987). Burke et al. (1991) estimated that a population of 13,210 was needed to provide adequate security. This estimate is likely somewhat high since it does not consider the security offered by establishing multiple, independent replicates of populations. Using techniques described by Quinn and Hastings (1987) and data provided in Burke et al. (1991), we estimate that 10 populations of 400 kangaroo rats would have > 99% chances of survival for the minimum time period recommended by Burke et al. (1991). This estimation requires the perhaps questionable assumption that smaller habitat areas are unaffected to the degree that larger habitat areas are by feral cats, exotic rodents, and other extrinsic problems.

Since no population currently has the minimum level of protection necessary for long-term conservation, we consider all potential habitat on private lands to represent Strategic Habitat Conservation Areas for different taxa of beach mice. Strategic Habitat Conservation Areas (Figure 40a-d) are proposed for populations of Choctawhatchee, St. Andrews, Anastasia Island, and southeastern beach mice. In some cases, the areas mapped as Strategic Habitat Conservation Areas may be in public ownership as a result of recent land-acquisition efforts.

Management activities within these areas and existing conservation areas should be a primary focus of beach mice conservation efforts. Management activities must consider the threat posed by cats (Humphrey and Frank 1992, Gore and Schaefer 1993) and to a lesser degree other natural predators and exotic rodents (Humphrey and Barbour 1979, 1981). These external threats will likely be most severe on smaller proposed or established conservation areas surrounded by human habitation (Holler 1992a, 1992b, Gore and Schaefer 1993). Gore and Schaefer (1993) provided evidence of the problems facing small beach mice populations found in close proximity to human populations. A population of Santa Rosa beach mice is restricted to a narrow band (approximately 150 m wide) of habitat that is bounded by residential development and a major highway. This population has shown steady declines due to predation by feral cats (Gore and Schaefer 1993). Large tracts of habitat are needed to provide sufficient protection against the many threats that might be created by surrounding land uses.

We also hasten to point out the importance of maintaining many replicate populations, as well as large habitat areas, to guard against the potentially devastating impacts of large storm systems (U.S. Fish and Wildlife Service 1986a). Reintroduction into areas of suitable habitat is another means of potentially expanding the geographic range of populations. Reintroduction efforts have been initiated at Guana River State Park (Anastasia Island beach mouse), Perdido Key State Recreation Area (Perdido Key beach mouse), and Grayton Beach State Recreation Area (Choctawhatchee beach mouse).

Section 6.2.7. Black-whiskered Vireo

The map of potential habitat for the black-whiskered vireo was developed using breeding bird atlas records (Kale et al. 1992) and the Landsat land-cover map. Within atlas blocks where black-whiskered vireos were recorded, mangrove swamp land cover was isolated and a zone extending out 100 m from the edges of patches of mangroves was created. Within this zone, upland hardwood forest and tropical hardwood hammock were isolated and included as potential habitat. Owre (1978) and Stevenson and Anderson (1992) describe the occurrence of black-whiskered vireos in hammocks adjacent to mangrove areas. Since these patches of appropriate land cover are too small to see at a statewide scale, Figure 41 shows the breeding bird atlas records used to create the map of potential habitat.

Potential habitat for the black-whiskered vireo is most extensive in south Florida (Figure 41) with approximately 85% of the estimated habitat occurring in Everglades National Park. However, populations also extend as far north as southern Volusia County on the east coast and Tampa Bay on the west coast (Figure 40), and these northerly populations appear to be disjunct from the Everglades population. Concentrations of appropriate habitat patches occur around Charlotte Harbor, Tampa Bay, Indian River Lagoon, and Mosquito Lagoon. The conservation of habitat within these northerly populations could be important to maintaining a broad geographic distribution of this species in Florida. Conservation of additional habitat areas could also help to conserve habitat for other rare species associated with mangrove land cover (see Millsap et al. 1990).

Densities of black-whiskered vireos have not been determined for many habitat areas in Florida, but a coarse estimate can be made based on survey information presented in Hamel (1992). Using a low density of five breeding pairs per km^2 of appropriate habitat, we estimate there are six conservation areas with sufficient habitat to support > 200 individuals; another eight conservation areas have sufficient habitat to support 50-200 individuals. If a higher density estimate of at least 10 breeding pairs per km^2 is substituted, there are eight conservation areas with sufficient habitat to support 200 individuals, and 12 conservation areas with sufficient habitat to support 50-200 individuals.

These estimates lead us to conclude tentatively that black-whiskered vireos lack the minimum level of habitat protection desired, primarily because protected blocks of habitat

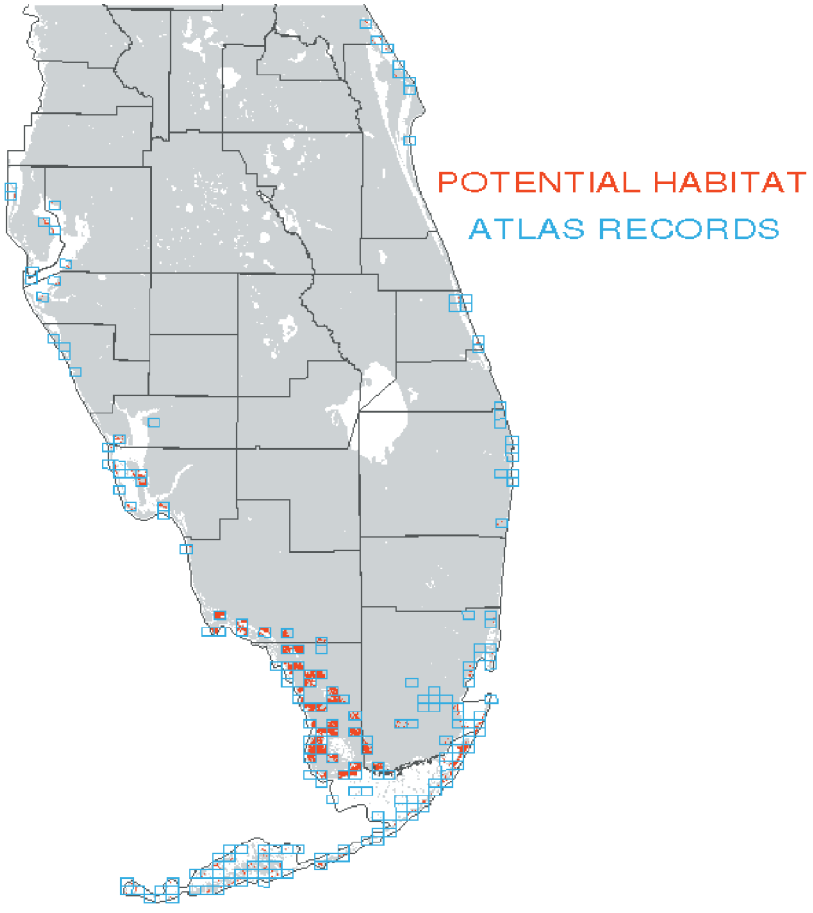


Figure 41. Habitat distribution map and breeding bird atlas records for the black-whiskered vireo.

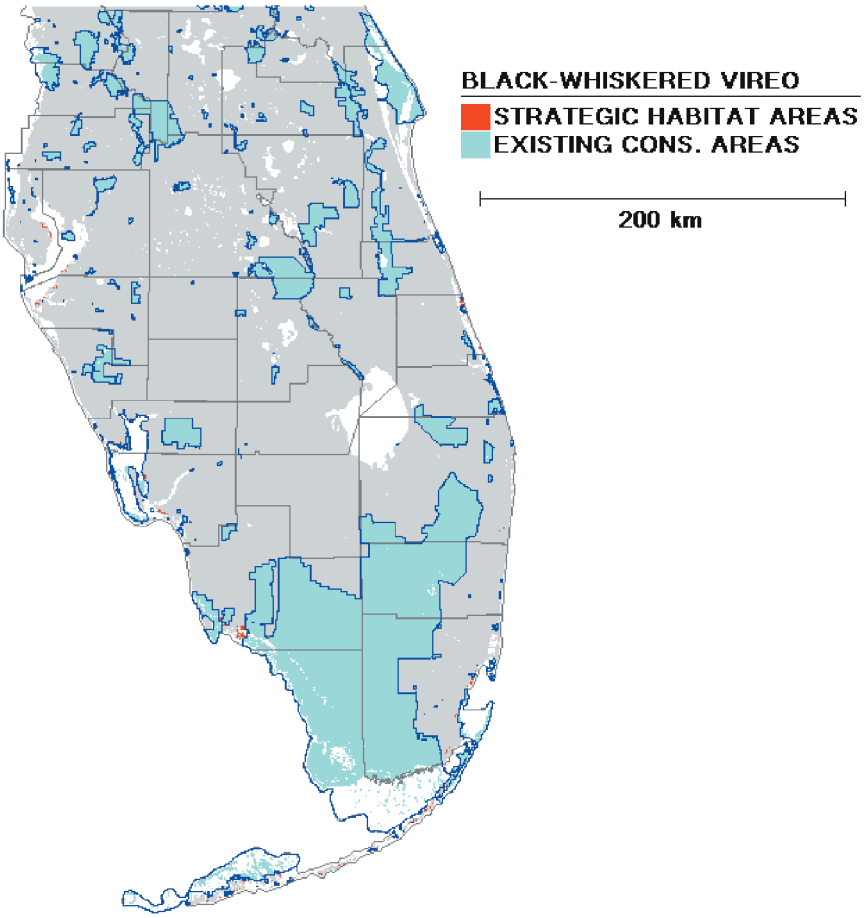


Figure 42. Proposed Strategic Habitat Conservation Areas for the black-whiskered vireo.

currently do not cover a broad area relative to the total range of the species. Thus, a large portion of the habitat available within existing conservation areas may be subject to a single catastrophic event (e.g., a hurricane). In addition, the rapid spread of both brown-headed and shiny cowbirds into the breeding range of this species places even very large populations at some risk (Cruz et al. 1988). Finally, the mangrove swamps used by black-whiskered vireos are managed through regulation and thus can receive protection without requiring fee-simple acquisition.

We isolated the potential habitat outside of existing conservation areas and eliminated patches smaller than 5 ha (an estimated home range size). Bancroft et al. (in prep.) showed a positive correlation of black-whiskered vireos and area of forest habitat. Of the 1,213 patches of habitat identified outside of current conservation areas, 250 satisfied this condition. The largest blocks of habitat satisfying this condition occurred in the Florida Keys, Tampa Bay, Charlotte Harbor, Indian River, and Biscayne Bay. These patches are proposed as Strategic Habitat Conservation Areas for the black-whiskered vireo (Figure 42). The total area covered by these patches of habitat is 17,000 ha (42,000 acres), with approximately 75% of the designated areas consisting of mangrove land cover that can probably be protected through regulatory mechanisms.

Section 6.2.8. Bobcat

The habitat distribution map for bobcat was created by selecting large blocks of "natural" land cover and the "disturbed" category of shrub and brush. McCord and Cardoza (1982) noted that the only habitat types not used by this species are barren lands and certain types of agricultural lands. All "natural" upland cover types were deemed suitable, and the wetland cover types included cypress swamp, hardwood swamp, bay swamp, and bottomland hardwood.

We isolated contiguous patches of these cover types and then eliminated patches smaller than 100 ha (250 acres). This size criterion represents an estimate of the average home range size of female bobcats in the southeast (Hall and Newsome 1976, McCord and Cardoza 1982). The habitat selection process was performed throughout the state since bobcats are believed to be fairly ubiquitous outside of major urban areas. Although this habitat distribution map does not reflect important differences in local habitat conditions that might influence the density of bobcats, it does reflect the tolerance of the species for a wide range of habitat conditions (McCord and Cardoza 1982).

Using an estimated density of 0.2/km^2 (McCord and Cardoza 1982) and the distribution of habitat in current conservation areas, we estimate that conservation areas do not currently provide sufficient habitat to support at least 10 populations of approximately 200 individuals. There are, however, seven conservation areas with sufficient habitat to support populations > 200, and another 26 conservation areas with sufficient habitat to sustain populations of 50-200. Thus, even though the habitat base available in current conservation areas does not meet the minimum standards established, there exists a large base of habitat for bobcats. Moreover, habitat conservation plans developed for several other focal species (e.g., Florida panther and black bear) will likely umbrella the requirements of bobcats. For these reasons, no specific habitat conservation plans were developed for this species.

Section 6.2.9. Bog Frog

Bog frogs are known only from 23 streams in and around Eglin Air Force Base in northwest Florida. Three of the records consist of single individuals and probably do not represent stable populations (Moler 1992c). Population sizes for the remaining populations are unknown.

The limited geographic distribution of bog frog populations makes it critical to conserve the habitat remaining within the range of the species (Moler 1992c). Only three streams outside current conservation areas contain significant populations. We propose the potential habitat areas within these drainages as Strategic Habitat Conservation Areas for the bog

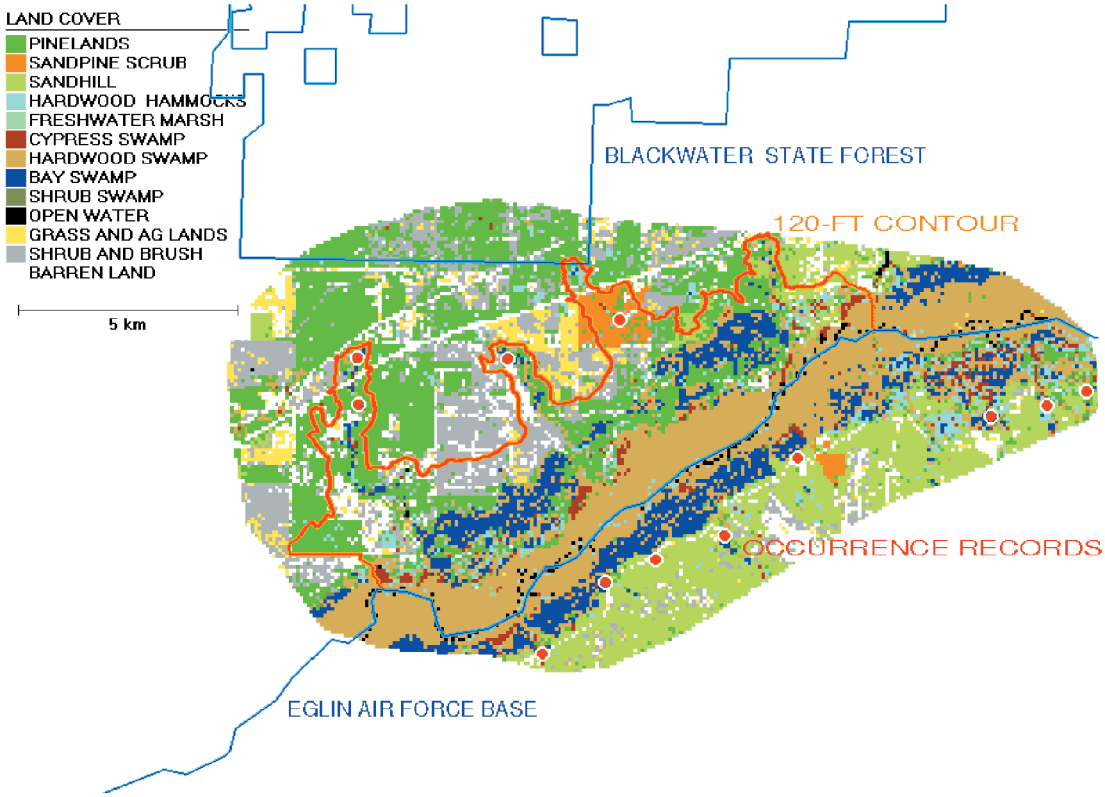


Figure 43. Proposed Strategic Habitat Conservation Area for the bog frog.

frog (Figure 43). The proposed conservation areas were created by digitizing the 120-foot contour line around each creek containing populations of bog frog from a 1:24,000 scale topographic map. Protection of habitat within these areas will also benefit such species as the white-topped pitcher plant, panhandle lily, and midland water snake.

Three primary threats confront bog frogs within current and proposed conservation areas (Moler 1992c). Stream impoundments have flooded some of the bog frog habitat along the eastern-most creek of the proposed habitat conservation area. Siltation and run-off from nearby roads (Interstate 10 and county roads) may have also had an impact. Additional stream impoundments should not be allowed within the proposed Strategic Habitat Conservation Areas, and management of storm water runoff is needed for impermeable surfaces surrounding the proposed conservation area. A third threat comes from habitat succession, which has reduced bog frog habitat on both public and private lands. Succession should be controlled through periodic burning.

Section 6.2.10. Cuban Snowy Plover

The habitat distribution map developed for Cuban snowy plover (Figure 44) was based on records in the Atlas of Florida Breeding Birds (Kale et al. 1992), Florida Natural Areas Inventory data, and information presented in Gore and Chase (1989). We isolated the coastal strand located within a small-radius circle (250 m) of point data describing Cuban snowy plover nesting locations. This created a 20 ha (48 acre) core habitat area within which the coastal strand land-cover type was isolated.

Figure 44. Habitat distribution map and occurrence records for the Cuban snowy plover in Florida.

Within breeding bird atlas blocks where Cuban snowy plovers were recorded, we isolated the coastal strand land cover and barren land cover that occurred within 60 m of coastal strand. Since some tidal flats are also occasionally used, we also isolated the barren land occurring within 60 m of the salt marsh land cover.

Figure 44 shows a sparse distribution of nesting areas restricted exclusively to the Gulf Coast. Coastal areas in the panhandle contain the greatest amount of appropriate habitat. Gore and Chase (1989) estimate > 70% of the Florida population occurs here. Another noteworthy concentration of habitat is found in southern Pasco and northern Pinellas counties. Florida's snowy plover population consists of 150-200 breeding pairs, and most are now restricted to areas within public lands where there is little human disturbance. Based on the criteria developed here for minimum levels of acceptable security, this species is not adequately represented in current conservation areas. Paul and Below (1991) list the Cuban snowy plover as the most endangered bird of the Florida coastline.

Simulations of Cuban snowy plover population dynamics (Page et al. 1983) indicate that populations in the range of 100-150 breeding pairs have good chances of long-term survival under favorable management conditions. Given the threat posed to Cuban snowy plovers by storms, predators, and human activities (Gore and Chase 1989), a primary concern in conservation efforts should be management of populations in current conservation areas and the establishment of a number of new habitat clusters regardless of their size. A greater number of habitat clusters could offset the impacts of environmental catastrophes affecting any one cluster in a given year. The fact that Cuban snowy plovers disperse great distances (Page et al. 1983) would also enable movement among clusters to occur at a high frequency. However, very small clusters adjacent to urban areas may not provide sufficient security against predators such raccoons, cats, dogs, foxes, gulls, and crows.

The acquisition of Cuban snowy plover habitat in Walton County recently protected one of the largest breeding populations on private lands in Florida. Additional private lands along Highway 30A (Walton County), Philips Inlet (Bay County), and Palm Point (Gulf County) each support < 10 breeding pairs (Gore and Chase 1989), but these small populations may provide big advantages in years when populations elsewhere are affected by storms, predators, etc. Thornton Key in southwest Florida also supports a small breeding population. These unprotected areas receive some incidental protection through coastal zone regulations, but more definite conservation measures should be permanently established for these sites. Owing to the scarcity of habitat on private lands and the importance of geographically distinct areas in plover conservation efforts, we propose the habitat areas found on private lands as Strategic Habitat Conservation Areas (Figures 45a and 45b).

Figure 45 (a-b). Proposed Strategic Habitat Conservation Areas for the Cuban snowy plover.

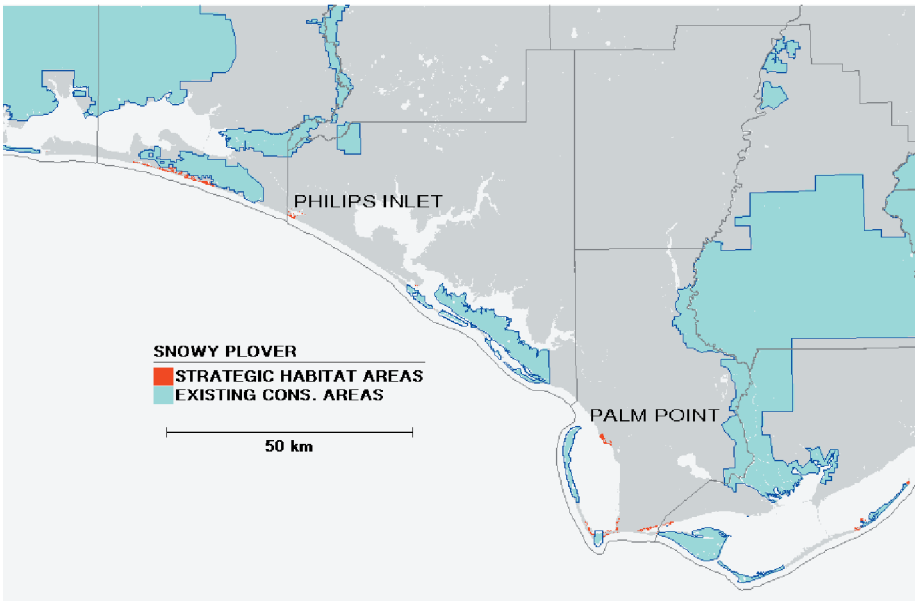


Figure 45a. Florida panhandle.

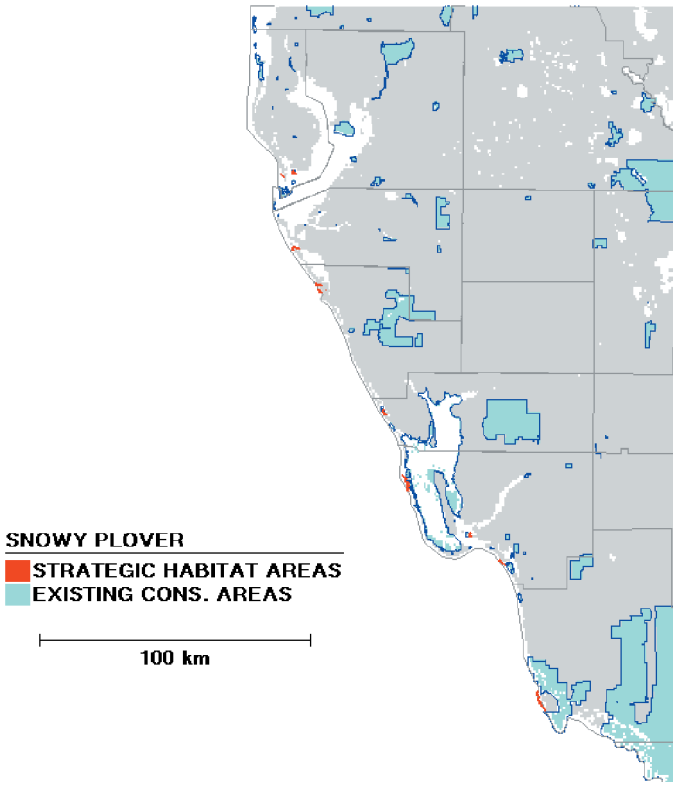


Figure 45b. South and central Gulf coast.

Conservation of populations of snowy plovers in Florida would also be enhanced significantly by restricting recreational activities near nesting areas in current conservation lands. The Division of Recreation and Parks, Florida Department of Environmental Protection, is considering limiting human access to snowy plover nesting areas on Caladesi Island State Recreation Area, Three Rooker Bar State Recreation Area, and Honeymoon Island State Park during the nesting season. This is a laudable effort that should likely provide great benefits to this species. O'Meara and Gore (1988) provide management guidelines for least terns that apply to some degree to areas supporting snowy plovers.

Programs that expand the habitat available for snowy plovers in central and south Florida are important since they could enhance the geographic distribution of Florida's breeding population. Habitat restoration might be considered in some areas where dredge spoils are frequently deposited. However, restoration of spoil islands is not adequate mitigation for the destruction of currently occupied habitat areas. Areas where habitat restoration and management might be effective are around coastal Pinellas and Pasco counties where a small number of snowy plovers currently breeds. Habitat restoration on spoil islands in this area might encourage nesting in new areas. Restoration of dune vegetation on dredged spoils around Charlotte Harbor and Marco Island in southwest Florida could also be of value to Cuban snowy plovers.

Important wintering habitat areas are not well known for Cuban snowy plovers, though large numbers are reported from several areas in Florida. Better information of this type needs to be collected in a systematic fashion. Cooperative management agreements with neighboring states (particularly Alabama) where Cuban snowy plovers breed would also be beneficial.

Section 6.2.11. Florida Black Bear

An initial map of potential black bear habitat was created by isolating the large, contiguous patches of appropriate habitat remaining in Florida. We merged the pineland, oak scrub, sand pine scrub, mixed hardwood-pine, upland hardwood forest, cypress swamp, mixed hardwood swamp, bay swamp, and bottomland hardwood classes into a single class categorized as "primary" black bear habitat (Wooding and Hardisky 1988, Maehr and Wooding 1992). Individual contiguous patches of primary black bear habitat were identified, and patches smaller than 0.15 km^2 (37 acres) were eliminated. Mykytka and Pelton (1989) found that habitat patches > 0.15 km^2 were important components of black bear habitat in the Osceola National Forest.

A 1-km zone was created around each of these large (> 0.15 km^2) patches, and small (< 0.15 km^2) patches of primary land cover eliminated in the previous step were reincorporated. This procedure enabled small patches in close proximity to larger habitat patches to be included as habitat areas.

A second class of black bear habitat was also established that included the dry prairie, sandhill, tropical hardwood hammock, shrub swamp, and shrub and brush classes. These land-cover types may be used frequently by black bears, but use of such areas depends to some degree on nearby land cover. For example, Wooding and Hardisky (1988) found that black bears avoided sandhill land cover on the Ocala National Forest. A single large patch of sandhill land cover is probably not as valuable as sandhill land cover found in close proximity to the other land-cover types used more frequently. The patches of secondary habitat found within 1 km of large patches (> 0.15 km^2) of primary land cover were included in the map of potential habitat.

A third category of black bear habitat was created through an analysis of the mangrove land cover. Recent studies have found that black bears frequently use mangrove swamps in southwest Florida (D. Maehr pers. comm.). We isolated the mangrove land cover within 5 km of primary and secondary land cover (as defined above). The edges of the mangrove land cover were isolated and a zone extending 300 m into the mangrove cover was created. The mangrove land cover along this 300-m zone was incorporated as appropriate habitat. We also eliminated the mangrove areas lying close to open gulf waters by creating a 90-m zone along the edge of open gulf waters. The mangrove land cover satisfying all previous conditions, but falling within this zone near water, was eliminated.

Densities of black bears in the southeastern United States fall in the range of 0.05-0.10 breeding individuals per km^2 (Carlock 1984, Wooding and Hardisky 1988, Hellgren and Vaughn 1989). A potentially secure population of black bears (as defined in Section 5) would require a habitat base of approximately 2,000-4,000 km^2 (490,000-980,000 acres). Whether the quantity of habitat sought for black bear habitat conservation areas lies towards the lower end or upper end of this range depends upon qualitative aspects of each area, as well as the type of management proposed for the area. Black bear habitat areas of these general sizes would provide sufficient habitat to support populations that would not experience high rates of inbreeding. These populations could also withstand substantial year-to-year fluctuations in environmental conditions. The provision of 10 such habitat conservation areas distributed across a broad geographic area would protect genetic diversity, provide security against catastrophic events, and further limit the effects of seasonal environmental variation.

A comparison of the map of potential black bear habitat with existing conservation areas produced an estimate of sufficient habitat to support two potentially secure, three insecure, and eight imperiled populations. A density of 0.05 breeding individuals per km^2 (Carlock 1984, Hellgren and Vaughn 1989, Wooding and Hardisky 1988) was used to estimate habitat capacity. As noted by Maehr and Wooding (1992), current conservation areas in Florida do not provide the habitat base needed for the long-term survival of black bear populations.

The chances of establishing 10 black bear habitat conservation areas, each about 2,000-4,000 km^2 (490,000-980,000 acres) in size, are remote since each of the four largest conservation areas in Florida currently provides only 810-1,620 km^2 (200,000-400,000 acres) of potential habitat. Nonetheless, a goal of establishing 10 black bear conservation areas of these general sizes might be sought within the total geographic range of the Florida black bear in the southeastern coastal plain of the U.S.

Because of the limited chances of establishing new and independent habitat conservation areas capable of sustaining 200 individuals, we limited our most detailed analyses to five conservation areas that currently provide at least 20 km^2 (50,000 acres) of potential habitat and are known to support stable black bear populations. These areas are the Big Cypress National Preserve (and other contiguous conservation

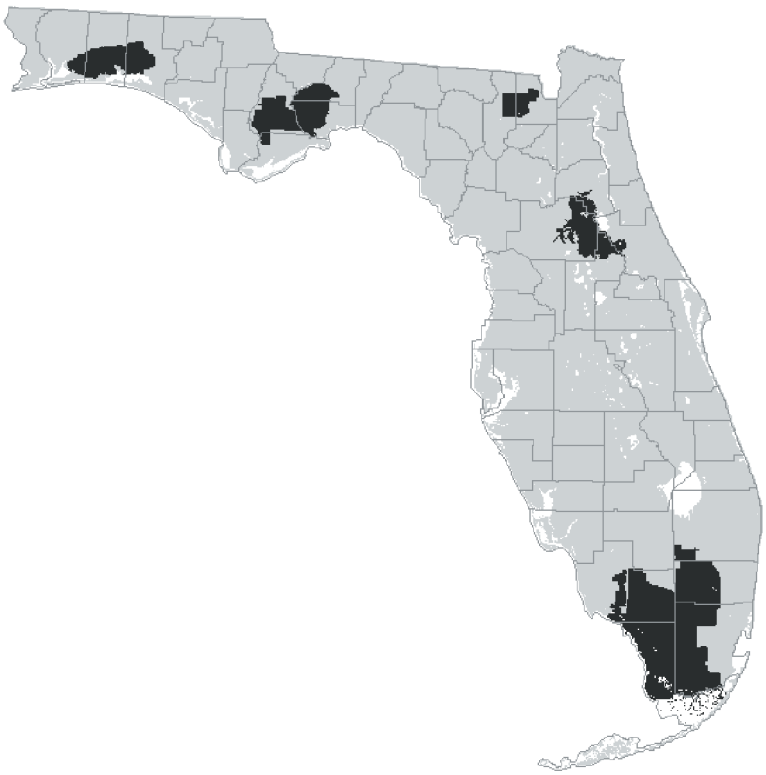


Figure 46. Large conservation areas in Florida with stable black bear populations.

areas), Ocala National Forest, Osceola National Forest, Apalachicola National Forest (and other contiguous conservation areas), and Eglin Air Force Base (Figure 46). We use information on black bear dispersal and movement characteristics to consider additional habitat protection options available outside these conservation areas. A discussion of other habitat areas where black bears occur follows this detailed analysis.

To assess qualitative aspects of the habitat areas in and around these larger conservation areas, we developed a second map of potential black bear habitat that included qualitative scores for patches of habitat identified in the first analysis. The first index score related to the specific land cover classes within each patch of potential habitat. Studies of black bear habitat use in Florida have shown a general preference for sand pine scrub, oak scrub, upland hardwood forest, and various forested wetlands (Maehr and Wooding 1992). We assigned sand pine scrub, oak scrub, mixed hardwood-pine, upland hardwood forest, cypress swamp, hardwood swamp, bay swamp, and bottomland hardwood forest a score of 3. Pineland, mangrove swamp, and shrub and brush land cover also may be important at different times of the year depending on food availability, and these areas were assigned a score of 2. The remaining "natural" cover types (e.g., sandhill, dry prairie, freshwater marsh, shrub swamp) within the habitat areas identified in the initial habitat map were assigned a score of 1.

Habitat areas were also scored using features other than land cover. A second score of potential black bear habitat was developed using the proximity of habitat areas to a conservation area with at least 20 km^2 (50,000 acres) of potential black bear habitat (without reference to whether the area currently supports black bears). This scoring was developed based on dispersal characteristics of black bears and the realization that it will be difficult to establish new conservation areas that are large enough to sustain black bears for long periods of time. Black bear conservation efforts must build upon the existing system of conservation areas.

Black bears may move great distances, occasionally dispersing > 140 km (Rogers 1987, Maehr et al. 1988). However, < 30% of the dispersal events recorded for black bears are > 60 km (Alt 1979, Rogers 1987, Maehr et al. 1988, Wooding and Hardisky 1988) and fewer than 2% are > 100 km. Potential habitat within 10 km of a large conservation area was assigned a score of 3, potential habitat within 20 km assigned a score of 2, and potential habitat within 30 km was assigned a score of 1. Note that two large conservation areas within 60 km of one another could be connected by the patches of habitat with an index score of 1. We thus use 60 km to define the limits of "frequent" dispersal among conservation areas.

Black bear distributions and use of specific areas may also be influenced by vehicular traffic volumes and thus the density of roads (Pelton 1985, Wooding and Brady 1987, Brady and Pelton 1989). We established a score for potential habitat areas based on patches created by the road network in Florida (Figure 16). Three categories of patch quality were scored based on the size and land-cover composition of habitat areas within roadless patches (see Section 3.3). A roadless patch < 10 km^2 (2,500 acres), which corresponds with the estimated home range of a female, was assigned a score of 0; a roadless patch > 10 km^2 (2,500 acres) but consisting of < 25% of the "primary" black bear cover types defined above was assigned a score of 1; and a roadless patch > 10 km^2 (2,500 acres) and consisting of at least 25% of the primary cover types was assigned a score of 2.

A final scoring of habitat areas was based on the diversity of cover types observed in an area. Numerous authors (Pelton 1985, Mollohan and LeCount 1989, Maehr and Wooding 1992) have described the importance of habitat diversity to black bear management efforts. We measured the diversity of four broad land-cover types using a neighborhood analysis (TYDAC 1991) that assigned scores to individual pixels based on the number of different classes found within a window of a specified size. We established a window size of 1 km to a side for this analysis. The four broad types of land cover created from the original land-cover map were forested wetlands (hardwood swamp, cypress swamp, bay swamp, mangrove swamp, shrub swamp, and bottomland hardwoods), forested uplands (pineland, sand pine scrub, sandhill, upland hardwood forests, and mixed hardwood-pine), freshwater marsh, and a category of low stature, open brush lands (xeric oak scrub, dry prairie, and shrub and

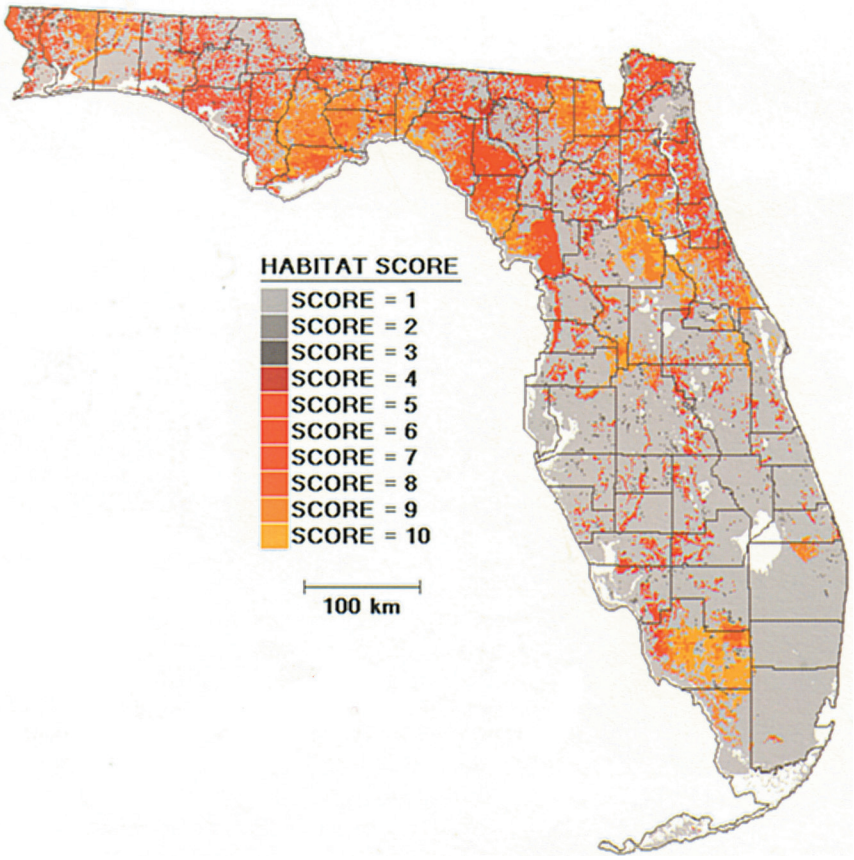


Figure 47. Qualitative measures of the potential habitat available to black bears in Florida. Habitat scores are based on proximity to existing conservation areas, size of roadless area, diversity of cover types, and the presence of specific cover types.

brush). Pixels with at least three of these broad cover types within 1 km were assigned a score of 2. Pixels with two or fewer classes were assigned a score of 1.

Simple addition of the four maps with index scores resulted in a map with scores ranging from 0-10 (Figure 47). The aggregate map scores Florida's remaining large forested tracts based on their land-cover composition, their proximity to large public lands, their position in a landscape of roads, and the diversity of four broad land-cover types within 1 km. When describing the "habitat quality" of different areas, we are referencing this map. Patches with the highest scores occur within 10 km of large public lands, are part of a large roadless patch with primary land cover, and also contain a diversity of other broad land-cover features nearby. The largest area with high index scores (> 6) surrounds the Apalachicola National Forest and extends along the Big Bend area in Jefferson and Taylor counties.

Below we review the habitat features within the vicinity (< 30 km) of the five large public land holdings containing at least 20 km^2 (50,000 acres) of habitat and supporting known black bear populations. Other areas where black bears are occasionally observed, and smaller conservation areas that currently support black bear populations but were not considered in association with these larger conservation areas, are discussed later. We then develop more specific minimum recommendations for the conservation of black bear habitat in Florida by considering (1) the need to establish habitat conservation areas in the range of 2,024-3,240 km^2 (490,000-980,000 acres); (2) the need to preserve a broad geographic distribution of managed black bear populations; and (3) an interest in conserving habitat areas important to both black bears and other rare species.

Region 1. Big Cypress National Preserve and Surroundings

The important features of the habitat in and surrounding the Big Cypress National Preserve include the small number of major roads (Figure 48), several large tracts of forested lands on nearby private land holdings, and the presence of several large conservation areas. Contiguous conservation areas (Big Cypress National Preserve, Florida Panther National Wildlife Refuge, Fakahatchee Strand State Preserve, Audubon Corkscrew Sanctuary, Collier-Seminole State Park, and portions of Everglades National Park) contain an estimated 2,100 km^2 (518,550 acres) of potential bear habitat with > 80% of the habitat areas scoring > 8 on the qualitative index map. These areas have the capacity to support about 105-210 breeding individuals assuming an average density of 0.05-0.1/km^2.

Although current conservation areas in this region satisfy our minimum recommendations for a single managed area, conservation of additional habitat will provide greater security for black bear populations statewide since it will be impossible to secure sufficient habitat for a total of 10 managed populations. Increasing the habitat base that can be effectively managed to approximately 1,000 km^2 (247,000 acres) would provide sufficient habitat to sustain a population (150-300 breeding individuals) capable of long-term survival even under very harsh environmental conditions. The largest contiguous blocks of high-quality habitat (based on index scores) outside of conservation areas are found west of the Fakahatchee Strand State Preserve and to the northeast of the Big Cypress National Preserve. There are approximately 607 km^2 (150,000 acres) of high quality habitat (index score > 7) northeast of the Big Cypress National Preserve (Area 1, Figure 48). An additional 235 km^2 (58,124 acres) of high quality habitat is found extending north of Interstate 75 to Corkscrew Swamp Sanctuary and east of Everglades Boulevard (Area 2, Figure 48). The Corkscrew Swamp Sanctuary contains an additional 40.5 km^2 (10,000 acres) of potential habitat (Area 3, Figure 48). The area west of Fakahatchee Strand State Preserve, north of Tamiami Trail, and east of State Road 951 contains 31.5 km^2 (77,928 acres) of high quality habitat (Area 4, Figure 48).

Conservation of habitat areas immediately north of Big Cypress National Preserve, areas surrounding Corkscrew Swamp Sanctuary, and the forested tracts that connect this

block of habitat with forested areas to the south may be among the more important tracts within the immediate area surrounding the Big Cypress National Preserve. Much of the area shown in Figure 48 to the northeast of Big Cypress National Preserve is scheduled to come into public ownership in the near future. Conservation of some of the high-quality habitat in other areas may prove difficult given the rate at which residential and agricultural development is occurring. However, chances of conserving an additional 1,000 km^2 (247,000 acres) are high if undertaken quickly, and some of the area might be conserved through conservation easements, land-use agreements, or other methods.

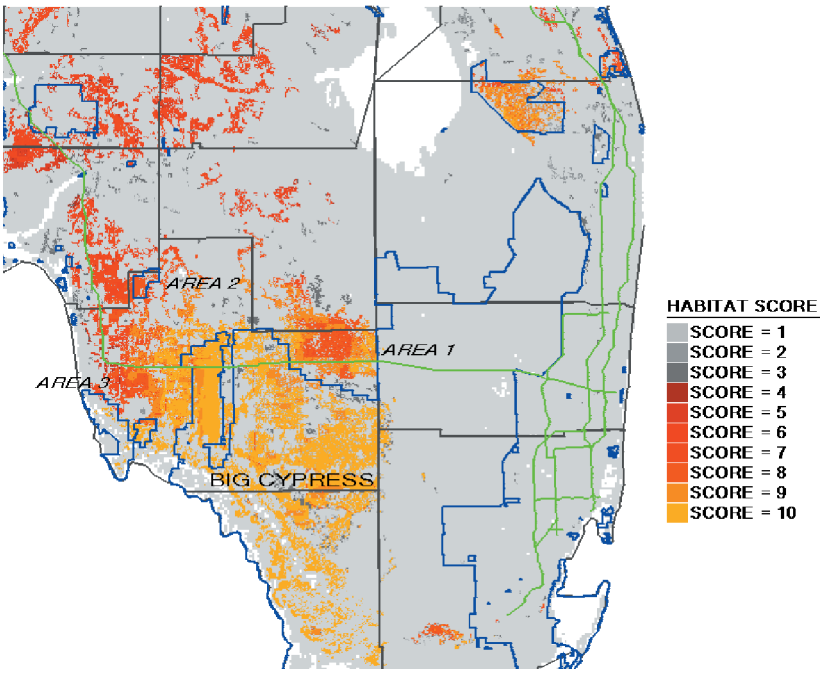


Figure 48. Potential black bear habitat in and around the Big Cypress National Preserve. Numbered areas are referenced in the text.

Region 2. Ocala National Forest

Approximately 1,649 km^2 (407,500 acres) of black bear habitat were mapped within the Ocala National Forest, Lake Woodruff National Wildlife Refuge, and contiguous conservation areas to the west and southwest. This area could support an estimated 82-165 breeding individuals. There are an additional 3,643 km^2 (900,000 acres) of high quality (index score > 7), unprotected black bear habitat within 30 km of the Ocala National Forest (Figure 49). These habitat areas could provide sufficient habitat to support a population with high chances of long-term survival. However, the area is also heavily crossed by roads, and > 60 black bears have died from collisions with vehicles in this area within the last decade (Wooding and Brady 1987, T. Gilbert pers. comm.). Construction of wildlife underpasses (see Foster and Humphrey 1993) could help to reduce some black bear mortality, but conservation of habitat acreage towards the upper end of the range estimated (i.e., 3,200 km^2, 800,000 acres) might also provide a population large enough to offset current levels of road mortality.

Commercial timber lands to the east, north, and west of the Ocala National Forest (and extending to southern Duval County) make up a large portion of the black bear habitat surrounding the Ocala National Forest. Documented dispersal (Wooding unpubl.) has occurred from the Ocala National Forest into forested lands in St. Johns, Brevard, Volusia, and Flagler counties through an area between Palatka and Crescent Lake (Area 1, Figure 49). Conservation of habitat along this corridor would enable black

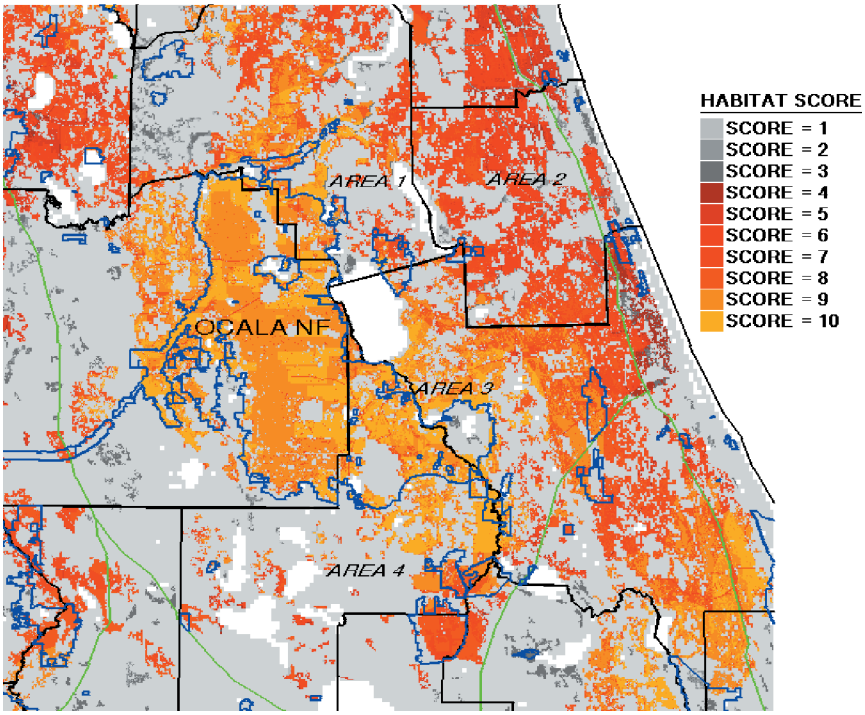


Figure 49. Potential black bear habitat in and around the Ocala National Forest. Numbered areas are referenced in the text.

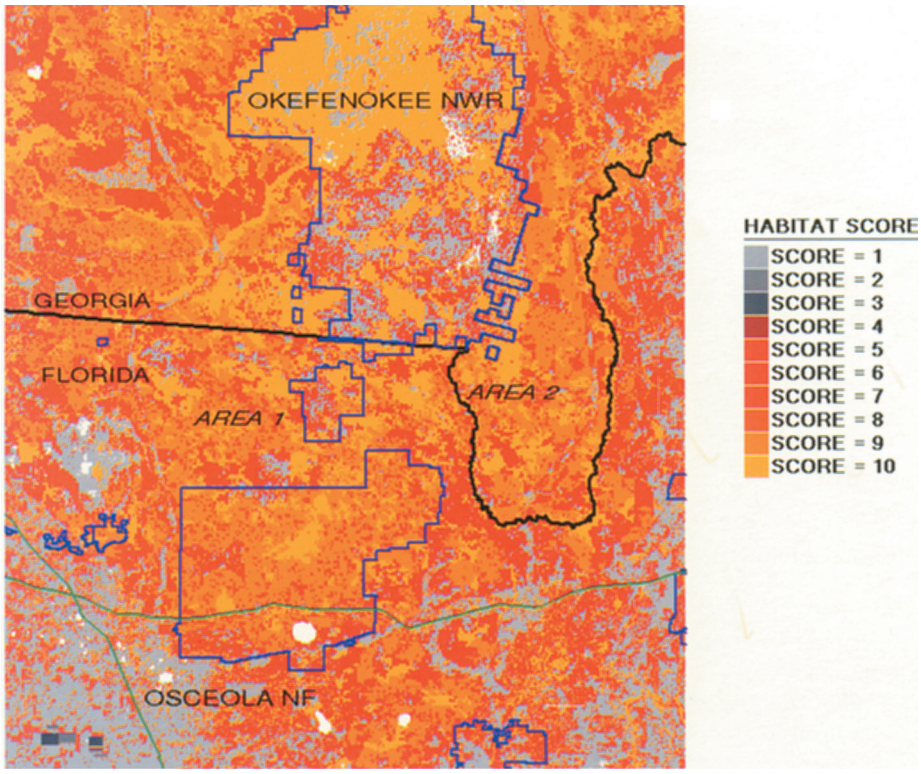


Figure 50. Potential black bear habitat in and around the Osceola National Forest and Okefenokee National Wildlife Refuge. Numbered areas are referenced in the text.

bears to continue to move into the large block of habitat extending throughout Volusia, Brevard, St. Johns, and Flagler counties (Area 2, Figure 49). However, conservation of a large block of black bear habitat in Volusia, Brevard, St. Johns, and Flagler counties is required for the conservation of this corridor to have any meaning. Black bears also likely move from the Ocala National Forest into these private forest lands using an area between DeLeon Springs and Seville (Volusia County) (Area 3, Figure 49).

Several conservation areas to the south of the Ocala National Forest contain black bear habitat yet are not currently contiguous with protected habitat on the forest. Public lands along the Wekiva River (e.g., Rock Springs Run, Wekiva River State Park) (Area 4, Figure 49) contain approximately 121 km^2 (30,000 acres) of black bear habitat and have the capacity to support 6-12 black bears. The total acreage of black bear habitat along the Wekiva River (including unprotected private lands) is about 536 km^2 (135,000 acres). Conservation of the black bear habitat on private lands in this area would significantly enhance the overall security of the Ocala black bear population, however conservation of additional habitat elsewhere surrounding the Ocala National Forest will also be needed.

Region 3. Osceola National Forest and Surroundings

To evaluate the habitat available to black bears in and around the Osceola National Forest, we obtained a classified land-cover map of Georgia developed from Landsat Thematic Mapper data collected in 1989 (ERDAS, 2801 Buford Highway, Suite 300, Atlanta, Georgia, 30329). The procedures performed for the Georgia land cover data were identical to those described earlier for the Florida land-cover data. Results for an area centered on the Osceola National Forest are presented in Figure 50.

The Osceola National Forest (including the Pinhook Swamp section; Area 1, Figure 50) provides 638 km^2 (157,700 acres) of black bear habitat, the smallest quantity of any of the five conservation areas in Florida with stable black bear populations. We estimate this area could support 32-64 breeding individuals. An additional 6,147 km^2 (1.5 million acres) of habitat occurs within the larger area of south Georgia and north Florida shown in Figure 50, and roughly 70% of this area has an index score > 8. Other large conservation areas within 30 km of the Osceola National Forest include Raiford Prison with 68 km^2 (17,000 acres) of habitat, and the Okefenokee National Wildlife Refuge, which contains 980 km^2 (241,810 acres) of black bear habitat. Habitat available on the Okefenokee National Wildlife Refuge could support approximately 50-100 black bears.

The black bear habitat available on either the Osceola National Forest and Okefenokee National Wildlife Refuge would not support the estimated number of bears needed for long-term survival. Conservation of an additional 1,000 km^2 (247,000 acres) of black bear habitat on the private lands lying between these two areas could establish a total habitat base of 2,630 km^2 (648,600 acres) and would significantly enhance the chances of long-term survival of both populations. Conservation of private lands in this area would also help to secure one of the largest forested wetland areas in the southeastern U.S. Some of the more important areas that are currently unprotected lie to the east and northeast of the Osceola National Forest, including Moccasin Swamp, Cross Branch, and the North Prong of the St. Mary's River (Area 1, Figure

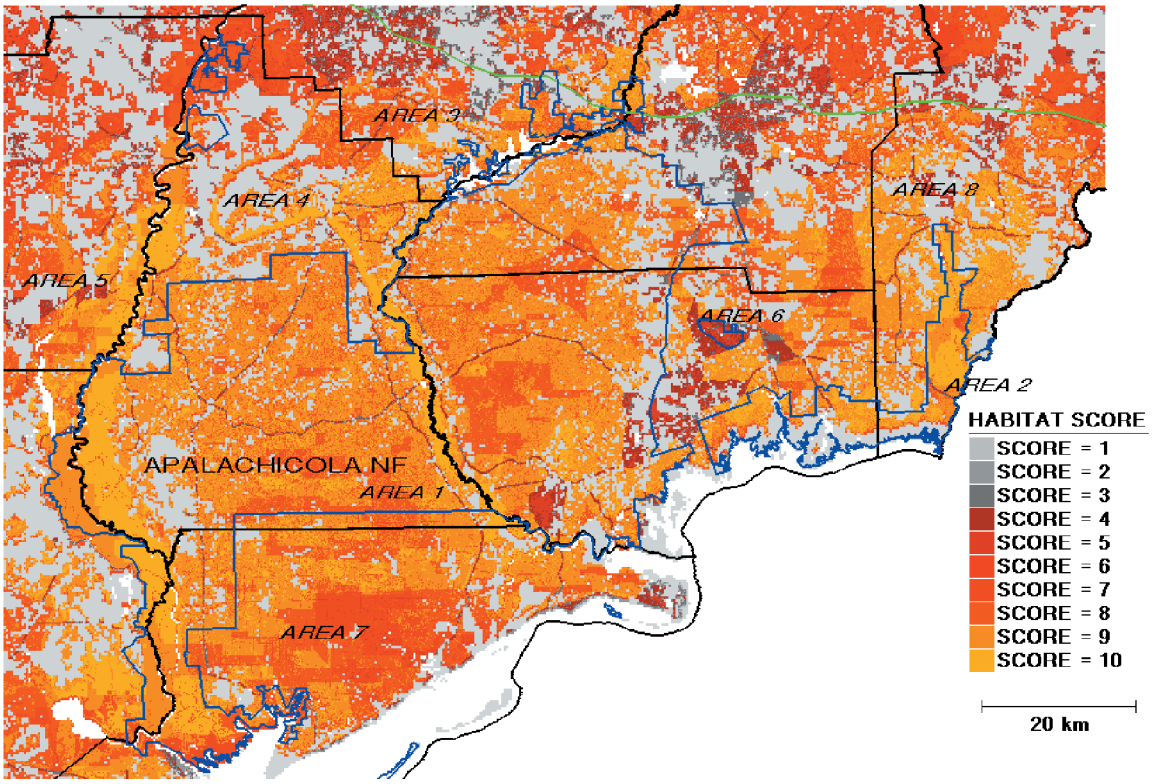


Figure 51. Potential black bear habitat in and around the Apalachicola National Forest and St. Marks National Wildlife Refuge. Numbered areas are referenced in the text.

50). Areas just to the north and west of the current boundaries of the Pinhook Swamp portion of the Osceola National Forest also appear important (Area 2, Figure 50). Areas extending west of the southwest corner of the Okefenokee National Wildlife Refuge to U.S. 94 also appear very important, as do areas east of the southeast corner of the refuge and extending south of U.S. 94.

Region 4. Apalachicola National Forest and Surroundings

There are roughly 10,930 km^2 (2.7 million acres) of potential black bear habitat extending from the Aucilla River west through the southern portions of Jefferson and Leon counties, and throughout most of Wakulla, Franklin, and Liberty counties (Figure 51). Most of the habitat has a qualitative index score > 7. At least 4,048 km^2 (1 million acres) fall within 30 km of the Apalachicola National Forest, and we estimate that this broad area of public and private lands has the capacity to support 200-400 black bears. Features of the region that make it particularly attractive to black bear conservation include the distribution of large public land holdings, the absence of major roads, and several large tracts of private timber lands with sparse human populations.

Public lands in this region encompass a large portion of the potential black bear habitat. The contiguous portions of the Apalachicola National Forest, Apalachicola River Wildlife and Environmental Area, and St. Marks National Wildlife Refuge (Area 1, Figure 51) contain roughly 2,744 km^2 (678,000 acres) of habitat, while the contiguous portions of St. Marks National Wildlife Refuge, Aucilla Wildlife Management Area, and Aucilla State Reserve (Area 2, Figure 51) contain an additional 108 km^2 (26,700 acres). We estimate that these public management areas can support approximately 140-280 and 5-10 black bears, respectively. Tyndall Air Force base in the southwestern portion of the area con-tains approximately 109 km^2 (27,000 acres) of habitat, enough to support roughly 5-10 black bears.

Although current conservation areas in this region satisfy our minimum recommendations for a single managed area, conservation of additional habitat may provide greater security for black bear populations statewide since it will be impossible to secure sufficient habitat for a total of 10 managed populations. Unprotected potential habitat shown north and west of Lake Talquin encompasses roughly 784 km^2 (193,800 acres; Area 3, Figure 51), but this area contains a large number of home sites and has many roads. Areas to the west of Lake Talquin along Telogia Creek (Area 4, Figure 51) provide approximately 1,012 km^2 (250,000 acres) of potential habitat with much lower human densities. Private lands along the Apalachicola River (Area 5, Figure 51) contain roughly 1,115 km^2 (275,600 acres) of potential black bear habitat and are not subjected to high levels of human disturbance. Private lands in Wakulla County (Area 6, Figure 51) contain roughly 624 km^2 (154,200 acres) of potential black bear habitat, but much of this area is undergoing residential development. The remote region around Tate's Hell Swamp (Area 7, Figure 51) contains approximately 781 km^2 (193,600 acres) of potential black bear habitat. Radio telemetry data collected by S. Siebert (pers. comm.) show that some of the more important areas in this region lie around the New and Crooked rivers and St. James Island. The large forested wetlands along the

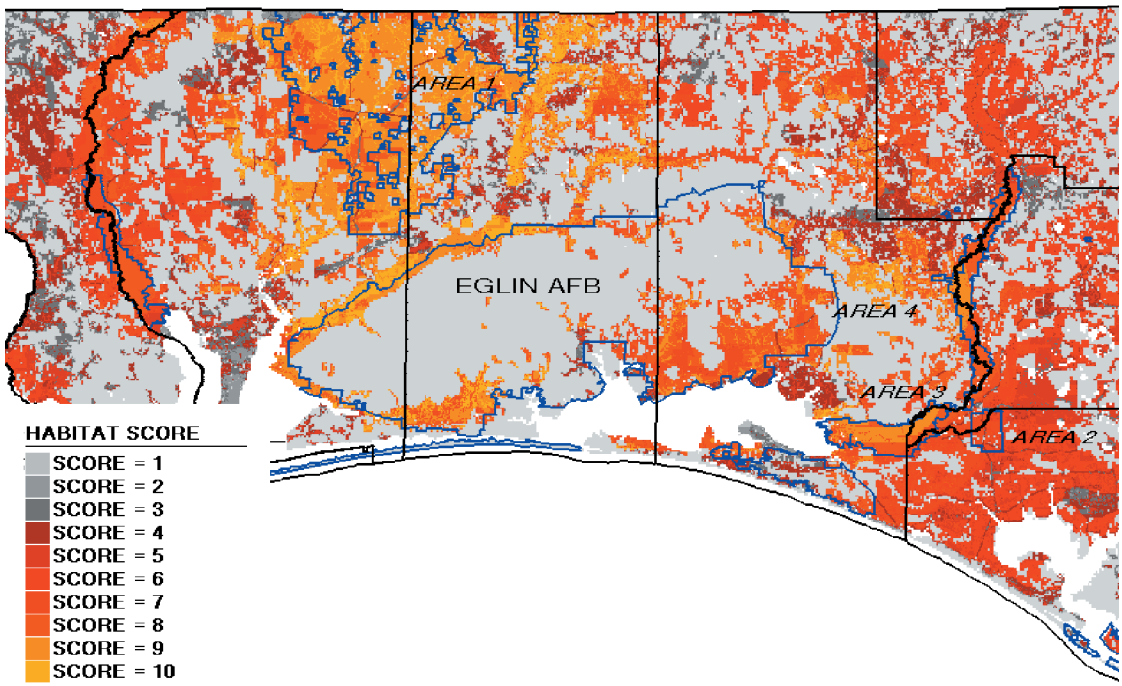


Figure 52. Potential black bear habitat in and around Eglin Air Force Base. Numbered areas are referenced in the text.

Aucilla and Wacissa rivers (Area 8, Figure 51) to the east of the St. Marks National Wildlife refuge provide 910 km^2 (225,000 acres) of potential habitat. The total quantity of black bear habitat encompassed by the private lands could support an additional 120-240 black bears. Conservation of these areas could establish the largest managed black bear population in the southeastern coastal plain.

Region 5. Eglin Air Force Base and Surroundings

Black bears are most frequently seen in association with the hardwood forests along the Yellow River at Eglin Air Force Base. The Air Force Base contains approximately 1,680 km^2 (415,000 acres) of black bear habitat, but only 43% is considered "high quality" due in part to the dominance of sandhill land cover. Black bears also frequent the eastern portions of Eglin Air Force Base and private lands farther east.

Lands surrounding Eglin Air Force Base appear capable of supporting a very large population of black bears, but only a portion of the area outside of Eglin is currently occupied. Blackwater River State Forest is estimated to have approximately 710 km^2 (175,370 acres) of potential habitat (Area 1, Figure 52), but black bears do not occur on this conservation area with any degree of regularity. Other nearby public parcels include Pine Log State Forest (Area 2, Figure 52) with 26.7 km^2 (6,600 acres) of habitat, water management district lands along the Lower Choctawhatchee River (Area 3, Figure 52) that provide 67.6 km^2 (16,700 acres), and areas along the Escambia River that contain 55 km^2 (13,700 acres) of habitat. Together these smaller protected areas might support an additional 4-8 black bears. Recent purchase of approximately 210 km^2 (51,870 acres) of black bear habitat east of Destin has the capacity to support 10-20 black bears and represents a potentially valuable patch of habitat if connected with Eglin Air Force Base and other conservation lands in the area.

Conservation of private lands between Eglin Air Force Base and Blackwater River State Forest is a potentially appealing black bear habitat conservation strategy that could help to conserve a large quantity of black bear habitat while requiring only a minimal investment. This linkage would establish a large 2,388 km^2 (590,000 acre) habitat conservation region, but the importance of this connection hinges on the ability of black bears to traverse Interstate 10 safely and the actual significance of lands to the north. Construction of wildlife crossings (see Foster and Humphrey 1993) along Interstate 10 and U.S. Highway 90 might allow bears to move between the areas more easily, but the current absence of black bears in Blackwater River State Forest, and the small number of road kills reported for this area (Wooding and Brady 1987), raise some questions about black bear use of the areas north of Eglin Air Force Base.

To the east of Eglin Air Force Base lies a large region of potential black bear habitat known to support black bears. This area (Areas 3 and 4, Figure 52) contains roughly 436 km^2 (107,830 acres) of potential black bear habitat, and the area connects Eglin Air Force Base with protected lands on the lower portion of the Choctawhatchee River. The area might support as many as 30-44 black bears, and in combination with Eglin Air Force Base would bring the total population supported by conservation lands in the region to roughly 150-210 black bears. Another large block of potential habitat occurs to the northeast of Eglin Air Force Base. This area may be effectively severed from Eglin Air Force Base by

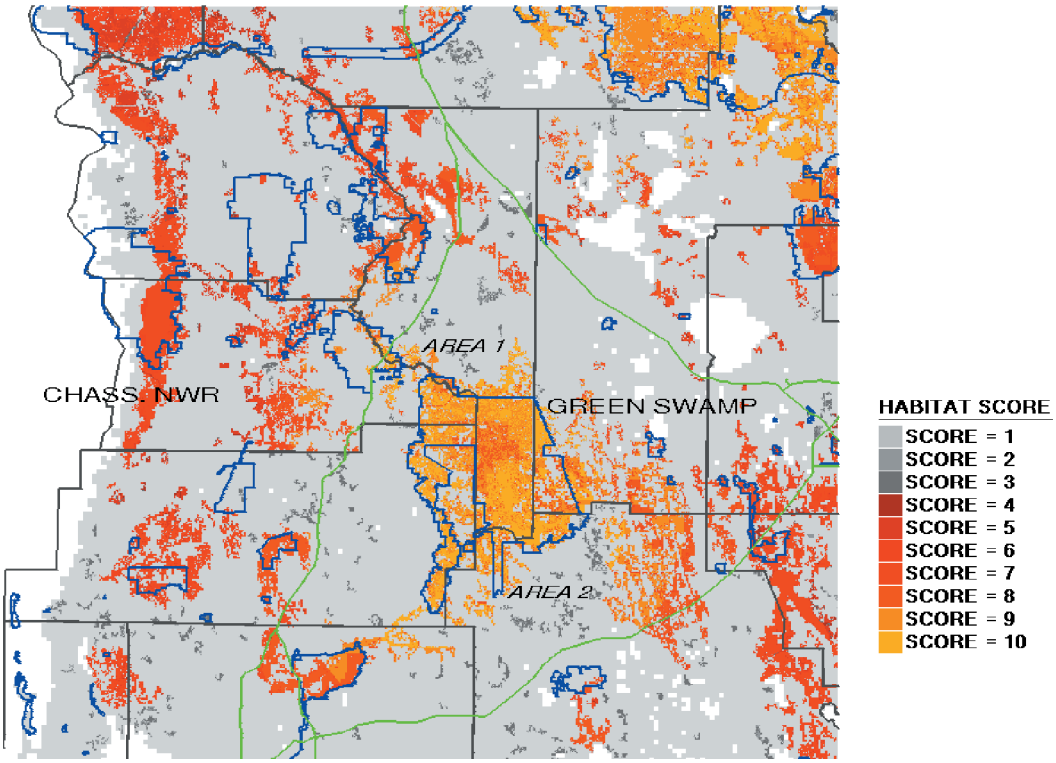


Figure 53. Potential black bear habitat in and around the Green Swamp and Chassahowitzka National Wildlife Refuge.

Interstate 10, but it contains approximately 129,000 acres of potential black bear habitat.

Other Important Black Bear Habitat Areas

Occurrences of black bears in other areas of Florida were determined from direct observations, reports of nuisance bears, and consultation with biologists within the Florida Game and Fresh Water Fish Commission. Occasional reports of black bears come from the Green Swamp region (Area 1, Figure 53) where current conservation areas provide 485 km^2 (120,000 acres) of habitat. These conservation areas are capable of supporting an estimated population of 24-48 black bears. Populations of this size have fair chances of survival over very long periods under favorable management condition, or if bolstered by occasional immigration or managed relocations. Efforts to link the population in the Green Swamp with the population in the Ocala National Forest might help to stem local extinctions within the Green Swamp, but the chances of black bears moving frequently between the two areas seem low given current land uses, the abundance of many high-use roads, the lack of a clear line of habitat lying between these areas, and the distance between the two conservation areas. The distance between Green Swamp and Ocala National Forest is about 55 km, which lies towards the upper range of frequent dispersal distances recorded for black bears. However, this small population certainly has the capacity to persist for many decades under favorable management conditions.

The Chassahowitzka National Wildlife Refuge (Area 2, Figure 53) currently provides approximately 86.9 km^2 (21,500 acres) of black bear habitat and supports a small (< 20) black bear population. The habitat base available on this conservation area is much too small to sustain a population for an extended period of time unless bolstered by frequent immigration. We estimate that a total of 850 km^2 (210,900 acres) of black bear habitat occurs within 30 km of the conservation area. Efforts to link this population to the population in the Ocala National Forest might help to sustain black bears in this area. However, the chances of black bears moving frequently between the two areas appear slim given the rate of development occurring in the region, the density of roads, the lack of a clear line of habitat, and the distance (> 50 km) between the Chassahowitzka National Wildlife Refuge and the Ocala National Forest.

Another potential linkage might be made between the Chassahowitzka National Wildlife Refuge and the Green Swamp area (Figure 53). The distance between these two conservation areas is approximately 45-50 km, and the total habitat available on the existing conservation areas that might be included in this proposed interconnected system is 531 km^2 (131,203 acres), enough to support 25-50 black bears. Private lands currently provide 273 km^2 (67,522 acres) of potential habitat and could bring the total habitat area available to black bears in the region to approximately 804 km^2 (198,725 acres). This total might support a fairly stable black bear population of about 40-80 breeding individuals. However, this estimate includes large blocks of potential

habitat that exist next to existing conservation areas (e.g., Areas 1 and 2, Figure 53) as well as the habitat used to connect the conservation areas.

The Big Bend region (Figure 54) provides another large block of potential black bear habitat, but black bears are not observed in this region regularly (Brady and Maehr 1985, Maehr and Wooding 1992). Potential habitat within this large region extends from central Jefferson and Taylor counties along the Gulf Coast through Levy County (Figure 54). The habitat area is contiguous to habitat described in the section on the Apalachicola National Forest, but black bears are not frequently reported very far east of the Aucilla River in the Big Bend area. The reason black bears are not found throughout much of this area may relate to poor habitat quality or historical hunting pressures. A line of reasoning that supports the historical hunting pressure argument is an increase in reports of black bears in areas in northwestern Taylor County recently brought into public ownership (J. Wooding pers. comm.). Pearson (1954) also suggested that hunting pressures contributed to the elimination of black bears in Levy County. A line of reasoning that supports the habitat-quality argument is that the population in and around Chassahowitzka National Wildlife Refuge (Citrus and Hernando counties) was also subjected to heavy hunting pressures in the past and yet managed to persist.

Conservation areas in the Big Bend region encompass a small portion of available bear habitat. The combination of the Lower Suwannee River National Wildlife Refuge, Manatee Springs State Park, and Andrews Wildlife Management Area provides a total of 172 km^2 (42,500 acres) of potentially high quality (index score > 7) black bear habitat along the Suwannee River. To the north and west of these public tracts lies the archipelago of public lands in the Big Bend Wildlife Management Area, which provides another 204 km^2 (50,400 acres). The total acreage of potential habitat in this region with an index score > 5 is 5,947 km^2 (1,469,000 acres). This area appears capable of supporting a very large population of 297-594 black bears under proper management.

Another block of habitat known to support black bears occurs along the northern portion of Fisheating Creek in Glades County and extending north into Highlands County (Figure 55). Although the exact size and distribution of this population is difficult to estimate, we estimate a total of 584 km^2 (144,250 acres) of black bear habitat lies between the Archbold Biological Station and Webb Wildlife Management Area (Figure 55). An estimated 120 km^2 (29,640 acres) occurs in the remaining portions of Glades and Highlands counties. Black bears have been recorded moving into this area from the Big Cypress region (Maehr et al. 1988). This linkage would be maintained by the Strategic Habitat Conservation Area proposed for the Florida panther (Section 6.2.14), and more information on the bear population inhabiting this area is needed.

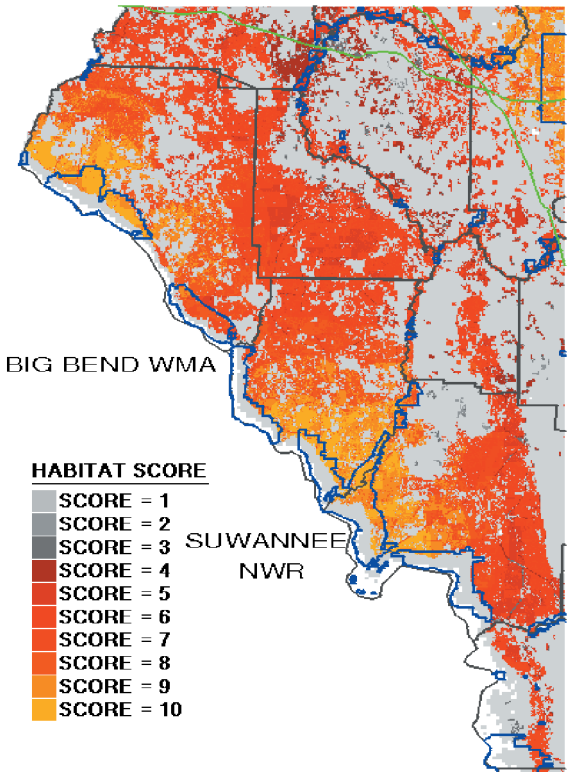


Figure 54. Potential black bear habitat in and around the Big Bend region.

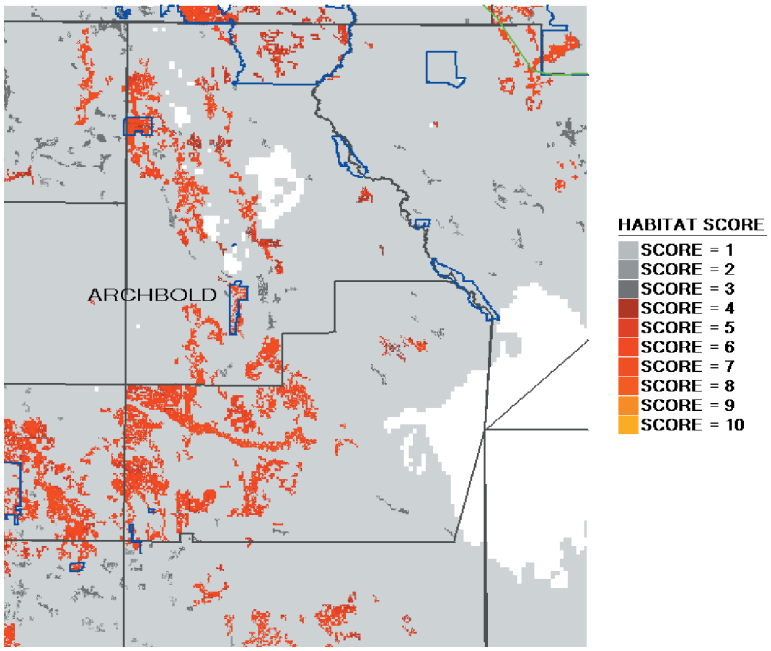


Figure 55. Potential black bear habitat in Highlands and Glades counties.

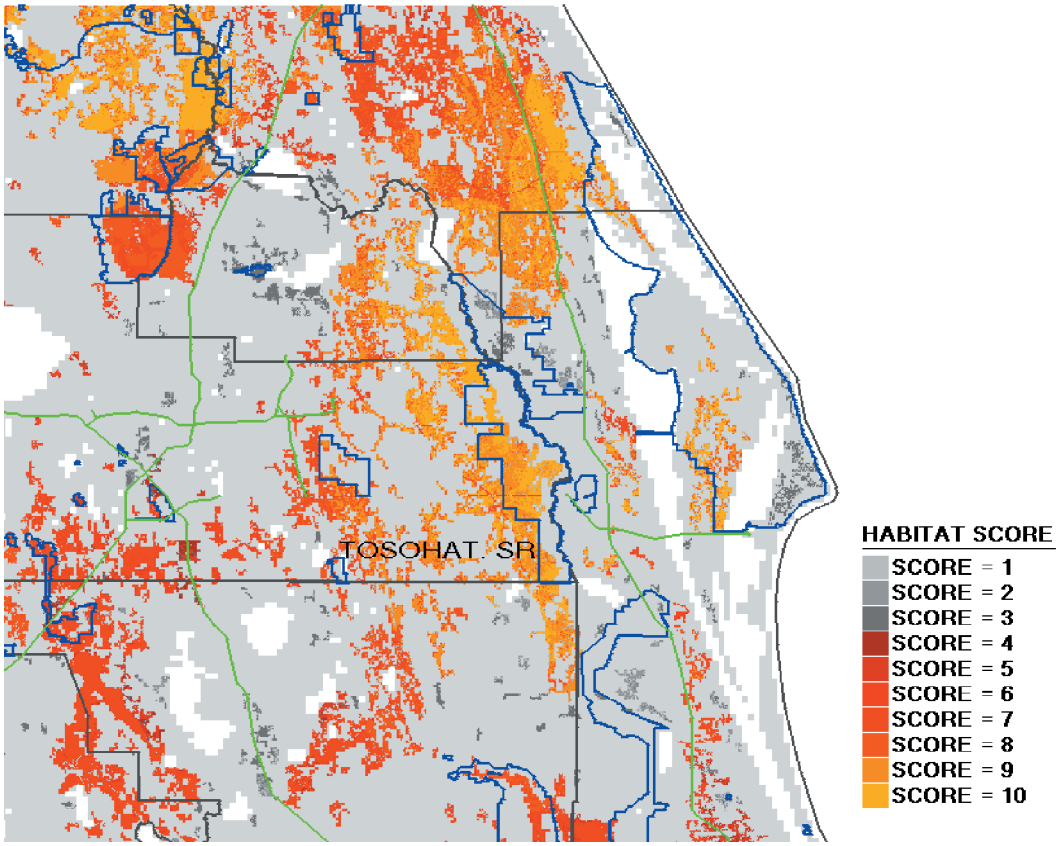


Figure 56. Potential black bear habitat in and around the Tosohatchee State Reserve.

The Tosohatchee State Preserve, St. Johns National Wildlife Refuge, and surrounding areas are thought to support a small black bear population (Figure 56). The total contiguous acreage on these conservation areas is roughly 93 km^2 (23,000 acres), which would support 5-10 black bears. This population is too small to persist for more than a few decades even under the best of conditions. However, the population may currently be part of a larger population that extends along the St. Johns River and into forested areas in Volusia, Brevard, Flagler, and St. Johns counties (e.g., Spruce Creek Swamp). The areas in Volusia, Brevard, Flagler, and St. Johns counties are contiguous to the Ocala National Forest (see discussion of Ocala National Forest).

Another area of frequent black bear sightings is the Durbin Swamp and Twelvemile Swamp area of St. Johns and Duval counties (Figure 57) near St. Augustine. The area east of Interstate 95 provides approximately 376 km^2 (92,870 acres) of black bear habitat. The area west of Interstate 95 is part of the large block of habitat described for Volusia, Brevard, St. Johns, and Flagler counties (see discussion of Ocala National Forest). The habitat base to the east of Interstate 95 is not capable of sustaining a population for an extended period of time, so the maintenance of this population will require occasional immigrants from nearby populations. Black bears have been recorded moving into the vicinity of Durbin and Twelvemile swamps from the Ocala National Forest, but Interstate 95 may limit the number of dispersing bears that actually reaches the Durbin and Twelvemile swamp area.

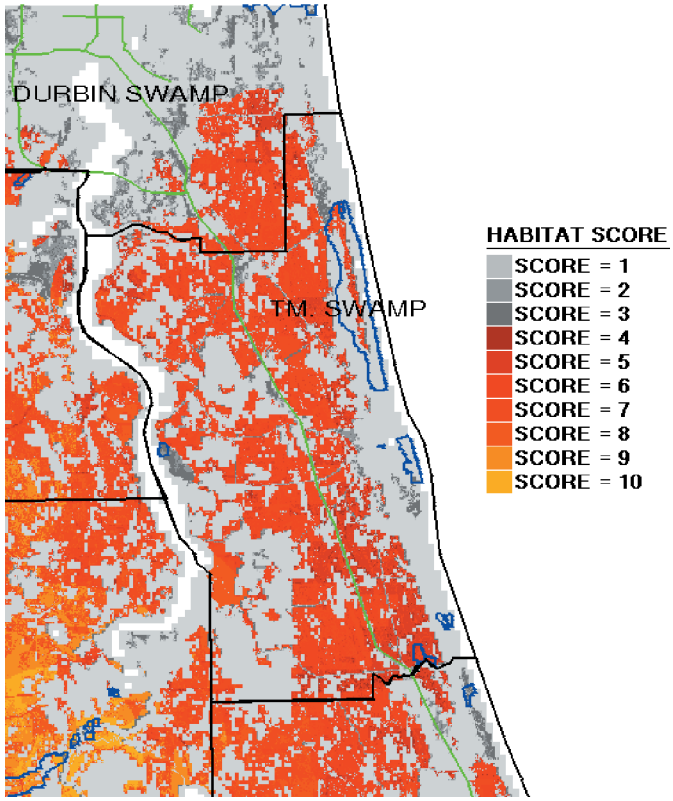


Figure 57. Potential black bear habitat in and around Durbin Swamp and Twelvemile Creek in St. Johns and Duval counties.

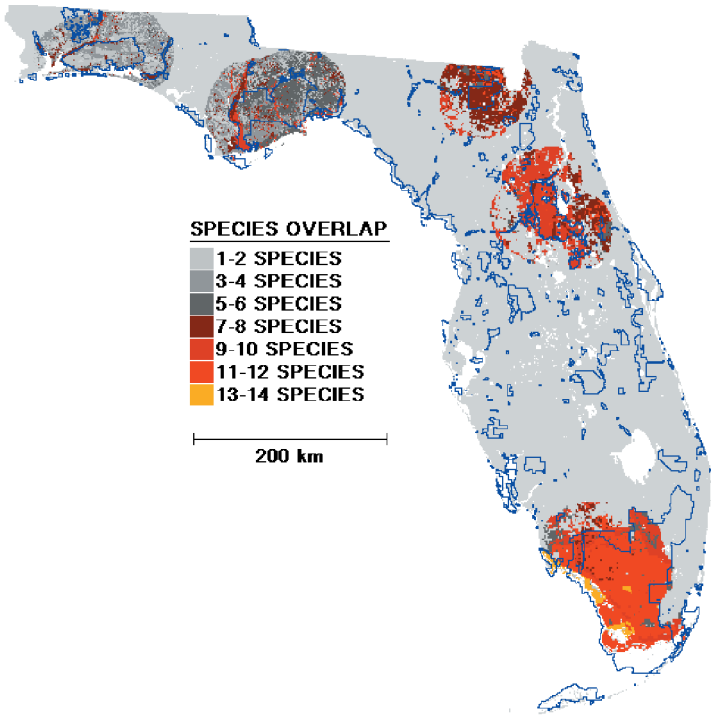


Figure 58. Combined gap analysis maps for 120 species (see Section 6.3.9) restricted to the potential black bear habitat within 50 km of existing conservation areas with stable black bear populations.

Proposed Strategic Habitat Conservation Areas for Black Bears

Acquisition of the black bear habitat described in the preceding pages could easily consume all funds available for land acquisition over the next 10 years. The fact that land acquisition funds are limited necessitates a careful evaluation of each area to determine which are most essential to black bear conservation efforts and also help to protect other rare species. The fact that black bear habitat requirements do not overlap with some of the other rare species analyzed must also be kept in mind since there are definite limits to the funding available for land conservation efforts.

An initial ranking of minimum habitat conservation areas sought for black bears should be based simply on the presence of stable, documented populations. As noted above, blocks of potential habitat in the southern portion of the Big Bend region, Blackwater River State Forest, and elsewhere are not known currently to support stable black bear populations. Potential habitat in and surrounding these areas must be relegated to a lower priority in comparison to the habitat areas surrounding other publicly held lands where black bears occur regularly.

The chances of an area supporting a stable population without recurring immigration is another criterion that should be used to evaluate minimum habitat conservation priorities. The level of immigration required to sustain some of the smaller populations described may be achieved through the establishment of habitat corridors, but required immigration rates may also be higher than habitat corridors alone can provide (see Section 6.1). The small populations described for Chassahowitzka National Wildlife Refuge, Durbin and Twelvemile swamps, Green Swamp, and other areas would also require major new land conservation efforts in order to provide a sufficient habitat base to sustain these populations for acceptable lengths of time.

For the remaining populations, the presence of other valuable natural resources can help to evaluate the importance of black bear conservation efforts to other species. Figure 58 shows the overlap of potential black bear habitat within 50 km of major conservation areas (Figure 46) with the gap analysis map for 120 rare taxa. The gap analysis map was created by overlaying potential habitat maps developed for 120 species (see Section 6.3.4) and provides a coarse indication of species-rich areas. Some of the larger areas with high species richness that also coincide with potential black bear habitat conservation areas occur north of Big Cypress National Preserve and north of Ocala National Forest.

Another type of evaluation is to consider records of plants and animals stored by the Florida Natural Areas Inventory and Nongame Wildlife Program Wildlife Observation database that occur near the major public land holdings with stable black bear populations. Table 9 provides occurrence records on private lands within 10 km of these existing large habitat conservation areas. Whether all of these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments. However, the large number of records (Table 9) for habitat areas surrounding the Big Cypress National Preserve, Ocala National Forest, Apalachicola National Forest, and Eglin Air Force Base provide a good indication of the importance of these areas to black bears and other rare species. Large-scale habitat conservation measures in these areas would help to maintain viable populations of black bears and conserve many other important natural resources.

Table 9. Rare species recorded in the Strategic Habitat Conservation Areas proposed for Florida black bear. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

BIG CYPRESS STRATEGIC HABITAT AREA

Birds
Crested caracara
Southern bald eagle
Wood stork
Little blue heron
Tricolored heron
Snowy egret
Great egret
Florida scrub jay

Reptiles
Eastern indigo snake
Gopher tortoise

Plants
Night-scented orchid
Ghost orchid
Cow-horned orchid
Tiny orchid
Fuch's bromeliad
Delicate ionopsis
Florida lantana
Carter's large-flowered flax
Pineland jacquemontia
Twinberry
Narrow-leaved caroline
Bird's nest spleenwort
Tampa vervain
Coastal vervain

OCALA STRATEGIC HABITAT AREA

Birds
Great egret
Bald eagle
Osprey
Florida scrub jay
Florida sandhill crane

Reptiles and Amphibians
Short-tailed snake
Eastern indigo snake
Gopher tortoise
Flatwoods salamander

Fish and Invertebrates
Snail bullhead
Dusky shiner
River goby
Seminole spring snail

Plants
Florida willow
Florida mountain-mint
Nodding pinweed
Large-flowered rosemary
Lake-side sunflower
Scrub bay
Fall-flowering ixia
Scrub holly

OSCEOLA STRATEGIC HABITAT AREA

Birds
Great egret
Little blue heron
Wood stork
Snowy egret

Amphibians and Reptiles
Carpenter frog
Many-lined salamander
Gopher tortoise
Canebrake rattlesnake

Fish
Eastern mudminnow
Blackbanded sunfish

Plants
Hartwrightia

APALACHICOLA STRATEGIC HABITAT AREA

Birds
Great egret
Osprey
American swallow-tailed kite
Southern bald eagle
Bachman's sparrow

Amphibians and Reptiles
One-toed amphiuma
Flatwoods salamander
Apalachicola kingsnake
Gopher tortoise
Eastern indigo snake
Spotted turtle
Florida pine snake
Apalachicola dusky salamander

Fish
Grayfin redhorse
Atlantic sturgeon
Spotted bullhead

Plants
Yellow fringeless orchid
Southern red lily
Apalachicola dragon-head
Baltzell's sedge
Scare-weed
Wiregrass gentian
Spoon-leaved sundew
Violet-flowered butterwort
Large-flowered grass-of-parnassus
Carolina grass-of-parnassus
Florida bear-grass
Chapman's butterwort
Chapman's crownbeard
White birds-in-a-nest
West's flax
Thick-leaved water-willow
A meadowbeauty
Curtiss' loosestrife
Corkwood
Pondspice

EGLIN STRATEGIC HABITAT AREA

Mammals
Round-tailed muskrat

Amphibians and Reptiles
Flatwoods salamander
Florida bog frog
Pine barrens treefrog
Alabama map turtle

Fish
Florida logperch
Bluenose shiner
Florida chub
Cypress darter

Plants
Panhandle lily
Curtiss' sandgrass
Pineland hoary-pea
White-top pitcher-plant
Sweet pitcher-plant
Ashe's magnolia
Pyramid magnolia
Chapman's crownbeard
Chapman's butterwort
Perplicata roundlake
Fuzzy pigtoe
Clench's elimia
Wiregrass gentian

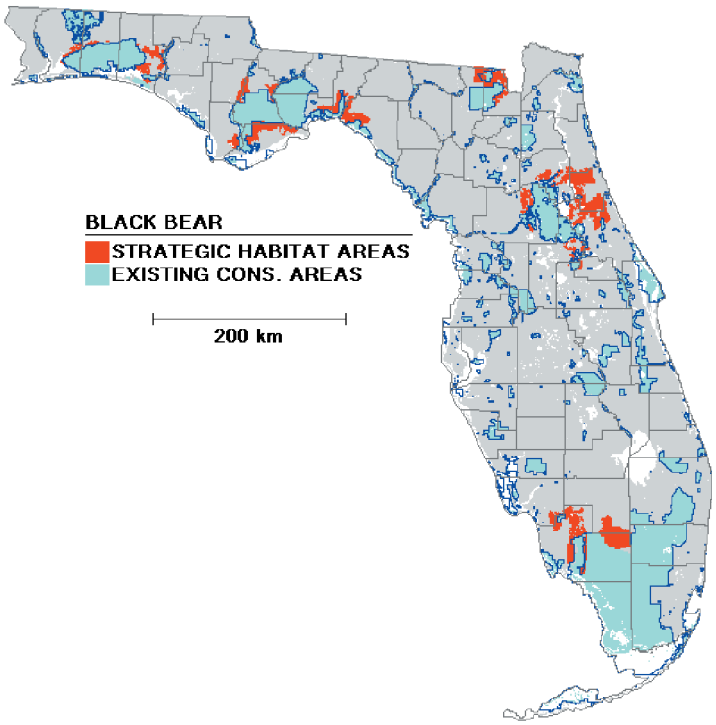


Figure 59. Proposed Strategic Habitat Conservation Areas for the Florida black bear.

Based on these overlays and analyses, we developed the following minimum habitat conservation goals for black bear populations in Florida.

1. Black bear habitat around the Big Cypress National Preserve appears to be of potentially greatest importance to black bears and many other rare species. Conservation of habitat areas north of current conservation lands would benefit species such as Florida panther, wood stork, Florida sandhill crane, American swallow-tailed kite, Audubon's crested caracara, and possibly some of the other species listed in Table 9. This subtropical region also represents a unique environmental setting for black bear populations in the southeastern United States. A conservation area of 1,655 km^2 (282,100 acres) is proposed for this area (Figure 59) that will increase the quantity of managed black bear habitat to 2,797 km^2 (690,820 acres). Note that much of the area shown to the northeast of the Big Cypress National Preserve has recently been brought into public ownership.

2. Conservation of black bear habitat areas around the Ocala National Forest would also provide multiple benefits. Unprotected lands adjacent to the Wekiva River south of the Ocala National Forest are important to several species of wading birds, Florida scrub jay, limpkin, American swallow-tailed kite, and possibly some of the other species listed in Table 9. Conservation of areas north of Ocala National Forest would protect xeric upland communities that provide habitat for Florida pine snake, southeastern kestrel, gopher tortoise, and others (Table 9). The forested areas lying between Crescent Lake and Palatka constitute a valuable documented dispersal corridor that currently is used by black bears moving between the Ocala National Forest and forested areas in St. Johns, Volusia, Flagler, and Brevard counties. The conservation of forested lands in St. Johns, Volusia, Flagler, and Brevard counties is needed as well as the conservation of this corridor. The habitat conservation area developed for this region (Figure 59) totals 2,773 km^2 (684,930 acres) and also may provide habitat for some of the species listed in Table 9.

3. Forested habitat north of the Osceola National Forest serves as a corridor to the Okefenokee National Wildlife Refuge and helps to enhance the security of one of Florida's smaller managed black bear populations. Forested wetlands in this area are also potentially important to several species of wading birds, bobcat, wild turkey, and some of the species listed in Table 9. The scarcity of both roads and humans also makes this area especially appropriate for black bear management. A Strategic Habitat Conservation Area (Figure 59) encompassing an additional 404 km^2 (100,000 acres) of habitat is proposed for this area. The total acreage of potential black bear habitat included in this Strategic Habitat Conservation Area and in existing conservation lands is 3,080 km^2 (761,000 acres), which we estimate will support 154-308 breeding individuals.

4. There are also scattered areas of potential importance in and around the Apalachicola National Forest. Areas immediately southwest of the Apalachicola National Forest and along the Apalachicola River are extremely important to American swallow-tailed kite (see Section 6.2.3), several rare wading birds, and some of the rare species listed in Table 9. This area also may support a number of endemic species of plants that are not well represented in current conservation areas in Florida (Section 6.3.1). Areas to the north of the Apalachicola National Forest also sustain several endemic species (Muller et al. 1989) (Table 9). Black bear habitat near the Wacissa and Aucilla rivers is part of the Strategic Habitat Conservation Area recommended for the American swallow-tailed kite (Section 6.2.3). This area is also of potential

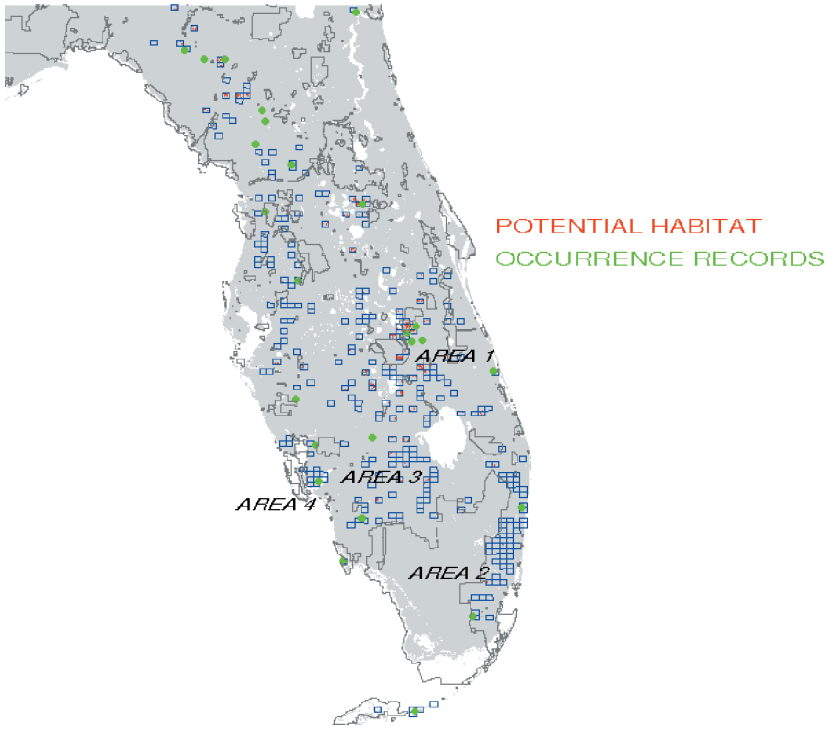


Figure 60. Habitat distribution map and occurrence records for the Florida burrowing owl.

importance to limpkins (Section 6.2.20) and other species listed in Table 9. A Strategic Habitat Conservation Area (Figure 59) encompassing an additional 971 km^2 (240,000 acres) is proposed for this area. The total area of potential habitat in existing conservation lands and these proposed Strategic Habitat Conservation Areas is 3,823 km^2 (944,281 acres), which would sustain an estimated 190-380 black bears.

5. Occupied black bear habitat immediately to the north of Eglin Air Force Base supports several rare amphibians and plants, including the bog frog, pine barrens treefrog, panhandle lily, and potentially some of the other species listed in Table 9. The occupied habitat immediately to the east of Eglin is important to endemic species of fish and some of the species listed in Table 9. A conservation area (Figure 59) encompassing an additional 575 km^2 (142,025 acres) is proposed for this area. The total area of potential habitat proposed for this black bear Strategic Habitat Conservation Area is 3,087 km^2 (762,640 acres), which would sustain an estimated 150-300 black bears.

All five of these areas are of great importance to black bear conservation and the conservation of other natural resources. Conservation and management of black bear habitat, perhaps more than the other species discussed, may entail a range of land-use activities. Preservation (fee-simple acquisition) should be used to conserve those habitat areas important to both black bears and to other rare species less tolerant of a wide range of land uses, while conservation (e.g., conservation easements) could be pursued elsewhere to maintain the forested conditions preferred by bears while also allowing private land uses. Within proposed conservation areas, commercial timber operations and grazing can be maintained, but all activities must be carefully evaluated since large-scale habitat changes may displace black bears (Pelton 1985, Weaver et al. 1990, Hellgren et al. 1991, Wooding et al. 1992). Land-use practices should perpetuate the "remote" quality of areas that black bears seek. More specific management recommendations for conservation areas have been outlined by Pelton (1985), Hillman and Yow (1986), and Weaver et al. (1990).

Section 6.2.12. Florida Burrowing Owl

The map of potential burrowing owl habitat was created by establishing a small-radius circle (250 m) around occurrence records stored in the Florida Natural Areas Inventory database. Breeding bird atlas blocks where burrowing owls were reported as "probable" or "confirmed" breeders (Kale et al. 1992) were also used. We isolated the dry prairie land cover within these atlas blocks. The map of potential burrowing owl habitat (Figure 60) shows small patches of potential habitat in very few areas of the state. Burrowing owl habitat is much more common than depicted here because ruderal areas that sustain burrowing owls cannot be identified from the land-cover map. The largest remaining patches of "natural" burrowing owl habitat occur along the Kissimmee River.

The greatest apparent concentration of "natural" burrowing owl habitat on conservation areas occurs along the Kissimmee Prairie region and includes Avon Park Air Force Range, Audubon Kissimmee Prairie Preserve, Arbuckle State Forest, and Three Lakes Wildlife Management Area. Outlining additional protection options for this species is problematic due to the difficulty in identifying appropriate habitat conditions, a lack of information on dispersal capabilities and population demographics, and a lack of knowledge on the density of territories in various habitat conditions.

However, by combining breeding bird atlas and Florida Natural Areas Inventory data onto a single map (Figure 60), some potentially important areas outside the current system of conservation areas stand out.

The concentration of occurrence records surrounding the Avon Park Air Force Range (Area 1, Figure 60) implies a sizeable population in this region, yet there are few records shown specifically within this conservation area. The area between Avon Park Air Force Range and Lake Kissimmee shows several atlas records and contains several patches of native dry prairie, while the area between Avon Park Air Force Range and Three Lakes Wildlife Management Area also shows a concentration of breeding bird atlas records and Florida Natural Areas Inventory records. If burrowing owl dispersal distances are on the order of 5-15 km, this region could be considered one large population.

A concentration of occurrence records in southeast Florida along the Miami Ridge (Area 2, Figure 60) implies a sizeable owl population on agricultural lands in this area. This population is confronted by a burgeoning urban environment, and more specific conservation plans must await better information on habitat use and distributions in this area.

There are also concentrations of records of burrowing owls on agricultural lands to the west, northwest, and southwest of Lake Okeechobee (Area 3, Figure 60). Many remnant patches of prairie habitat in these areas warrant consideration for conservation. Conservation of rangeland within this general area would also benefit burrowing owls. An apparently large, unprotected population of owls also inhabits west central Lee County and Charlotte County (Area 4, Figure 60). The population in Lee County occurs largely on Cape Coral and has been the subject of an ongoing survey program (Millsap and Bear 1989).

No specific habitat conservation recommendations were developed for burrowing owls because of the difficulty of identifying appropriate ruderal habitat areas. We believe the conservation recommendations developed for other species (e.g., Audubon's crested caracara, sandhill crane, and Florida grasshopper sparrow) will, to a large extent, also benefit burrowing owls.

Section 6.2.13. Florida Grasshopper Sparrow

Delany et al. (1985) and Delany and Cox (1986) found 182 Florida grasshopper sparrows at nine sites. The largest protected populations occur on Avon Park Air Force Range and Three Lakes Wildlife Management Area, which each have > 50 breeding pairs (Delany 1993). The Audubon Prairie Preserve in Okeechobee County also supports a breeding population of Florida grasshopper sparrows and contains sufficient habitat to support a large population. Results from Florida's breeding bird atlas project (Kale et al. 1992) and additional surveys by Delany (1993) added only a few new locations to the above list. The information provided through these surveys lead us to conclude that Florida grasshopper sparrows currently lack the habitat base desired for long-term security.

Identifying appropriate grasshopper sparrow habitat was difficult using the Landsat cover map exclusively. The dry prairie land-cover class often includes areas with widely spaced pine trees, and such areas are not usually inhabited by grasshopper sparrows. We refined our map of potential habitat in several ways. First, we digitized all locations where grasshopper sparrows were reported by Delany and Cox (1986) and Delany (1993). We also isolated dry prairie land cover in breeding bird atlas blocks where grasshopper sparrows were recorded, with the additional condition that prairie land cover be at least 0.1 km away from other forested land-cover types. This distance was based on recommendations provided by M. Delany (pers. comm.). Finally, we obtained additional information on grasshopper sparrow locations in Okeechobee County (R. DeLotelle pers. comm.).

These data sets (Figure 61) point to an extremely limited number of options available for this species. The only large blocks of grasshopper sparrow habitat not known to occur within current conservation areas are in Desoto, Glades, Osceola, Okeechobee, and Highlands counties. The area between Avon Park Air Force Range and Florida Audubon Society Prairie Preserve (Figure 61) contains several important blocks of unprotected or restorable habitat. Other blocks of potential habitat on private lands occur north and west of Lake Okeechobee (as indicated by two occurrence records) and in southeastern Desoto County. There is likely more habitat in these areas than shown, but lack of access has prevented collection of additional information (Delany 1993).

The recovery plan adopted for Florida grasshopper sparrow by the U.S. Fish and Wildlife Service (1988) recommends conserving sufficient habitat to support a minimum of 10 populations consisting of at least 50 breeding pairs. This is consistent with the general conservation goals outlined in Section 5.3. Based on territory sizes estimated by Delany (1993), each of these populations would require > 600 ha (1,482 acres) of appropriate habitat. Conservation of appropriate habitat on private lands within the general regions shown in Figure 62 represents a top priority in efforts to maintain this species in Florida. These areas are proposed as Strategic Habitat Conservation Areas for the Florida grasshopper sparrow (Figure 62).

There is a need to augment Florida grasshopper sparrow populations on Florida's conservation areas through habitat management and restoration and, perhaps, population reintroduction. Restoration of rangeland and dense, unburned scrub areas to native dry prairie land cover on existing conservation areas (Delany 1991) is a research project that warrants special attention. Conservation areas that occur within the historic range reported by Delany and Cox (1986) should be evaluated for their potential to support Florida grasshopper sparrows.

Section 6.2.14. Florida Panther

The Florida panther population is estimated at 30-50 adults and occupies a limited area of southwest Florida (Belden 1989). Home range sizes in panthers average about 550 km^2 (135,850 acres) for males and 300 km^2 (74,100 acres) for females (Maehr 1987, Belden 1989). Home range size relates to habitat quality, prey abundance, and other factors (Maehr 1987, Belden 1989). Maehr (1987) estimated a density of 1/110 km^2 (1/42 mi^2) based on home range information from south Florida, and we used a density of 1 panther/110 km^2 (1/42 mi^2) to develop habitat conservation strategies for this species.

Our generalized population viability model for Florida panthers indicates that a population of about 50-70 would have a good chance of persisting for at least 200 years under favorable management conditions. This estimate agrees with recommendations made to the Florida Panther Interagency

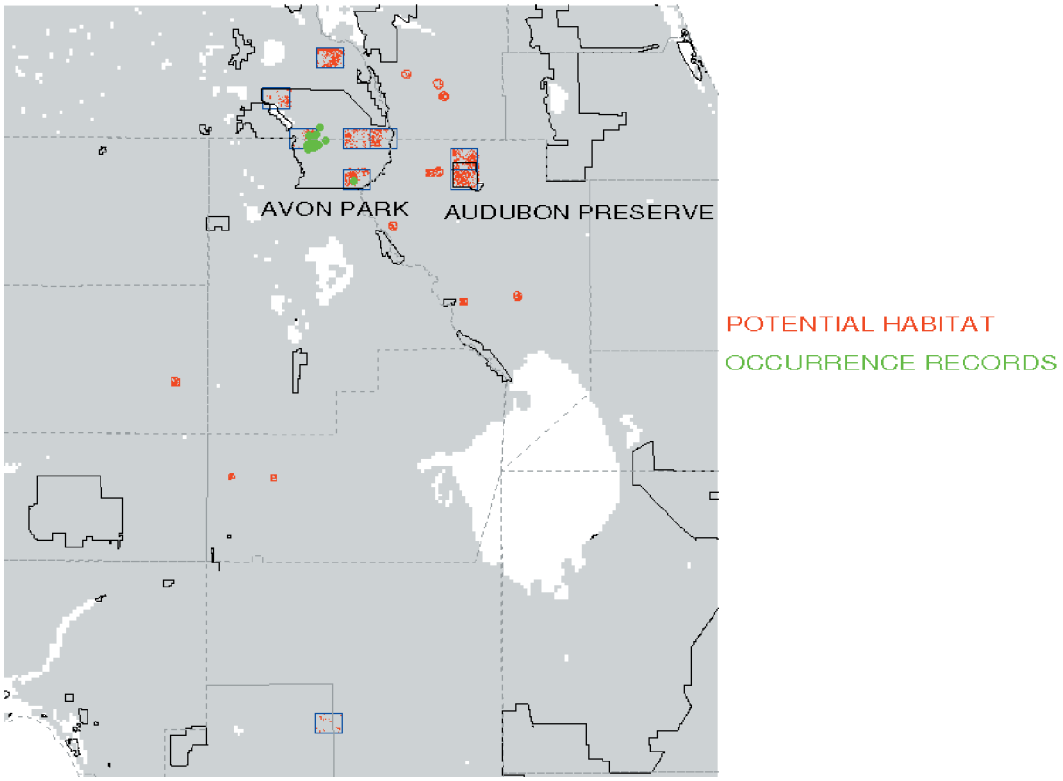


Figure 61. Habitat distribution map and occurrence records for the Florida grasshopper sparrow.

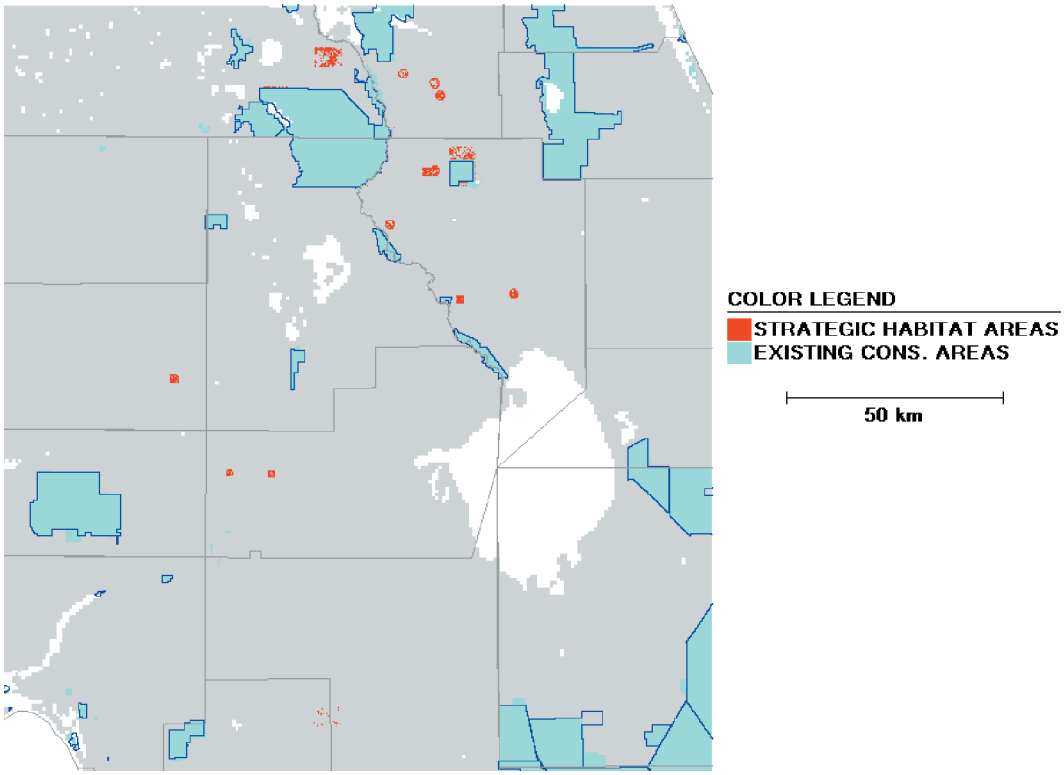


Figure 62. Proposed Strategic Habitat Conservation Areas for the Florida grasshopper sparrow.

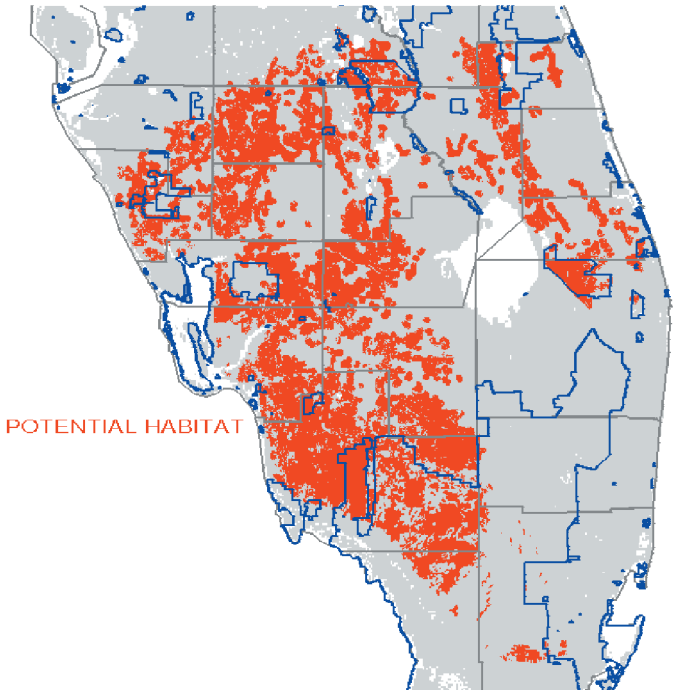


Figure 63. Potential Florida panther habitat in southwest Florida.

Advisory Committee (Ballou et al. 1989) as well as an independent estimate developed for cougar populations in California (Beier 1993). A single secure population of panthers thus might require as much as 8,100-16,200 km^2 (2-4 million acres) of habitat.

Although the current population of Florida panthers found in southwest Florida is viable, the population is by no means adequately represented on conservation lands in the region. Maehr (1990) estimates that current conservation areas could support only 18-24 panthers. Conservation of additional habitat areas is needed to place the size of the manageable population within the range needed for long-term survival.

Belden et al. (1988) and Maehr et al. (1991) found that panthers inhabited a landscape consisting of large patches of hardwood hammock, pineland, hardwood swamp, and cypress swamp cover types. Large areas without roads, large public conservation areas, and large private land-ownership patterns are also important features of the landscapes occupied by panthers (Maehr et al. 1991, Belden and Hagedorn 1992). Intensive agricultural areas and barren land cover are not regularly used by Florida panthers (Maehr et al. 1991).

We developed qualitative scores for panther habitat based on the information presented in Belden et al. (1988) and Maehr et al. (1991). These analyses were restricted to the Treasure Coast, Southwest Florida, South Florida, Tampa Bay, East Central Florida, and Central Florida regional planning council areas where the core population occurs (Belden 1989, Maehr 1992). However, we also conducted a second analysis throughout the state to help determine suitable reintroduction areas.

We first established "preferred" and "secondary" habitat types using the land-cover map. Preferred land-cover types included pineland, hardwood hammock, and cypress swamp (Maehr et al. 1991). Secondary habitat types included hardwood swamp, dry prairie, oak scrub, and other cover types that may not be often used by panthers but appear to be important in determining the presence of panthers in an area (Maehr et al. 1991). We isolated patches of preferred land cover and eliminated patches that were smaller than 0.4 km^2 (100 acres) in size. We then added patches of "secondary" land cover and the smaller patches of preferred land cover occurring within 1 km of the edges of the larger patches of preferred land cover. These distance and patch size criteria were based on observations of occasional excursions of panthers outside of large, contiguous forest areas (D. Maehr pers. comm.)

We modeled panther avoidance of barren land cover (Maehr et al. 1991) by isolating individual patches of barren land and eliminating contiguous patches that were smaller than 0.4 km^2 (100 acres). We then eliminated preferred and secondary land cover that fell within 300 m of large ($\geq$ 0.4 km^2) patches of barren land cover. The distance of 300 m was arbitrarily selected, but it produced a conservative estimate of habitat distribution away from currently barren lands. The resulting map of potential habitat areas is shown in Figure 63.

We further refined this map of potential Florida panther habitat by evaluating patches of habitat in the context of other geographic features. First, we established a measure of the size of roadless patches and the composition of land-cover types within roadless patches. We cross-tabulated our map of potential panther habitat with our map of roadless patches (Figure 16). Roadless patches < 190 km^2 (46,720 acres), an approximate home range size for a female (Maehr et al. 1991),

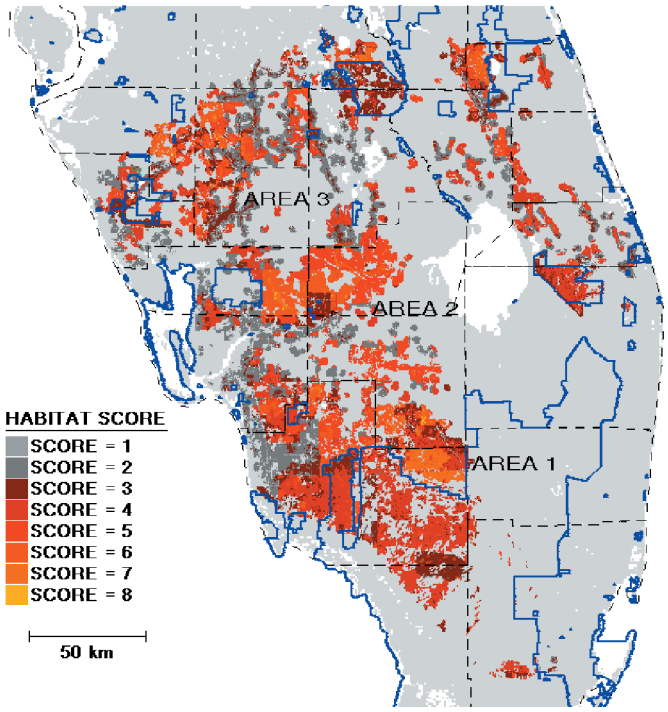


Figure 64. Qualitative measures of potential Florida panther habitat in southwest Florida.

were assigned a score of 1 regardless of the habitat composition within the patch. Roadless patches > 190 km^2 but containing < 15% of the preferred land-cover types were assigned a score of two. Patches > 190 km^2 and having at least 15% coverage of preferred land-cover types were assigned a score of 3.

Second, we established a qualitative measure for habitat based on the quantity and composition of land cover on private parcels. Parcels having < 100 km^2 (2,470 acres) of the preferred land-cover types were assigned a score of 1. Parcels having > 100 km^2 (2,470 acres) of preferred land cover but having less than a 15% coverage of preferred land-cover types were assigned a score of 2. Parcels having > 100 km^2 of preferred land cover and at least 15% of preferred land-cover types were assigned a score of 3.

Third, we established a qualitative score for patches of preferred forest cover based on patch size. Patches of preferred habitat at least 10 km^2 (2,470 acres) were assigned a score of 2, and patches smaller than 10 km^2 (but at least 0.4 km^2, see above) were assigned a score of 1.

We combined these maps to produce a composite map with scores ranging from 1-8 (Figure 64). The distribution of high-scoring habitat areas corresponded well with documented panther home ranges based on radio telemetry data (Maehr 1987) and field surveys of sign within the occupied range (Roof and Maehr 1988). The largest blocks of high-scoring land cover are found in Collier, Lee, Charlotte, Hendry, and Glades counties. Private lands immediately north and northwest of the Fakahatchee Strand State Preserve, Big Cypress National Preserve, and Florida Panther National Wildlife Refuge, together with lands within these preserves, formed the largest contiguous block of land cover with high index values (Area 1, Figure 64). Another large block of habitat with high index scores is found in western Glades and eastern Charlotte counties (Area 2, Figure 64) where frequent signs of panther have been reported (Roof and Maehr 1988).

Eastern Manatee and Sarasota counties and western Hardee and DeSoto counties also show high index scores (Area 3, Figure 64). No thorough survey information exists for this area, so the presence of a stable panther population is possible but unknown. There is also a wide break in the continuity of areas with high index scores in southeastern DeSoto County, and this break may represent an effective barrier to panther movements into the areas in eastern Manatee and Sarasota counties.

Another large region with high index scores occurs in southeast Polk, northeast Highlands, and northwest Okeechobee counties (Area 4, Figure 64). Credible signs of panthers have been reported in portions of this region in recent years (e.g., Layne and Wassmer 1988), but no survey has been attempted due to the difficulty of gaining access to large private lands. There is some break in the habitat between this area and the areas known to be occupied to the southwest, and recent conversion of large areas of suitable habitat to citrus production may have enlarged the gap in habitat continuity.

Private lands in southwest Florida are estimated to contain more than 50% of the occupied range of Florida panthers (Maehr 1990), and habitat quality on private lands is higher than habitat quality on public lands due to soil productivity and drainage characteristics. Conservation of a total of approximately 8,100 km^2 (2 million acres) is needed to achieve the conservation goals outlined here and elsewhere (Maehr 1990). This area represented the extent of the range occupied by Florida panthers in south Florida in the late 1980's (Maehr 1990). Based on the high index areas shown

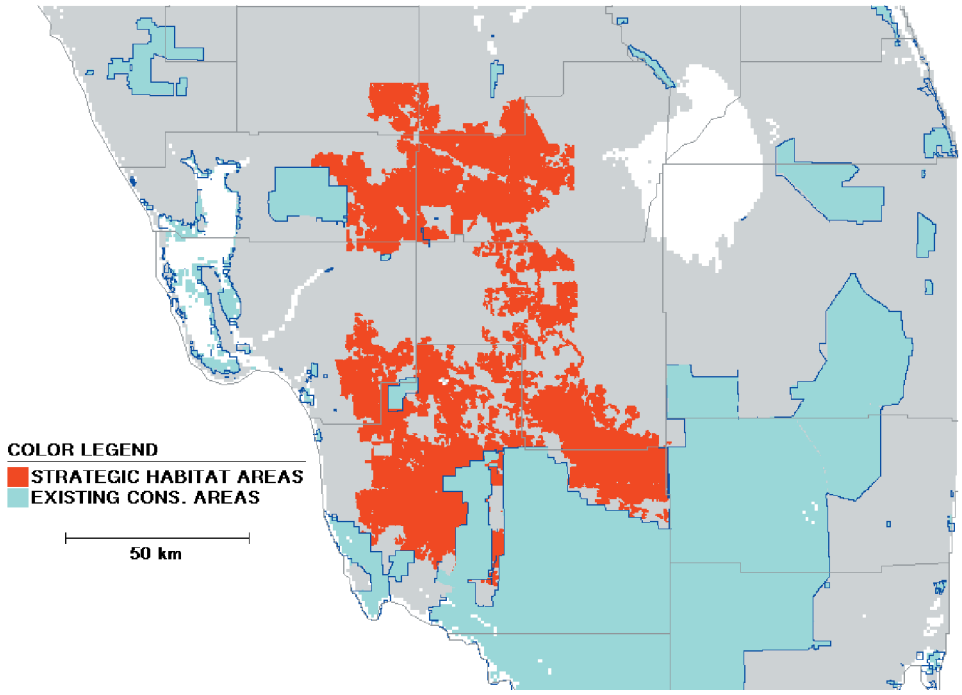


Figure 65. Proposed Strategic Habitat Conservation Area for the Florida panther.

in Figure 64 and the recommendation to conserve approximately 8,100 km^2 (2 million acres) of habitat, Figure 65 presents a proposed Strategic Habitat Conservation Area for the Florida panther that, in combination with existing conservation areas, encompasses most of the radio telemetry locations and includes most of the areas with high index scores. The potential panther habitat on private lands in this area totals 6,480 km^2 (1.6 million acres).

Conservation of panther habitat within this proposed management zone is critical to maintaining the south Florida panther population (Maehr 1990) and will also help to protect many other rare species. This area provides habitat for other species, such as black bear (Section 6.2.11), Florida sandhill crane (Section 6.2.15) and Audubon's crested caracara (Section 6.2.5), that lack an adequate habitat base in current conservation areas. A listing of rare plants and animals recorded within the proposed panther habitat conservation areas by the Florida Natural Areas Inventory and Nongame Wildlife Program Wildlife Observation databases are provided as Table 10. Whether these species benefit from the proposed habitat conservation areas depends on more specific habitat assessments.

This large management zone should be conserved primarily using conservation easements and other land-use agreements with fee-simple acquisition being an alternative in selected cases. Conservation programs that maintain suitable habitat conditions on private properties are badly needed (Maehr 1990), and the Florida Panther Interagency Technical Advisory Committee has developed a habitat conservation plan for Florida panthers that is consistent with the goals outlined here.

The threats facing Florida panthers require quick and aggressive actions if panthers are to be saved from extinction. The situation may seem desperate given the magnitude of the many problems described (Belden 1989), but the situation is far from hopeless if quick actions are taken. Other wildlife species reduced to population sizes comparable to those of the Florida panther have rebounded to more stable levels over time (Bonnell and Selander 1974, Ballou et al. 1989). A very encouraging sign comes from the fact that demographic and behavioral characteristics of Florida's panther population are similar to those of western cougars (D. Maehr pers. comm.). Even though the effective population size of Florida panthers has probably numbered only a score of individuals (or fewer) for many generations and the population is doubtlessly highly inbred, only recently has inbreeding apparently begun to affect survival and reproductive capabilities to the point that it is now believed to present a problem.

One of the greatest threats to the continued existence of panther habitat in south Florida is conversion of large areas of rangeland and native land cover to agriculture (Maehr 1990). Citrus acreage in southwest Florida has doubled from roughly 300 km^2 (74,100 acres) to 600 km^2 (148,200 acres). Surface water permits for citrus have been considered or issued for 902 km^2 (222,800 acres) in Lee and Collier counties by the South Florida Water Management District (Pearlstine and Kitchens 1992). Approximately 308 km^2 (76,080 acres) of the proposed Strategic Habitat Conservation Area for the Florida panther lie within areas considered for permits (Figure 66). Most of the areas where permits have been considered lie northeast of Immokalee, along Collins Slough and Camp Keais Strand (Figure 66). As shown in Figure 66, continued expansion of citrus areas could effectively subdivide the proposed panther habitat conservation area. Conserving the habitat areas south of the Caloosahatchee River in Hendry and Collier counties (e.g., between Devil's

Table 10. Species recorded within the Strategic Habitat Conservation Areas proposed for Florida panther. Whether these species actually benefit from proposed habitat conservation areas will depend on more detailed habitat analyses.

Birds	*Amphibians and Reptiles*	Edison's ascyrum
		Pineland jacquemontia
Great egret	Gopher frog	Ashe's savory
Snowy egret	Gopher tortoise	Scrub bay
Little blue heron	American alligator	Twinberry
Tricolored heron	Florida scrub lizard	Pygmy fringe-tree
White ibis	Sand skink	Hairy jointweed
Glossy ibis	Eastern indigo snake	Scrub plum
Wood stork	South Florida rainbow snake	Coastal vervain
Southern bald eagle		Tampa vervain
Short-tailed hawk		Florida lantana
Crested caracara	*Plants*	Britton's bear-grass
Florida sandhill crane		Powdery catopsis
Florida burrowing owl	Narrow-leaved caroline	Fuch's bromeliad
Red-cockaded woodpecker	Wedge-leaved button-snakeroot	Cow-horned orchid
Florida scrub jay	Scrub holly	Night-scented orchid
Florida grasshopper sparrow	Curtiss' milkweed	Delicate ionopsis
	Florida gay-feather	Tiny orchid
Mammals	Paper-like nail-wort	Ghost orchid
	Nodding pinweed	Bird's nest spleenwort
Florida black bear	Pine pinweed	
Florida panther	Highlands scrub hypericum	

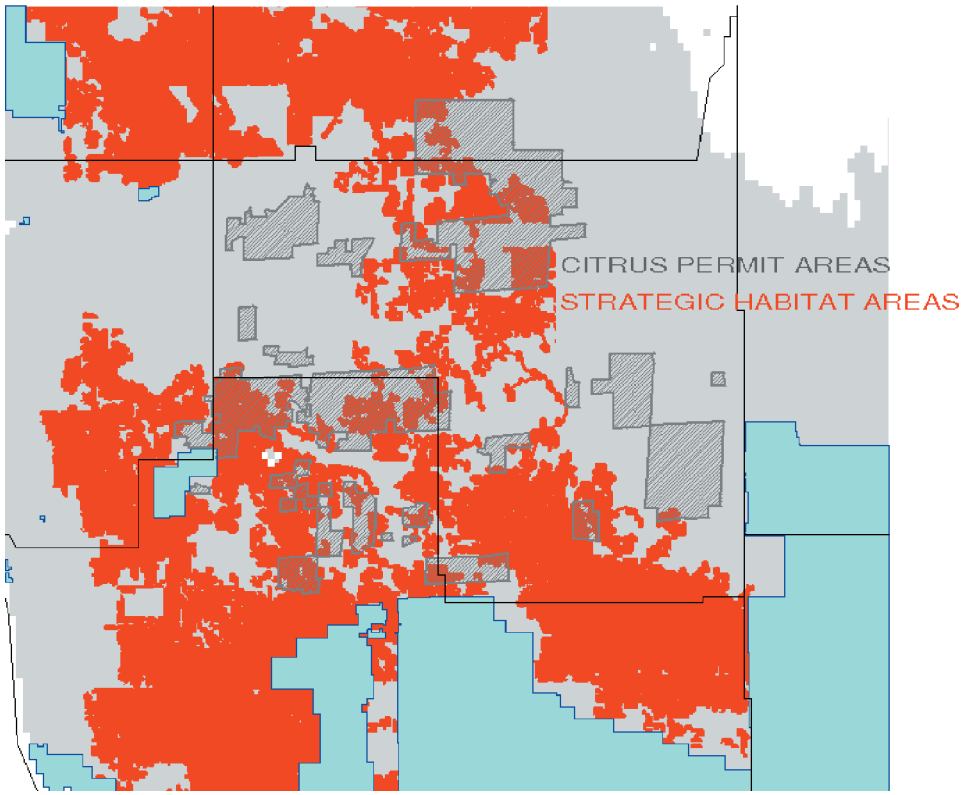


Figure 66. Surface water permit applications within the Strategic Habitat Conservation Areas proposed for the Florida panther.

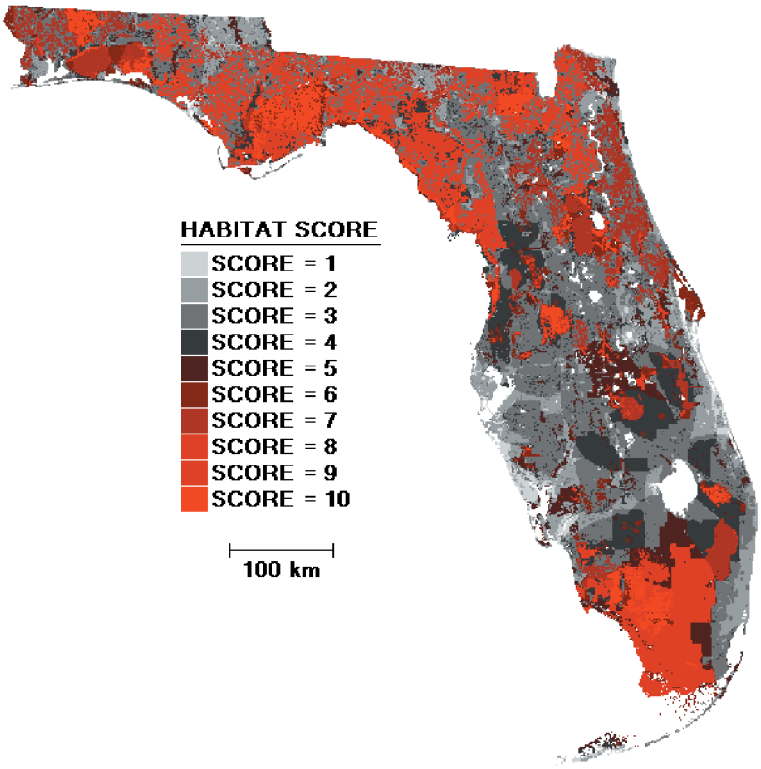


Figure 67. Qualitative measures of potential reintroduction areas in Florida for the Florida panther.

Garden and Keri and around Collins Slough, Okaloacoochee Slough, Wild Cow Island, Grassy Marsh, and Graham Marsh) is critically important. Patches of prairie and pineland in a triangle north of the Caloosahatchee River defined by Palmdale, Ortona, and Lake Hicpochee may also be important to panther conservation.

Although addressing the habitat conservation, genetic, and human-related problems within the proposed habitat conservation area are the most important steps that can be taken to conserving a healthy population of Florida panthers, another pressing need is the establishment of additional populations elsewhere in the former range of the taxon. Epizootic diseases or other catastrophic events could quickly decimate the existing south Florida population (Ballou et al. 1989). Additional populations would also help to maintain higher levels of genetic diversity (Ballou et al. 1989).

Credible signs of Florida panthers have occurred in northeastern and central Florida in recent years, but it is not known if these sightings reflect the presence of a stable population. Areas where reintroduction of Florida panthers would likely be most successful are large forested areas with few roads, large conservation areas, and large private land holdings (Belden et al. 1986). We prepared maps reflecting these criteria to help identify where such areas occurred. First, we identified large public land holdings with at least 200 km^2 (50,000 acres) of upland forest cover and radiated out 50 km from these areas. This procedure emphasizes areas that are close to established conservation areas. Public lands with > 200 km^2 (50,000 acres) of upland habitat included Ocala, Osceola, and Apalachicola national forests; Eglin Air Force Base; Blackwater River State Forest; Camp Blanding Military Reserve; Avon Park Air Force Range; Cecil Webb and Green Swamp wildlife management areas; and Big Cypress National Preserve. Forest land cover within these buffer areas (and including cover within the conservation area) was assigned a value of 2, and all other land cover types that might be used by panthers were assigned a value of 1.

We next calculated an index score for roadless areas. Large roadless areas containing > 190 km^2 (50,000 acres) of forested land cover were assigned a value of 2, and all other roadless areas were assigned a value of 1. We also identified large landownerships with at least 40 km^2 (10,000 acres) of upland land cover and assigned these parcels a value of 2 and all other landownerships a value of 1. A final criterion used in this analysis was the number of occupied homes per county (Shermyen et al. 1991). In their review of panther reintroduction to the Osceola National Forest, Belden and Frankenberger (1988) stressed the importance of counties around the Osceola National Forest having densities of roughly 3 or fewer occupied housing units per km^2 (Shermyen et al. 1991). We used this variable as an index score for counties. Counties with < 4 occupied units/km^2 were given a value of 3; counties with 4-10 occupied units/km^2 were assigned a value of 2; and counties with > 10 occupied housing units/km^2 were assigned a score of 1.

Addition of these various maps produced a single map with index scores of 1-10 (Figure 67). Based on these criteria, it should be no surprise that the best potential reintroduction sites in Florida occur around the Osceola and Apalachicola national forests. These areas were recommended by Belden et al. (1986). The Florida Panther Recovery Plan (U.S. Fish and Wildlife Service 1987d) and the Florida Panther Viability Analysis and Species Survival Plan (Ballou et al. 1989) recommend establishment of six free-ranging populations that each contain a minimum of 50 adult animals. Florida appears to be capable of supporting at least three of these populations:

one in southwest Florida (currently occupied); one in the Okefenokee-Osceola region (currently unoccupied); and one in the Apalachicola region (currently unoccupied). Reintroduction experiments have been initiated (Belden and Frankenberger 1988) near the Osceola National Forest; however, no decision has yet been made to use the Apalachicola National Forest as a second reintroduction site.

The black bear management zones described in Section 6.2.11 will provide some of the habitat base needed for reintroduced populations of Florida panthers. However, still larger areas will be needed to provide an adequate base of habitat for a population of 50 panthers. We estimate that 4,000-6,000 km^2 are needed for secure panther populations, while our proposed black bear management zones are only about 2,400 km^2 in size.

If reintroduction of Florida panthers is determined to be feasible based on current experiments in north Florida, an expanded habitat conservation area incorporating the Osceola National Forest and Okefenokee National Wildlife Refuge may eventually be needed to support a population of panthers in this area. Figure 68 shows a hypothetical management zone for this area based on the distribution of major roads in the region rather than on a detailed analysis of habitat. This zone covers 4,800 km^2 and, based on data provided by Belden and Frankenberger (1988) and Maehr (1990), might support 30-60 panthers. Forty-seven percent of the area (2,257 km^2) is currently in private ownership. Cooperative management agreements and conservation easements need to be established among state, federal, and private landowners in this area. Areas warranting special attention are the ecotones between forested wetlands and neighboring pine flatwoods. These ecotones have been heavily used by western cougars serving as part of reintroduction experiments (Belden and Frankenberger 1988).

If reintroduction of Florida panthers in the Apalachicola National Forest is considered, a potential panther management zone such as shown in Figure 69 might be needed to sustain the population. This proposed management zone is based on the distribution of major roads in the area, and covers 5,350 km^2, of which 36% is in private ownership. The two habitat conservation areas shown for potential reintroduction sites are hypothetical and are not based on a detailed analysis of available habitat. The areas are not included in the final figure of Strategic Habitat Conservation Areas.

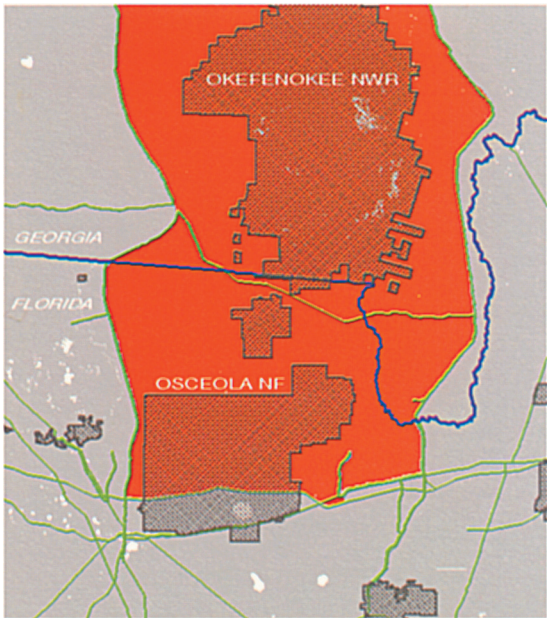


Figure 68. Potential habitat conservation area for the Florida panther in northeast Florida. These areas are not included in the final map of Strategic Habitat Conservation Areas.

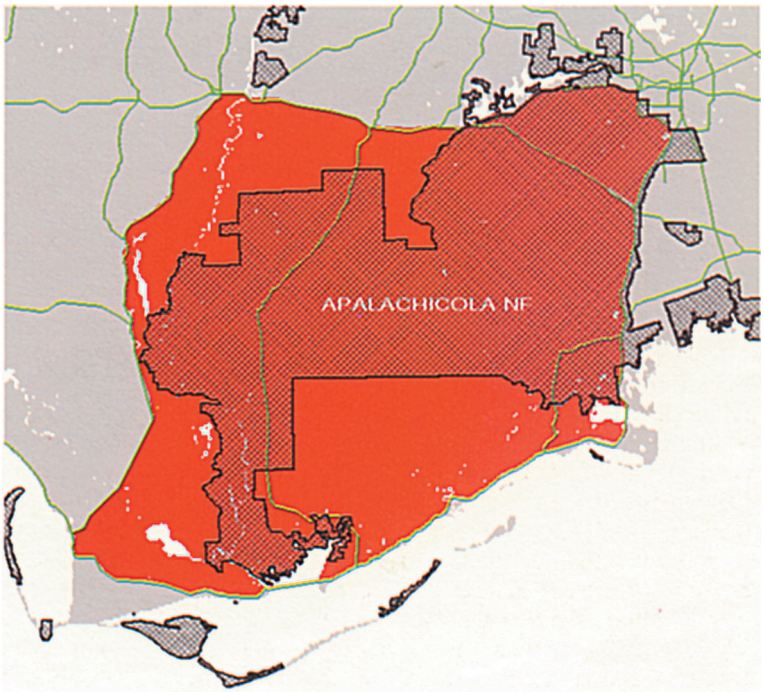


Figure 69. Potential habitat conservation area for the Florida panther in the panhandle. These areas are not included in the final map of Strategic Habitat Conservation Areas.

Section 6.2.15. Florida Sandhill Crane

Potential sandhill crane habitat was identified using the land-cover map, breeding bird atlas records, and three additional sources of information. One set of point data came from the Florida Natural Areas Inventory, which has processed records of approximately 40 sandhill crane territories and population centers. We digitized the polygons depicting large population centers as recorded by the Florida Natural Areas Inventory. A second set of information comes from Dwyer and Tanner (1992), who mapped sandhill crane territories in northern Polk County. A third set of occurrence information comes from a survey of sandhill crane territories in the Treasure Coast region (K. Atkins unpubl.). We created a large-radius circle (1 km) around these point data sets and isolated the dry prairie, grass and agriculture, shrub and brush, shrub swamp, and freshwater marsh land-cover types found within this 314 ha (775 acre) circle. We also isolated the dry prairie, grass and agriculture, and freshwater marsh land cover in the Florida Natural Areas Inventory polygons depicting population centers.

The breeding bird atlas data were handled in a different manner due to the coarser nature of these data. Within breeding bird atlas blocks where sandhill cranes were listed as "confirmed" or "probable" breeders (Kale et al. 1992), we identified edges between freshwater marshes and appropriate upland cover types. We grouped the dry prairie and grass and agriculture classes into a single broad class categorized as appropriate upland cover. Next, we radiated out 250 m from the identified edges and isolated the freshwater marsh, dry prairie, and grass and agriculture land cover occurring within this extended area. Sandhill cranes may venture farther away from the edge of a marsh than this model allows for, but the model does focus on the core areas closest to potential nesting sites. The habitat distribution map developed using these techniques (Figure 70) shows a concentration of potential habitat around the Kissimmee prairie region of central Florida. Smaller patches of potential habitat exist in north central Florida, but they are difficult to see at this small scale.

Sandhill crane habitat may be scattered over larger areas, so populations should be defined using higher levels of organization of smaller patches of appropriate habitat. Social interactions may also be an important component of sandhill crane biology (Walkinshaw 1976), and clusters of territories are generally needed to allow such interactions to occur. After the breeding season, for example, young cranes gather into small flocks that wander over large areas (Wenner and Nesbitt 1984). These flocks help birds locate new nesting areas and may serve other important yet unknown purposes (Wenner and Nesbitt 1984).

To estimate population sizes, we refined the initial map of potential crane habitat by considering information on sandhill crane home range and dispersal characteristics. We call the first level of organization (larger than an individual patch of habitat) a "neighborhood." Neighborhoods represent patches of habitat that might be frequently visited by resident cranes over an annual period. Adult sandhill cranes are relatively sedentary (Holt 1930, Walkinshaw 1976, Wenner and Nesbitt 1984), but Bennett (1989) found a maximum linear movement of about 2.3 km (1.5 mi) for adults in the Okefenokee National Wildlife Refuge in Georgia. Juvenile birds range over an average area of 2,130 ha (5,260 acres) (Nesbitt and Williams 1990) and may eventually move as far as 10-30 km

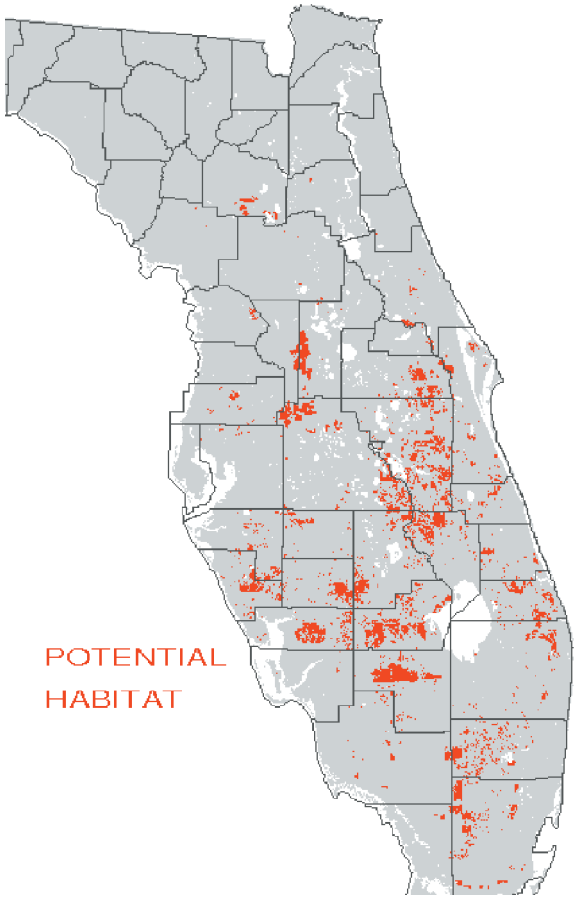


Figure 70. Habitat distribution map for the Florida sandhill crane.

(6-18 mi) from natal areas (Wenner and Nesbitt 1984). We use 3 km (1.7 mi) to set the extent of a neighborhood area that, over the course of a year, might be visited frequently by territorial cranes occupying an area.

The next level of organization of individual patches is called a "region." These are more expansive areas where cranes might interact over less frequent time periods, say once every 2-5 years, with most interactions likely stemming from dispersing juvenile birds. We use a 15-km (9.3 mi) distance to define habitat patches within a "region." Note that this procedure connects two patches of habitat that fall within 30 km of one another.

We isolated the potential crane habitat on existing conservation areas and established 2 zones extending 3 and 15 km (1.7 and 9.3 mi) from the edge of the available habitat within each area. This technique identifies conservation areas that are not contiguous yet fall within a single larger region or neighborhood. This procedure produced 9 regions and 49 neighborhoods (Figure 71) throughout the state. The regions are numbered to aid in their identification. The potential habitat available on existing conservation lands and surrounding areas is presented in Table 11 for these regions. Estimates for the number of territories in each region (see below) are based

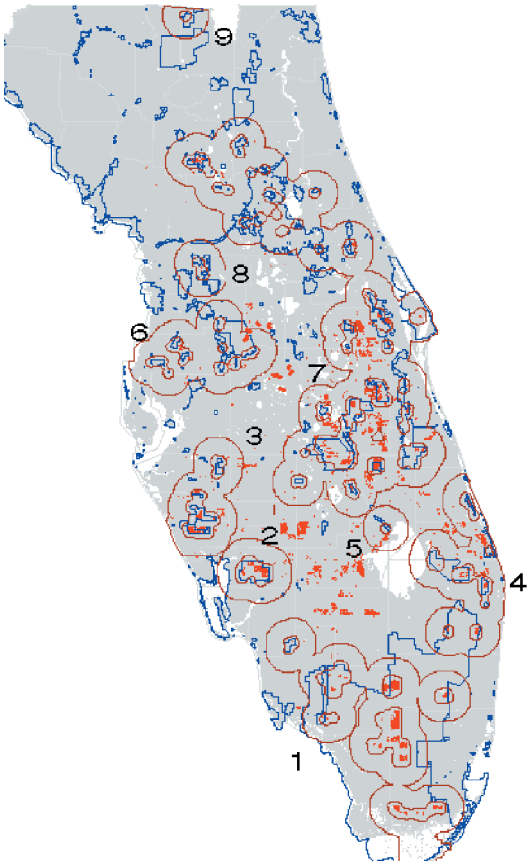


Figure 71. Higher order aggregations of potential Florida sandhill crane habitat. Definitions for regions and neighborhoods are provided in the text. Numbered areas are referenced in the text.

Table 11. Quantity of sandhill crane habitat (in ha) supported by existing conservation areas in Florida. Subtotals are arranged by regions as described in text and shown in Figure 71. WMA = Wildlife Management Area.

REGION	NAME	CONSERVATION AREAS (ha)	PRIVATE LANDS (ha)
1	Everglades	29,976	2,490
2	Webb WMA	7,003	5,685
3	Myakka SP	7,440	12,820
4	Southeast	7,829	16,290
5	Okeechobee	120	6,440
6	Green Swamp	1,938	10,240
7	Kissimmee Prairie	34,230	95,800
8	Panasofkee	395	660
9	North Region	35	10

on an estimate of 1 territory/447 ha (1,250 acres) (Nesbitt and Williams 1990). The acreage of habitat calculated for both private and conservation lands also helps to show the quantity of additional habitat in close proximity to current conservation lands. The largest region (Region 7, Figure 71) extends from the southern edge of Alachua and Putnam counties south to Glades County. The numerous neighborhoods within this region contain about 34,230 ha (50,650 acres) of potential habitat on conservation lands, enough to support roughly 80 territories. The total number of territories estimated for current conservation areas in Florida is about 200. We conclude that current conservation areas do not provide populations of sandhill cranes with the minimum habitat base needed for long-term security.

To outline new habitat conservation options for sandhill cranes, we evaluated regions for their capacity to support a population of roughly 50-80 territories. The analysis of population viability for sandhill cranes indicated that a population of approximately 50-80 breeding pairs has a very high chance of long-term survival. A population of this size requires about 25,300-40,000 ha (62,000-100,000 acres) of habitat based on an estimated 1 territory per 446 ha (1,250 acres) (Bishop 1987, Nesbitt and Williams 1990).

Only Region 7, which is estimated to have sufficient habitat on existing conservation areas to support roughly 80 territories, satisfies this minimum level of protection. Two of the remaining regions are not very good candidates for additional protective measures. Only a small portion of the habitat available in the North Region (Area 9, Figure 71) falls outside of current conservation areas. This population is also buttressed by a larger population in the Okefenokee National Wildlife Refuge across the Georgia border (Bennett 1989) and will benefit from habitat protection efforts described for black bear (Section 6.2.11). Habitat patches in Everglades National Park and Big Cypress National Preserve form a small region, but again there is very little habitat (< 10% of total) that is not already in some type of conservation area. Management initiatives probably offer the best chances of bolstering populations of sandhill cranes in these two areas. In addition, our estimate of potential habitat in the Everglades area, which is based on known nesting areas, may be low because of limited coverage of these large public landholdings by breeding bird atlas participants and other data collectors.

Three additional considerations were made in our assessment of the important habitat conservation areas for sandhill cranes. First, clusters of territories are important in allowing social interactions to occur, so we give some priority to establishment of habitat areas that support at least 10 territories (requiring 4,470 ha or 11,040 acres) within the distance defined by a neighborhood. Second, we imposed our map of potential crane habitat over a composite map of potential habitat for other bird species that inhabit the dry prairie and freshwater marsh systems of central and south Florida (see Section 6.3.6). This provides a picture of places where conservation activities that benefit sandhill cranes might also benefit other rare species. Third, we also attempted to provide better continuity among some of the regions shown in Figure 71. This consideration emphasizes habitat patches that lie between major crane population centers. We believe this latter consideration is less important than simply protecting blocks of habitat, but if habitat blocks offer similar benefits

when measured using other criteria, the parcel capable of providing better continuity among regions might be favored.

The Webb Wildlife Management Area and Myakka River State Park in southwest Florida (Figure 72) are each capable of supporting about 17 territories. These estimates agree with estimates obtained from field surveys conducted for these areas (e.g., Bishop 1987). The total amount of habitat on private lands within 15 km of Webb Wildlife Management Area is estimated at 5,685 ha (14,040 acres), which could support an additional 13 territories. A total of 12,820 ha (31,660 acres) is estimated to occur on private lands within 15 km of Myakka State Park, which could support an additional 28 territories. Conservation of habitat within 15 km of each area may establish populations that, based on our model of sandhill crane population dynamics, are capable of long-term survival.

There are also several large patches of unprotected crane habitat > 15 km from these conservation areas that support other rare prairie species (Figure 72). We have numbered some of the larger blocks to help with their identification. The largest patches of unprotected potential habitat that would benefit sandhill cranes and other rare prairie birds are in Areas 1, 2, and 3. Conservation of appropriate habitat in Areas 1 and 2 could help to enhance the continuity of sandhill crane populations on Myakka and Webb with sandhill crane populations occupying public lands in the Kissimmee Region. Conservation of the large block of habitat in Area 3 could help to enhance the continuity to sandhill crane territories in the Everglades Region.

Current conservation areas in the southeast region (extending south of Savannas State Preserve) (Figure 72) are capable of supporting a total of about 18 territories. A large block of habitat occurs on private lands to the east Lake Okeechobee (Area 4, Figure 72) that would significantly enlarge the habitat base available on conservation lands and also potentially enhance continuity with populations associated with the Kissimmee Prairie region to the northeast. This large block of habitat also appears to be of potentially great importance to many other birds that inhabit the prairies of central Florida.

Another large area of potential sandhill crane habitat is Area 6 in Figure 72. Although this block of habitat may not significantly enhance the continuity among sandhill crane populations, this area represents a large block of habitat important to numerous other rare species. The importance of Area 6 to sandhill cranes and other species warrants some type of conservation action. Area 5 (Figure 72) also has many small, scattered patches of native dry prairie intermixed with grass and agriculture cover types. Due to the patchy distribution of sandhill crane habitat in this area, it seems an appropriate place to seek conservation easements that protect sandhill crane populations without eliminating private use of the land.

The potential sandhill crane habitat remaining in west central Florida (Figure 73) presents fewer options than the previous two areas. Much of the valuable crane habitat in this area is found just outside of major

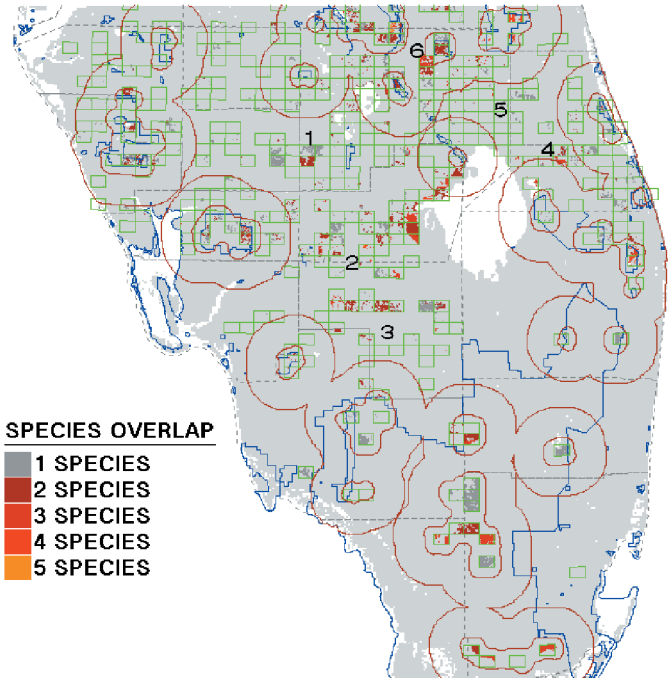


Figure 72. Potential sandhill crane habitat in southwest Florida. The number of species refers to an overlay of habitat distribution maps for other species that inhabit the prairies and marshes of south central Florida. Numbered areas are referenced in the text.

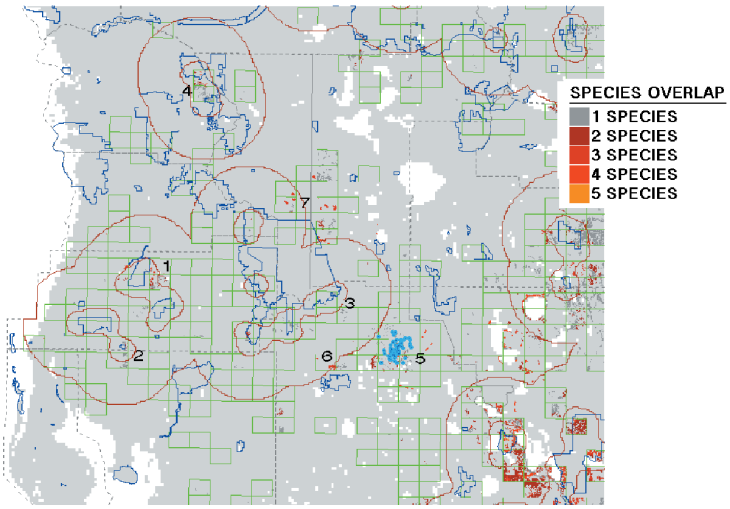


Figure 73. Potential sandhill crane habitat in west central Florida. The number of species refers to an overlay of habitat distribution maps for other species that inhabit the prairies and marshes of Florida. Numbered areas are referenced in the text.

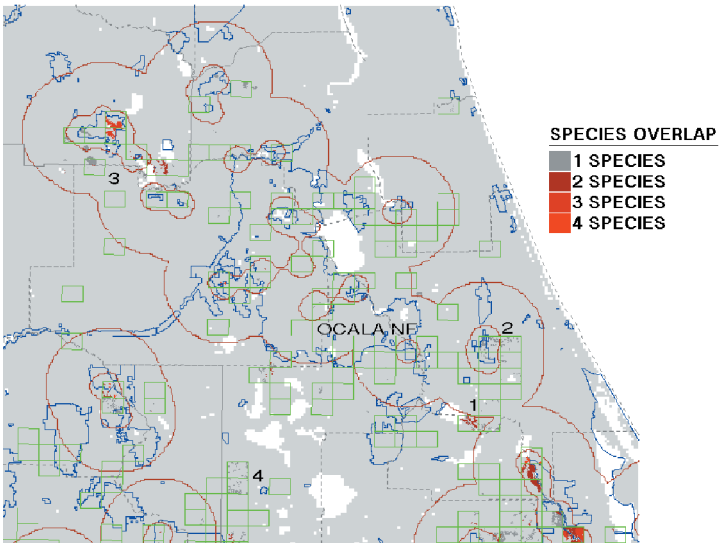


Figure 74. Potential sandhill crane habitat in north central Florida. The number of species refers to an overlay of individual habitat distribution maps for other species that inhabit the prairies and marshes of Florida. Numbered areas are referenced in the text.

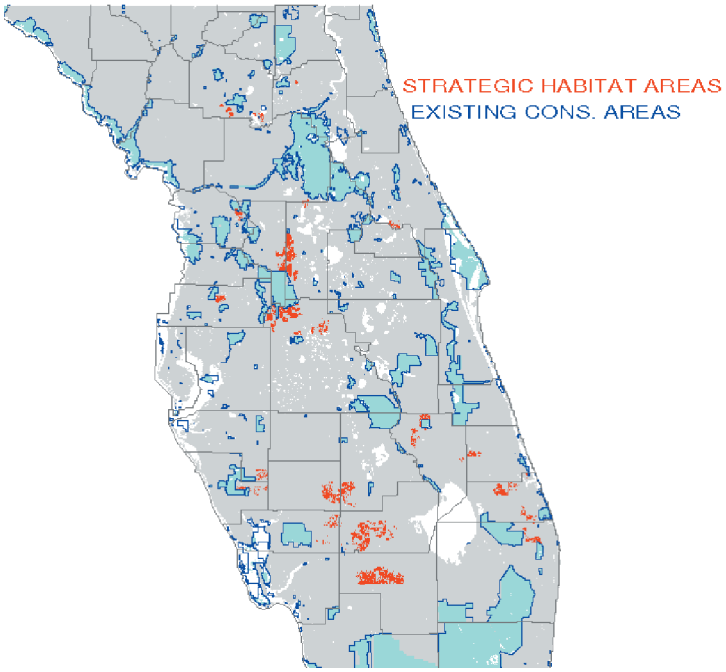


Figure 75. Proposed Strategic Habitat Conservation Areas for the Florida sandhill crane.

public land holdings. The small size of populations within conservation areas argues for emphasizing the conservation of patches of habitat adjacent to existing conservation areas. Areas numbered 1, 2, 3, and 4 would be the most appropriate sites for expanding the boundaries of existing conservation areas to protect sandhill crane populations. Potential habitat in Areas 5 and 6, on the other hand, would help to protect large patches of habitat while also protecting other species associated with prairies. Area 5 in Figure 73 contains a very high density of nesting sandhill cranes (Dwyer and Tanner 1992) that, if conserved, could effectively double the size of the manageable population across this larger region. In addition, the large block of habitat shown in Area 7 could potentially enhance the movement of cranes between this area of west central Florida and habitat areas farther north.

The potential habitat mapped in areas of north central Florida (Figure 74) is estimated to fall within the same region as the potential habitat along the St. Johns and Kissimmee rivers. However, this connection hinges on several small blocks of habitat located on the Ocala National Forest (Figure 74). We estimate the total habitat base available on the Ocala National Forest and conservation areas to the north is about 6,100 ha, which could support approximately 12 territories. Given the small base of habitat and tenuous connection these northern populations have with the crane population along the Kissimmee and St. Johns rivers, conservation of habitat in the areas numbered in Figure 74 would help expand the managed habitat base and also be important to several other species associated with freshwater marsh systems (e.g., southern bald eagles and several species of wading birds).

When considering habitat quantity, the importance of habitat areas to Florida sandhill cranes and other species, and maintenance of continuity among currently protected patches of crane habitat, habitat areas shown in Figure 75 are proposed to offer the best options. These areas are proposed as Strategic Habitat Conservation Areas for this species. Conservation easements that conserve rangeland activities can help maintain sandhill cranes in many of these areas, but fee-simple acquisition should probably be used to secure areas that support both sandhill cranes and other species that are more sensitive to land-use changes. The total amount of crane habitat encompassed by these proposed Strategic Habitat Conservation Areas is 172,010 ha (425,000 acres), enough to triple the number of territories currently supported by conservation lands in Florida. As important, each of the areas has one or more of the following characteristics: (1) the area enhances small, local populations that may not be secure; (2) the area protects patches of sandhill crane habitat throughout a large portion of the current range of the species; (3) the area may facilitate movement among all protected populations, and (4) the area contributes to the protection of other rare

prairie species. Some of the rare plants and animals recorded within or near the proposed Strategic Habitat Conservation Areas are tricolored heron, southern bald eagle (3 records), crested caracara (2 records), eastern indigo snake (2 records), banded wild-pine, and Florida three-awn.

Section 6.2.16. Florida Scrub Jay

Archbold Biological Station is developing a habitat conservation plan for Florida scrub jays using a statewide inventory of currently occupied territories (J. Fitzpatrick, pers. comm.). The new data on territory locations were not available to us during the preparation of this report, but we believe they would alter results from some the analyses presented below. We plan to develop new maps of important habitat areas for scrub jays as soon as the new information becomes available. Interested parties should contact the Office of Environmental Services for the most recent versions of the scrub jay maps and any new maps of proposed Strategic Habitat Conservation Areas.

The creation of a map of potential habitat for the Florida scrub jay involved several types of data sets and analyses. The Florida Natural Areas Inventory mapped Florida scrub jay locations published in Cox (1987) and reported by other researchers. K. Dryden and J. Beever (pers. comm.) have mapped many Florida scrub jay locations in southwest Florida. We created 160-m circles around these point data and isolated the patches of oak scrub, sand pine scrub, and dry prairie within the 8 ha (20 acres) defined by the circles. Circles of this diameter approximate the average size of a scrub jay territory (Woolfenden and Fitzpatrick 1984, Fitzpatrick et al. 1991). We also mapped concentrations of occurrences. A Voronoi diagram was created using the point data, and we highlighted areas where patch size defined by neighboring points was < 810 ha (2,000 acres).

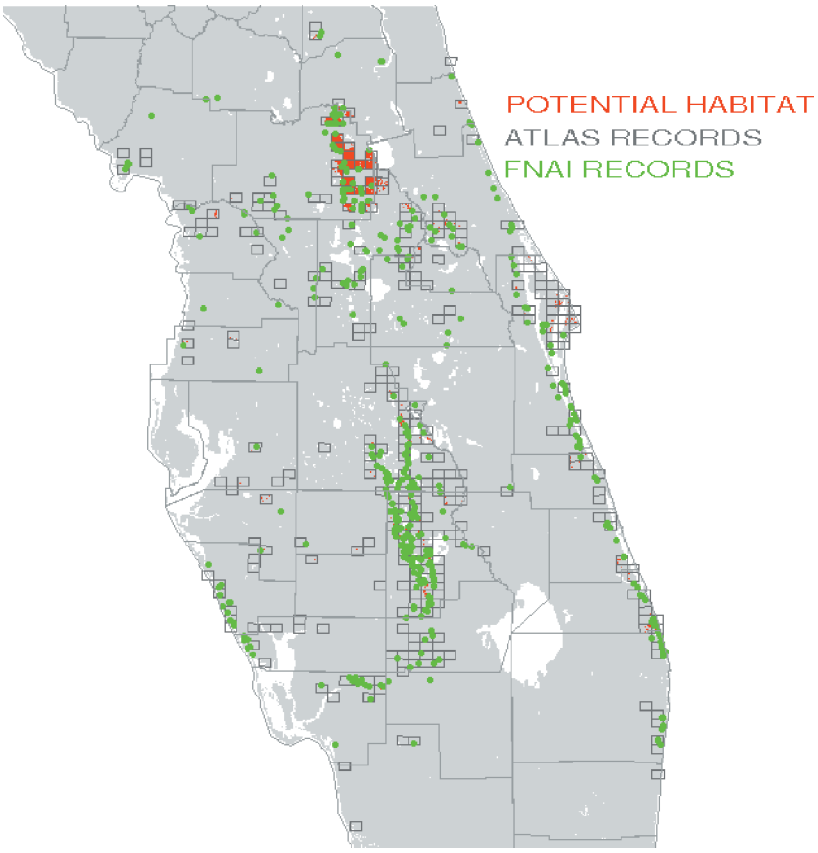


Figure 76. Habitat distribution map for the Florida scrub jay.

Several other data sets were also used to help refine the map of potential Florida scrub jay habitat. Locations of scrub jays in Brevard County were mapped based on a proposal submitted to the Conservation and Recreation Lands Trust Fund (Anon. 1992). Records from the Atlas of Florida Breeding Birds (Kale et al. 1992) were used to document other occurrences of Florida scrub jays. Within atlas blocks where jays were recorded, we isolated contiguous blocks of oak scrub and sand pine scrub > 2 ha (5 acres). This procedure eliminated small patches of scrub that are probably incapable of sustaining scrub jay territories (Fitzpatrick et al. 1991). We also radiated out 120 m from the edges of patches > 2 ha and incorporated the dry prairie, smaller scrub patches, and shrub and brush land cover that fell within this area.

The habitat distribution map produced by these techniques (Figure 76) shows a sparse distribution of habitat areas throughout much of central Florida. General regions where several large blocks of potential scrub jay habitat occur are Brevard, Highlands, Polk, Marion, and Martin counties.

Fitzpatrick et al. (1991) estimated a population with 40+ territories would provide high chances of survival over long periods of time. Our analysis of population viability matches this estimate. We estimate a habitat base of 400-800 ha (1,000-2,000 acres) is needed to support such a population, if properly managed. This estimate is slightly larger than the estimate developed by Fitzpatrick et al. (1991) due to variation in the quality of habitat that we estimate will support Florida scrub jays. In addition, the land cover map does not provide information on the structure of scrub habitat that is mapped. Since habitat structure has a profound influence on jay densities (Fitzpatrick et al. 1991), restoration of appropriate habitat conditions will be necessary in some instances to establish jay populations in the range of population sizes estimated here.

A comparison of the map of potential Florida scrub jay habitat with current conservation areas indicates that only five conservation areas contain large, potentially secure scrub jay populations. A density of 1 territory/16 ha (40 acres) was used to estimate habitat capacity on conservation areas. The five conservation areas with sufficient habitat to sustain large populations are: (1) Ocala National Forest, (2) Merritt Island National Wildlife Refuge, (3) the contiguous area comprising Arbuckle State Forest, Kicco Wildlife Management Area, and Avon Park Air Force Range, (4) Jonathan Dickinson State Park, and (5) Archbold Biological Station. In the case of Merritt Island National Wildlife Refuge, Avon Park/Arbuckle/Kicco, and Ocala National Forest, the habitat base supports three very large jay populations each totalling well in excess of 100 territories.

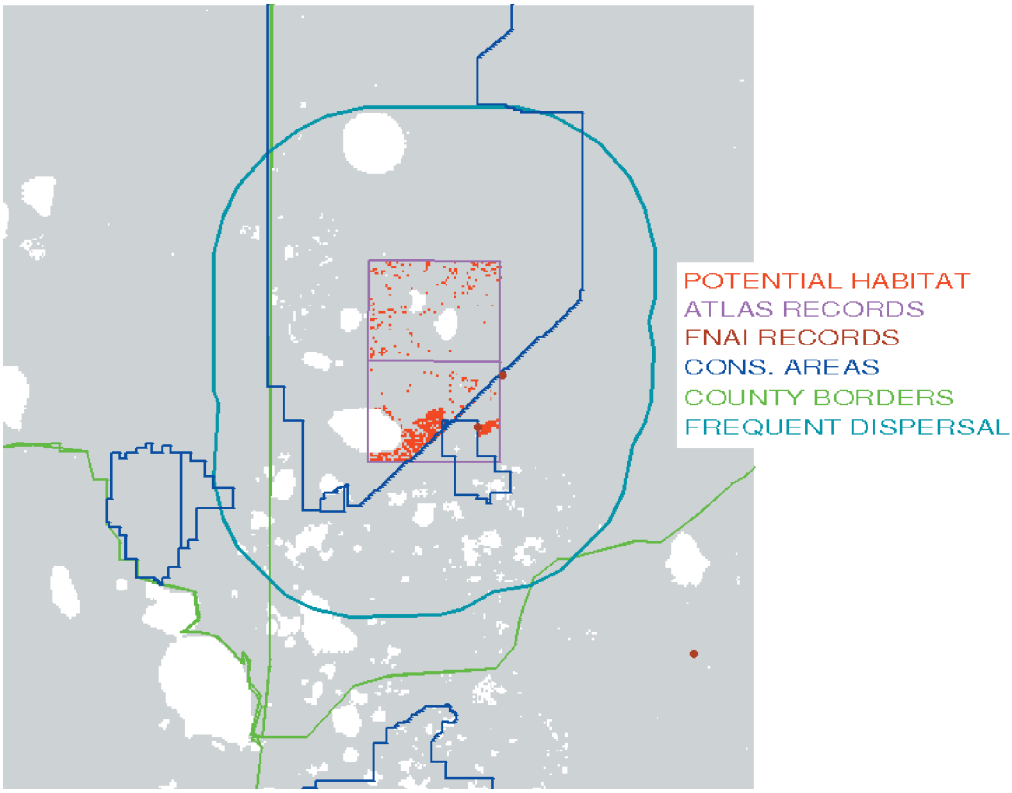


Figure 77. Scrub jay habitat in and around Camp Blanding Military Reserve and Goldhead Branch State Park.

Although current conservation areas support a few large Florida scrub jay populations, fewer than 10 potentially secure population exist. Conservation of additional areas is needed to provide the minimum habitat base sought for long-term survival. Protection of additional habitat areas is especially important since scrub jay populations may experience periodic population crashes due to catastrophic fires or diseases. These threats may place even large populations at risk of extinction over long periods of time. These threats also argue for maintaining a broad geographic distribution of several populations, each > 40 territories.

There are nine conservation areas that have sufficient habitat to support modest scrub jay populations (5-20 territories) yet fall well below the acreage needed to support a population with high chances of long-term survival (i.e., 40 territories). These are (1) the combined, contiguous areas of Camp Blanding and Goldhead Branch State Park, (2) Cedar Key Scrub State Preserve, (3) Highlands Hammock State Park, (4) Savannas State Preserve, (5) Cross-Florida Barge Canal Lands (Marion Co.) and Carlton Halfmoon Ranch Wildlife Management Area, (6) Tiger Creek Preserve, (7) Wekiva Springs State Park, (8) Hontoon Island State Park, and (9) Lower Wekiva River State Preserve. These last three areas are in close proximity to one another and should be considered part of a larger population (see below).

Protection of additional habitat areas surrounding these various public land holdings may be an effective way of providing scrub jay populations with the minimum level of habitat protection desired for long-term security. While this strategy may not adequately protect all important components of scrub communities (see Section 6.3.8), it will establish a manageable statewide scrub jay population with high chances of long-term persistence.

To review conservation options around these conservation areas, we isolated potential scrub jay habitat that occurred within 5 km of scrub jay habitat within each of the conservation areas described above. We use this distance as an estimate for "frequent" dispersal distances. Greater dispersal distances have been recorded for Florida scrub jays (Woolfenden and Fitzpatrick 1984), but the 5-km distance used here covers most of the published dispersal records for Florida scrub jays. Note that two areas located within 10 km of one another would appear to be connected.

The acreage of potential scrub jay habitat within Camp Blanding and Goldhead Branch State Park (Figure 77) is estimated to total 485 ha (1,200 acres), but much of it is in poor condition. The scrub land cover mapped on Camp Blanding consists of tightly planted sand pines that are unsuitable for scrub jays. Even so, the area appears to have the potential to support a stable population of jays if it were under more favorable management conditions. A small patch of scrub land cover to the northeast of Goldhead Branch State Park supports scrub jays, but few other areas exist outside these conservation lands where scrub jays are likely to occur. Management of scrub jay habitat on Camp Blanding coupled with the protection of scrub land cover outside of Goldhead Branch State Park represent the best options to pursue in this region. When taken together, these actions would protect or reestablish nearly 570 ha (1,400 acres) of scrub jay habitat and help to secure the northernmost population of this species.

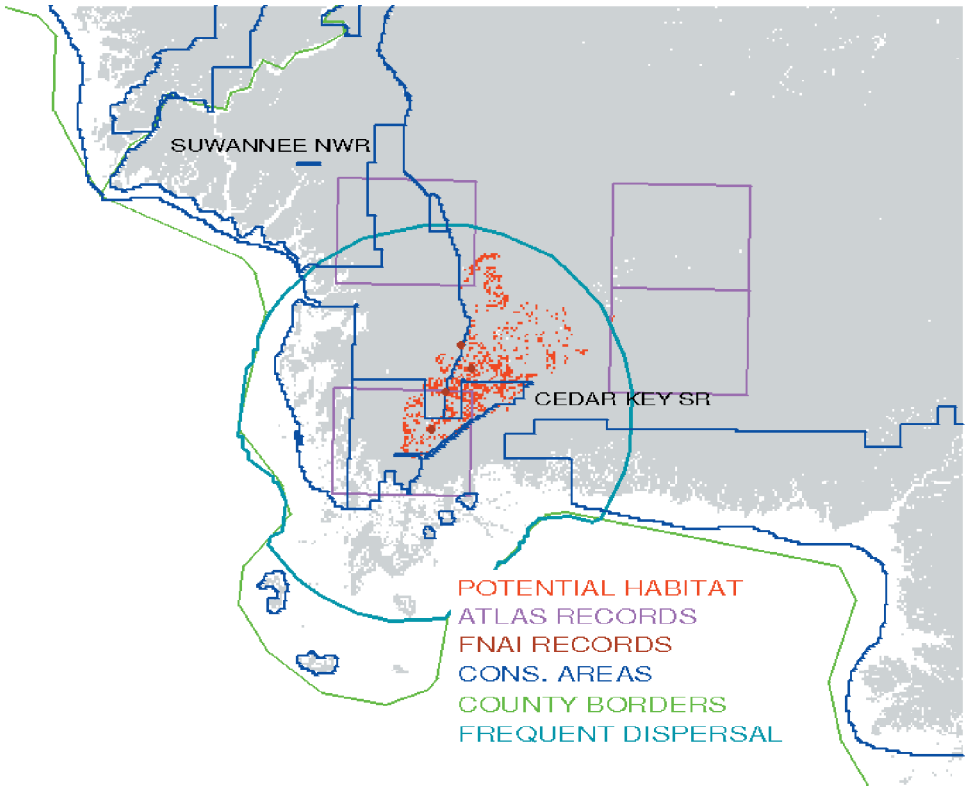


Figure 78. Scrub jay habitat in and around Cedar Key State Preserve and Lower Suwannee River National Wildlife Refuge.

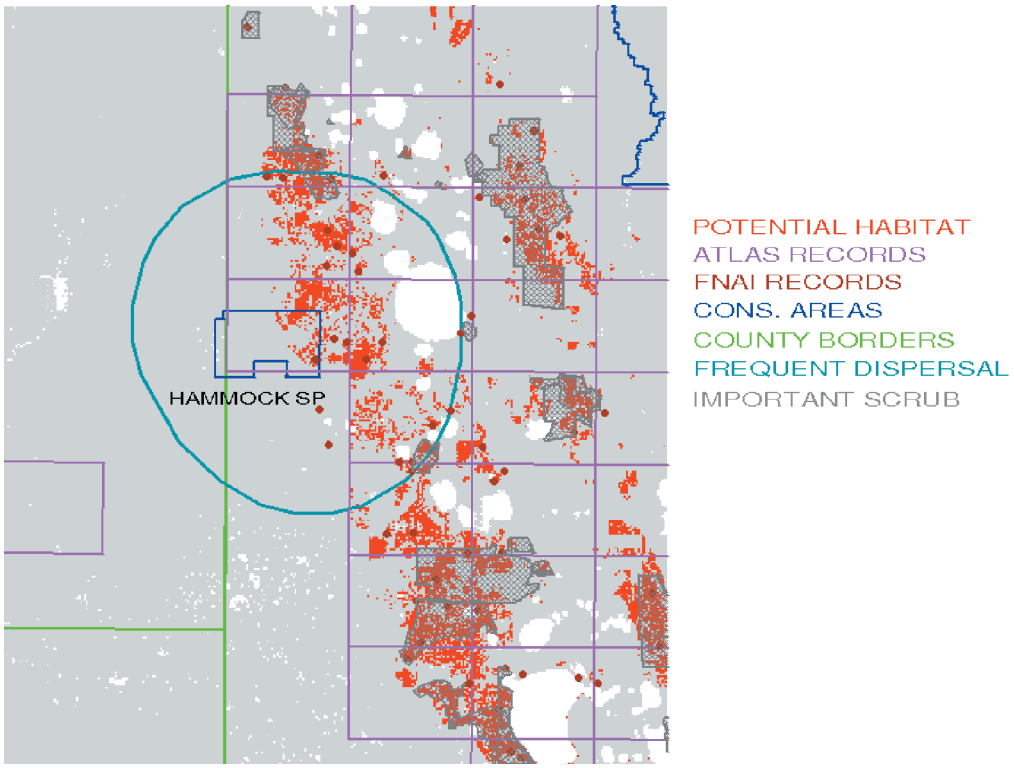


Figure 79. Scrub jay habitat in and around Highlands Hammock State Park.

Scrub habitat on Cedar Key State Reserve and the Lower Suwannee River National Wildlife Refuge (Figure 78) supports an important but declining population of scrub jays that represents the northern limit of the species along Florida's Gulf Coast. The established preserves contain approximately 180 ha (450 acres) of jay habitat, but approximately 730 ha (1,800 acres) of scrub jay habitat occurs within 5 km of current conservation area boundaries. We estimate an additional 320-480 ha (800-1,200 acres) of habitat is needed to provide adequate security for this population.

The bulk of the unprotected scrub habitat occurs to the north and east of current public land boundaries, and a large block of unprotected habitat exists between the western edge of the Cedar Key State Reserve and the eastern edge of the Lower Suwannee River National Wildlife Refuge. This block of habitat takes on added significance since there are historic records for scrub jays from Shired Island (Stevenson and Anderson 1992), which is now part of the Suwannee River National Wildlife Refuge. The area on Shired Island is currently overgrown (J. Cox pers. obs.) but could be restored. Breeding bird atlas data indicate that scrub jays also occur some 7.5 km to the northeast, but conservation of 40+ territories within 5 km of the preserve would probably offer better chances of long-term survival for this population.

Several patches of scrub surround Highlands Hammock State Park (Figure 79), but only a few hundred acres of scrub occur within park boundaries. The scrub habitat within the park is capable of sustaining roughly 8-16 territories, while approximately 1,140 ha (2,800 acres), enough to sustain scores of territories, is found within 2 km of the park. An additional 1,140 ha (2,800 acres) of habitat is found within 5 km of the park, and several large blocks of potential habitat (i.e., > 100 ha) occur just beyond a 5-km boundary. Breeding bird atlas data indicate that much of the scrub habitat surrounding the conservation area is occupied, while data from the Florida Natural Areas Inventory show scrub jay population centers just to the north and just to the southeast of the park boundaries.

An inventory of scrub parcels performed by Archbold Biological Station (see Section 6.3.8) shows important scrub tracts less than 5 km to the north and south of the park, and several larger tracts nearby that support large scrub jay populations. An evaluation of scrub tracts in this area was conducted by Archbold Biological Station and forms the basis of the Lake Wales Ridge National Wildlife Refuge (U.S. Fish and Wildlife Service 1992). The scrub tracts identified in this proposed refuge system will significantly enhance the security of the scrub jay population on Highlands Hammock State Park and, more importantly, protect other valuable scrub sites containing scrub jays and many other rare species of plants and animals. Scrub tracts along the Lake Wales Ridge represent priority conservation areas.

Potential scrub jay habitat (Figure 80) identified within the Savannas State Preserve (St. Lucie County) amounts to approximately 142 ha (350 acres), but there may be more habitat than we estimate. The preserve is dominated by dry prairie land cover, which includes both scrubby flatwoods and dry prairie (as defined by Florida Natural Areas Inventory 1990). Both communities may support scrub jays. An additional 40 ha (100 acres) of scrub habitat exist within 2 km of the preserve, and a total of approximately 570 ha (1,400 acres) exists within 5 km of the preserve. Conservation of an additional 325-486 ha (800-1,200 acres) within this larger area would provide the minimum levels of protection desired.

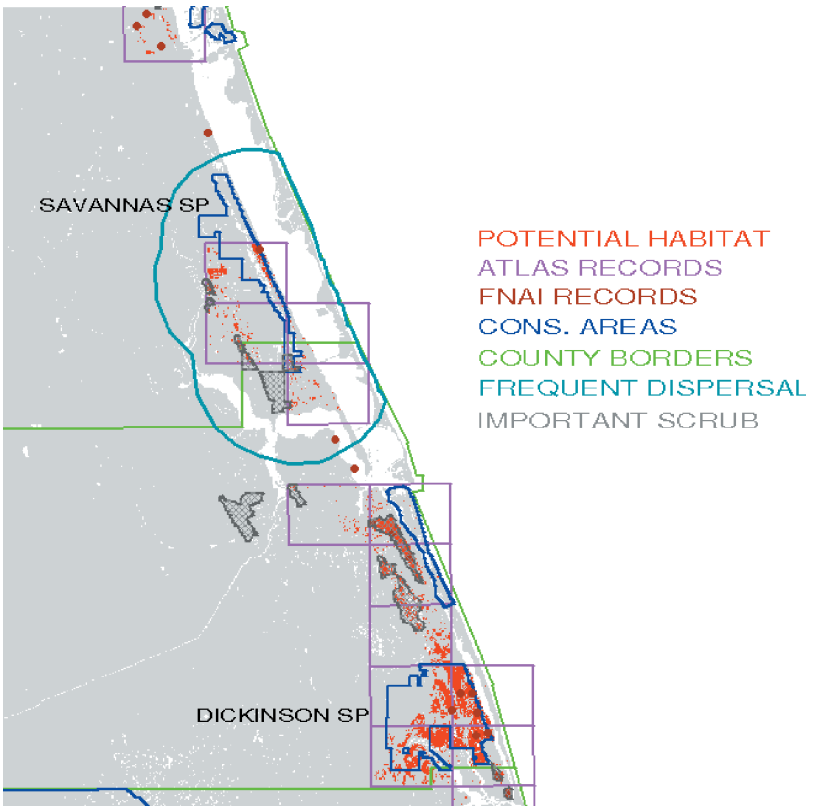


Figure 80. Scrub jay habitat in and around Savannas State Preserve.

Most of the unprotected scrub habitat in this larger area occurs south and west of the current preserve. Breeding bird atlas records show scrub jays occurring within 5 km of the southern edge of the preserve, while Fernald (1989) mapped several important patches of scrub habitat within 5 km of the southern boundary of the preserve (see Section 6.3.8). Protection of these habitat areas would help to bolster the regional population of scrub jays as well as protect other rare species associated with scrub communities (Fernald 1989). Florida Natural Areas Inventory data indicate several other rare plants and animals in the area. Protection of these areas represents a top priority in efforts to enlarge the protected population of scrub jays in the vicinity of Savannas State Preserve.

The boundaries of the deauthorized Cross Florida Barge Canal in southwestern Marion County (Figure 81) traverse an ancient dune ridge that still contains scrub land cover and scrub jays. The habitat within Barge Canal lands totals about 100 ha (250 acres), but much of the habitat consists of overgrown sand pine that are not currently suitable for scrub jays (J. Cox pers. obs.). An additional 546 ha (1,350 acres) of habitat exists within 2 km of the current boundaries of the preserve, and a total of 720 ha (1,780 acres) of potential scrub jay habitat exists within 5 km of the preserve. Most of the habitat occurs along the ancient dune ridge and extends north of the current boundaries of the conservation area. Florida Natural Areas Inventory data show several records of scrub jays and other important resources in the area, and there are nearby breeding bird atlas records for scrub jays.

Occurrence records and potential habitat areas on Carlton Halfmoon Ranch Wildlife Management Area indicate a population of > 20 territories to the west and southeast of Barge Canal lands. Conservation of appropriate habitat areas between the Barge Canal lands and Carlton Halfmoon Ranch could establish a much larger regional population capable of long-term survival. At the very least, an additional 400 ha (1,000 acres) of the ancient dune ridge to the north and south of the Barge Canal lands should be conserved to enhance the size of the protected population on Barge Canal lands.

The Tiger Creek Preserve and Kissimmee River State Park (Figure 82) support small populations of scrub jays and have sizeable tracts of scrub land cover just outside of their boundaries. The two areas are close enough for jays to move between them frequently, but movement would be enhanced by protecting patches of habitat between the two areas. There are approximately 324 ha (800 acres) of scrub within 2 km of Kissimmee State Park, and 283 ha (700 acres) within 2 km of Tiger Creek Preserve. The total quantity of potential habitat within 5 km of both areas is approximately 1,133 ha (2,800 acres), including habitat within each protected area. Some of the scrub patches within the 5-km zone include important scrub sites that were mapped by biologists at Archbold

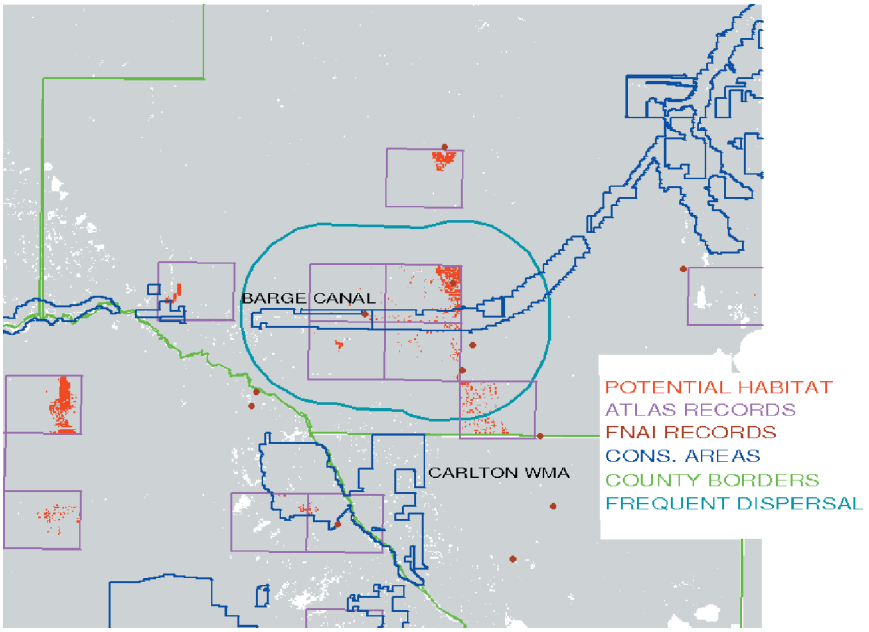


Figure 81. Scrub jay habitat in and around Cross Florida Barge Canal lands in Marion County.

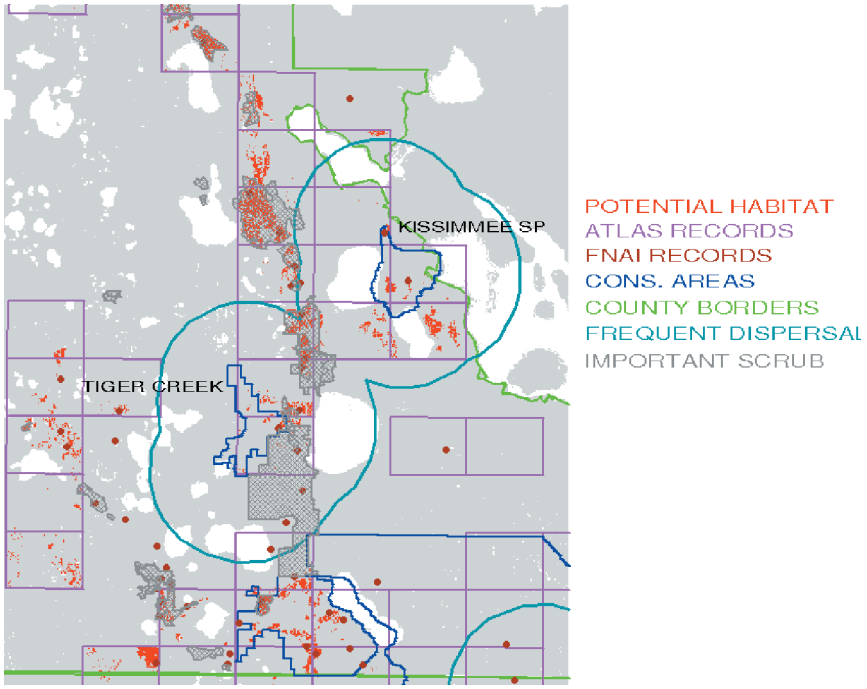


Figure 82. Scrub jay habitat in and around Tiger Creek Preserve and Kissimmee River State Park.

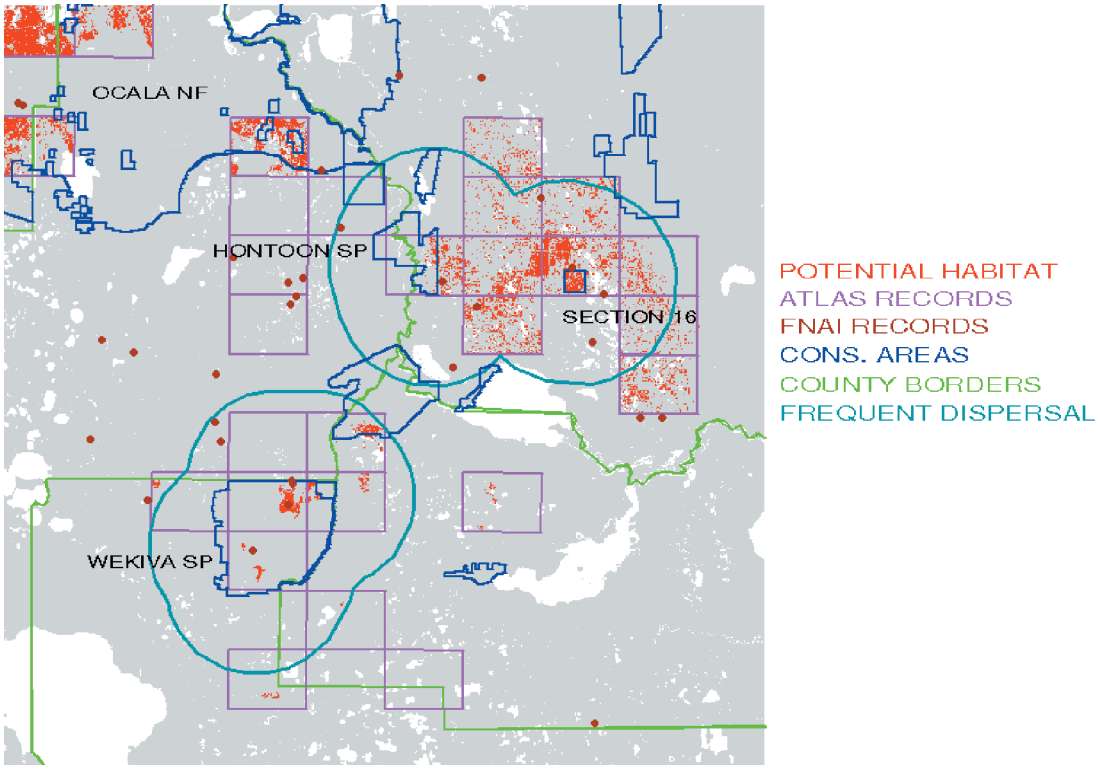


Figure 83. Scrub jay habitat in and around Hontoon Island State Park, Wekiva Springs State Park, Rock Springs Run State Park, and Lower Wekiva River State Reserve.

Biological Station (Section 6.3.8) and are known to support many rare species of plants and animals. These should be top priorities for fee-simple acquisition, and a total of at least 810 ha (2,000 acres) should be sought in this area.

The scrub jay habitat on conservation lands in Lake, Orange, Seminole, and Volusia counties (Figure 83) includes several separate conservation areas: Hontoon Island State Park, Wekiva Springs State Park, and Rock Springs Run State Park. Potential habitat also exists on a "Section 16" parcel in Volusia County. Section 16 lands were originally set aside for schools; this parcel is owned by the state and is leased to the local school board by the Trustees of the Internal Improvement Trust Fund. The Section 16 lands shown here contain approximately 170 ha (420 acres) of potential scrub jay habitat; an additional 543 ha (1,343 acres) lies within 2 km of the Section 16 lands. Management is needed to realize the potential of the Section 16 parcel, but the opportunity of establishing a unique environmental education program should be pursued on the Section 16 lands in Volusia County.

Hontoon Island State Park lies to the west of the Section 16 lands and contains an estimated 97 ha (240 acres) of potential scrub jay habitat. This state park is within 5 km of the Section 16 lands, and scrub habitat is interspersed throughout the area between Hontoon Island and the Section 16 lands. However, Interstate 4, commercial developments, and extensive residential developments may effectively separate habitat on the Section 16 lands from habitat on conservation areas to the west. The total area of potential scrub jay habitat within 5 km of both public land holdings is nearly 1,700 ha (4,200 acres), and there are breeding bird atlas records for scrub jays throughout the area between the two sites.

The amount of scrub jay habitat in and around Wekiva Springs State Park (Figure 83) appears to be limited in comparison to the amount surrounding Hontoon Island and Section 16 lands to the northeast. We estimate 345 ha (850 acres) of habitat occurs in Wekiva Springs State Park, and about 121 ha (300 acres) within Lower Wekiva River State Preserve (north and east of the state park). The scrub habitat in the Lower Wekiva River State Preserve is about 1.6 km north of the scrub habitat on Wekiva Springs State Park. There may be some unmapped scrub jay habitat immediately to the north and east of these areas since there are breeding bird atlas records and Florida Natural Areas Inventory records indicating the presence of scrub jays. The total amount of scrub jay habitat on all areas appears capable of supporting a stable population, but a key issue is maintaining appropriate conditions for dispersal between the two preserves. This is particularly important from the perspective of the small jay population on Lower Wekiva River State Park. Current efforts by the Conservation and Recreation Lands program (Anon. 1993) to conserve these intervening habitat areas will likely maintain continuity among these populations.

Several other sites of potential importance to scrub jay conservation efforts were identified using other data sets. Scrub sites in Brevard County have been proposed for acqui-

sition by the State's Conservation and Recreation Lands Trust Fund (Anon. 1992). The Valkaria site in southern Brevard County contains approximately 166 ha (410 acres) of dry prairie, scrubby flatwoods, and scrub that might support a potentially stable population of jays (Figure 84). Within 2 km of the site are an additional 2,430 ha (6,000 acres) of flatwoods and dry prairie where some jays are known to occur, and a total of 5,670 ha (14,000 acres) of mixed flatwoods, oak scrub, sand pine scrub, and dry prairie occurs within 5 km of the site. However, much of the potential habitat to the west lies within the city limits of Palm Bay. We have no recommendations for the placement of conservation areas in this region.

A Voronoi tessellation of the available point data showed four additional clusters of scrub jay occurrences in northeast Lee County, central Glades County, southwest Sarasota and northwest Charlotte counties, and central Lake County that also warrant consideration for conservation activities. The area in northeast Lee County (Figure 85) contains approximately 15-25 territories around the Caloosahatchee State Recreation Area. Potential habitat occurs

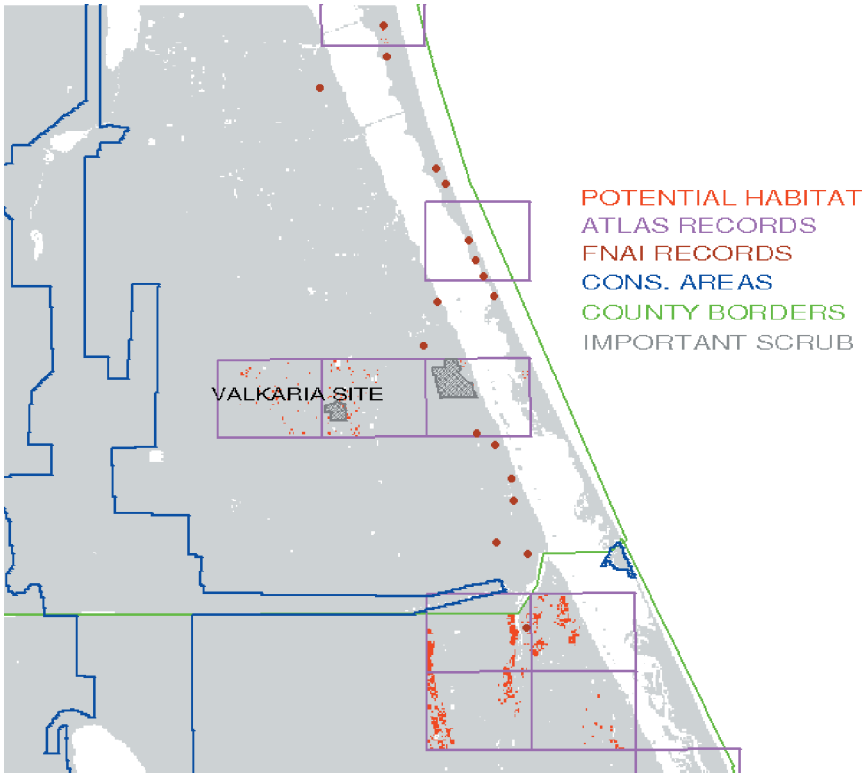


Figure 84. A portion of the scrub jay habitat in Brevard County.

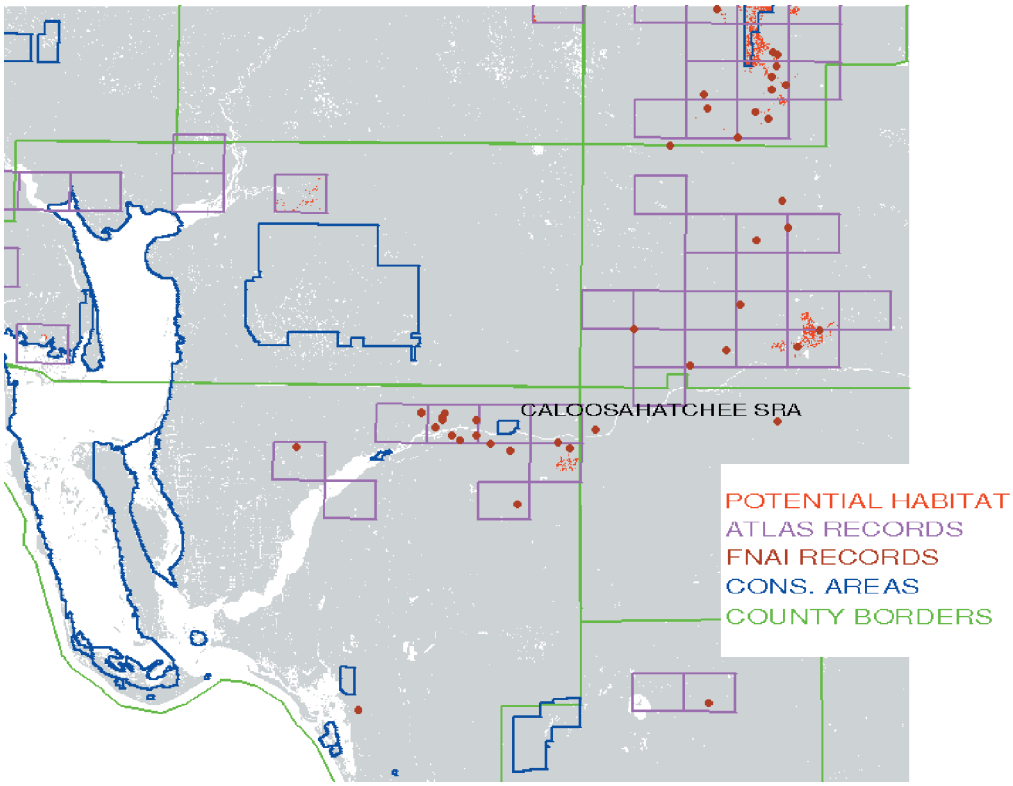


Figure 85. Scrub jay habitat in Glades, Hendry, and Lee counties.

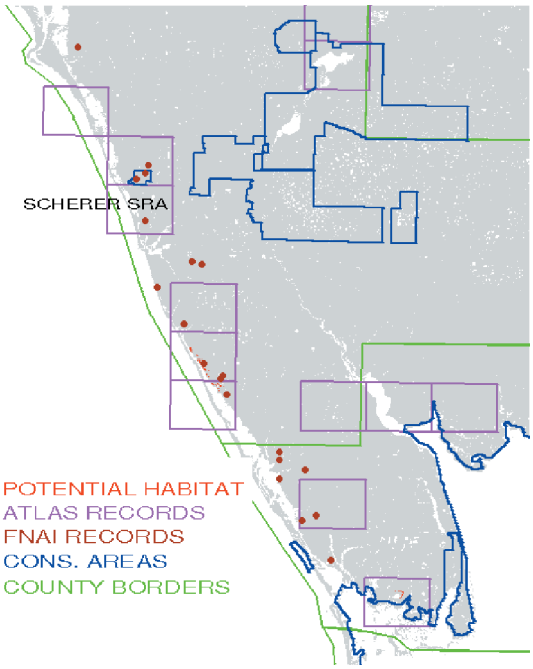


Figure 86. Scrub jay habitat in southwest Sarasota and northwest Charlotte counties.

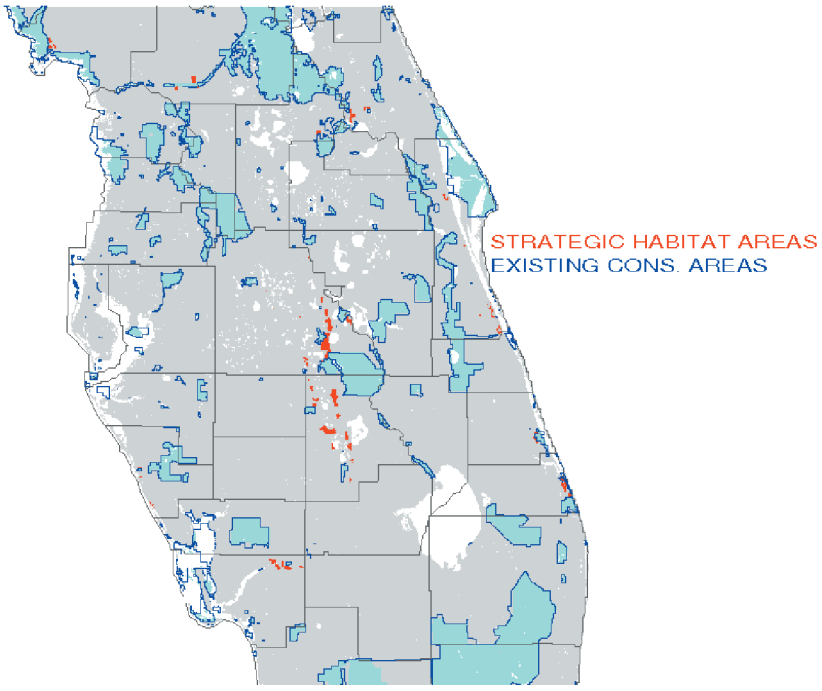


Figure 87. Proposed Strategic Habitat Conservation Areas for the Florida scrub jay.

on both sides of the Caloosahatchee River, and though the area is not apparently heavily populated with jays, it may play an important role in maintaining a broad geographic distribution of scrub jay populations. This area is also important in habitat conservation efforts for the Big Cypress fox squirrel (Section 6.2.18.).

An area with known occurrences in central Glades County (Figure 85) consists mostly of dry prairie and scrubby flatwoods with interspersed pockets of oak scrub. Point data sets show several nearby locations with scrub jays, and breeding bird atlas data indicate that there are other areas within the region where scrub jays likely occur. This area could be important in maintaining a broad geographic distribution of scrub jay populations and in facilitating movement between the scrub jay populations in Lee County and scrub jays along the Lake Wales Ridge. The distance from the southern tip of the Lake Wales ridge to the Glades County scrub jay clusters is about 10 km (6 mi); the distance from the Glades County cluster to the Lee County cluster is about 12.2 km (7.6 mi). These distances are generally greater than the distances that scrub jays have been shown to move regularly, making frequent dispersal seem uncertain.

Potential scrub jay habitat indicated by a cluster of points in southwest Sarasota and northwest Charlotte counties (Figure 86) is insularized from other scrub jay populations by major urban areas. Oscar Scherer State Recreation Area supports a population of about 10-20 territories. There is apparently no other habitat within 5 km of this site, and the nearest occurrence records are some 10 km to the south near the towns of Manasota and Venice Gardens. There are also numerous atlas records and occurrence points from areas surrounding Myakka River State Park, 16 km to the northeast of Oscar Scherer State Recreation Area. Recent banding studies conducted at Oscar Scherer State Recreation Area have shown that scrub jays may disperse among these areas, so conservation of habitat areas near Manasota and Venice, or Myakka River State Park, might help to protect a larger regional population. However, there is very little additional scrub habitat adjacent to Oscar Scherer State Recreation Area.

In summary, several areas exist where increased habitat protection will significantly increase the long-term survival potential of Florida scrub jays. We propose habitat patches within general areas shown in Figure 87 as Strategic Habitat Conservation Areas for this species. Strategic Habitat Conservation Areas are proposed specifically to expand the scrub jay populations in seven general areas discussed above: the Barge Canal lands, Wekiva River area, central Lake Wales ridge, southeast Atlantic Coast, Cedar Key, and southwest Florida. These new conservation areas are proposed to maintain

the current geographic distribution and to bring the size of protected scrub jay populations above the minimum number deemed acceptable for long-term security. Conservation of habitat within the proposed Strategic Habitat Conservation Areas may not adequately protect all key components of Florida's endemic scrub community (see Section 6.3.8), but it will provide a minimum level of security for scrub jay populations in Florida. Management and conservation efforts should also consider the potential threats posed by increasing urbanization in areas surrounding all scrub jay conservation areas. Scrub jay mortality may be elevated next to roads with heavy vehicle use, as well as by the presence of feral cats and dogs associated with residential development. Fitzpatrick et al. (1991) describe additional management considerations as well as aspects of jay behavior and biology that could be used to heighten the awareness of human residents of scrub lands surrounding proposed conservation areas.

Section 6.2.17. Florida Scrub Lizard

The map of potential habitat for the Florida scrub lizard was prepared primarily from point data sets processed by Enge et al. (1986) and the Florida Natural Areas Inventory. We used a small-radius circle (250 m) to isolate the sand pine and oak scrub land cover near each point. We also isolated the shrub and brush land cover on scrub soil types within 250 m of each record. The patches of potential scrub lizard habitat produced by these procedures are generally too small to see at a statewide scale, so Figure 88 presents the point data used to create the map of potential habitat.

We used a sparse density estimate of 10/ha to assess the relative security of scrub lizard populations in current conservation areas. K. Enge (pers. comm.) confirmed that densities were higher than this in suitable habitat areas. This figure leads to an estimated 10 populations > 200 and numerous smaller populations with a broad geographic distribution. Figure 89 shows public lands classified into three broader classes based on the size of the population of scrub lizards they

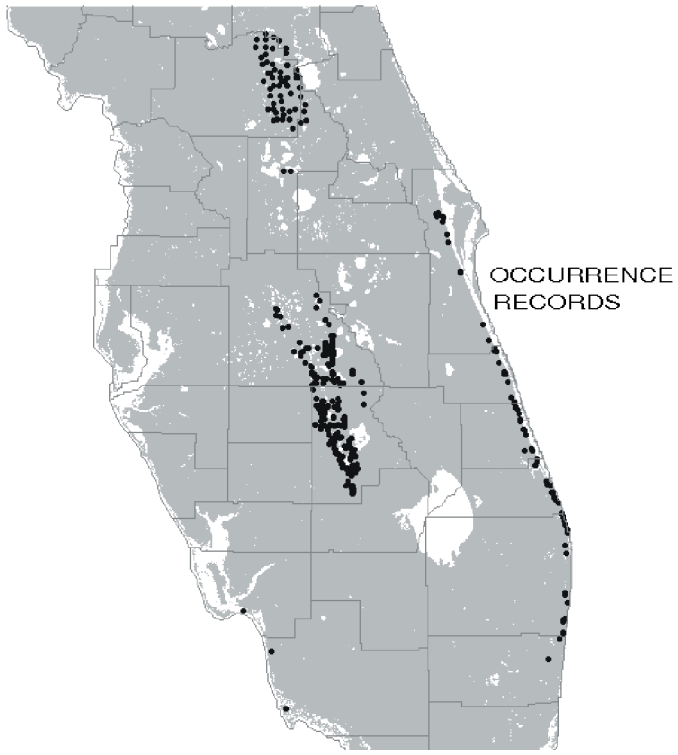


Figure 88. Data sets used to construct the habitat distribution map for the Florida scrub lizard.

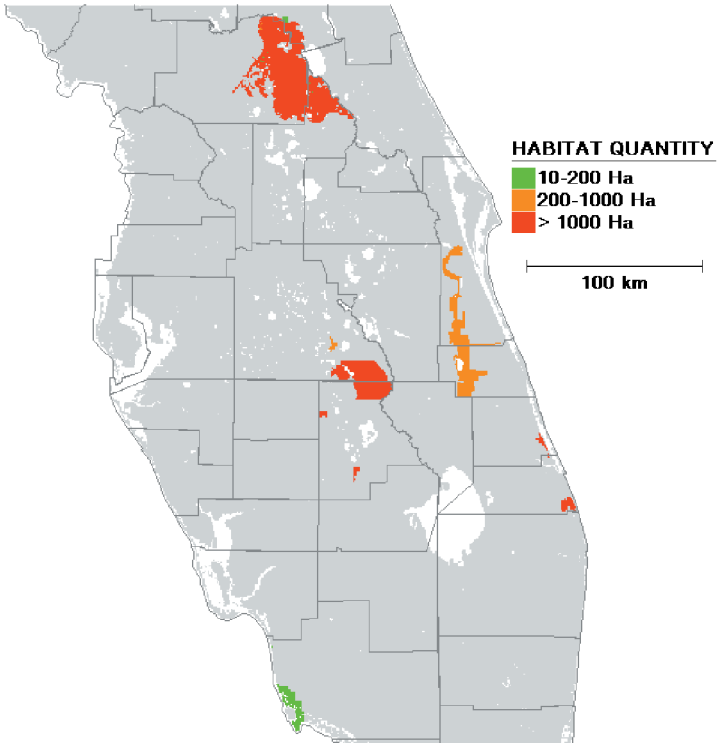


Figure 89. Existing conservation areas categorized by the quantity of potential scrub lizard habitat each contains.

contain. We conclude that current conservation areas provide the minimum habitat requirements sought for populations of scrub lizards. However, this does not imply that other elements of the scrub community are adequately protected.

Section 6.2.18. Fox Squirrels

Three subspecies of fox squirrel occur in Florida (Moore 1956, Turner and Laerm 1993). The Big Cypress fox squirrel (*Sciurus niger avicennia*) occurs south of the Caloosahatchee River and is ecologically and morphologically distinct (Turner and Laerm 1993). Sherman's fox squirrel (*S. n. shermani*) occupies a broad range extending north from southeastern Florida to central Georgia and west to approximately Walton County (Turner and Laerm 1993). The *shermani* subspecies appears to intergrade with the *niger* (or *bachmani*) subspecies (Turner and Laerm 1993) in the panhandle north and west of Walton County.

The *niger* and *shermani* subspecies appear to have similar ecological requirements (Weigl et al. 1989). Potential habitat for these subspecies was estimated using a similar habitat model. The sandhill, mixed pine-hardwood, and dry prairie land-cover types were consolidated into a single class categorized as appropriate land cover (Moore 1957, Kantola 1992). The pineland land cover in the Tampa Bay, Central Florida, Southwest Florida, and Treasure Coast regions was also categorized as appropriate habitat since these areas tend to consist of open pine flatwoods where fox squirrels may occur. The pineland class on public lands in north and northwest Florida was also treated as appropriate fox squirrel habitat. However, the pineland land cover on private lands in northwest Florida was excluded since these areas typically consist of commercial pine plantations that are not used frequently by fox squirrels (Weigl et al. 1989).

We isolated individual patches of these "preferred" cover types, calculated their sizes, and eliminated patches smaller than 10 ha (25 acres), an approximate home range size (Kantola 1986, Weigl et al. 1989). A 120-m zone was then created around the remaining large patches. Small patches of preferred cover, and infrequently used land-cover types such as hardwood hammock and cypress swamp, within this 120-m zone were included as potential habitat for fox squirrels. A final stipulation was that potential habitat be located at least 60 m away from barren land cover, which is generally avoided by fox squirrels. This last condition produces a conservative estimate of potential habitat areas.

The map of potential fox squirrel habitat represents only a portion of the total habitat occupied by these subspecies. Both *shermani* and *niger* inhabit rangeland areas interspersed with oak trees and the edges of forested wetlands and rangeland. These conditions are difficult to model using only the land-cover map. However, the model of potential habitat can be used to estimate the habitat provided by current conservation areas and to identify many of the remaining habitat areas on private land.

We used a density of 0.05-0.10/ha (Kantola 1986, Weigl et al. 1989) to estimate the security of habitat capacity in current conservation areas. Based on the analysis of population viability performed in Section 5.1., we estimate that secure fox squirrel populations require approximately 2,000-4,000 ha (4,940-9,880 acres) of appropriate habitat. However, habitat and population management within conservation areas of these general sizes is especially critical to ensuring fox squirrel persistence (see Section 5.1).

A cross-tabulation of potential habitat by current conservation areas indicates that conservation areas within the range of *shermani* support at least 10 populations > 200 individuals. The largest blocks of habitat on conservation areas within the range of *shermani* occur on the Ocala National Forest, Apalachicola National Forest, Osceola National Forest, Withlacoochee State Forest, and Camp Blanding Military Reserve. The geographic distribution of habitat on conservation areas also extends throughout the range of the subspecies in Florida, and we conclude that the *shermani* race has the minimum base of habitat needed for long-term security.

A similar cross-tabulation performed for conservation areas within the range of the *niger* subspecies shows sufficient habitat to support at least two very large populations (> 200 individuals). And two populations in the range of 25-200 individuals. The largest habitat areas are found on Eglin Air Force Base and Blackwater River State Forest. These conservation areas provide an estimated 2,432 km^2 (600,800 acres) of potential habitat, which could support approximately 12,000-24,000 fox squirrels. The recent acquisition of approximately 210 km^2 of potential fox squirrel habitat in Walton County may establish a third potentially secure population in west Florida. However, current habitat conditions on this site are largely unsuitable, and an undetermined portion of this area may be returned to private ownership. Given the fact that this subspecies has a very limited range in northwest Florida (Turner and Laerm 1993) and is represented by at least two very large populations, we conclude that it has sufficient representation on the existing system of conservation areas in Florida.

Identification of habitat features important to the *avicennia* subspecies focussed on the pineland and dry prairie land cover in southwestern Florida. Habitat requirements of this subspecies are not well known (Humphrey and Jodice 1992), but open pinelands and prairies (with interspersed pines) appear to be a primary habitat requirement. Based on food preference studies (Humphrey and Jodice 1992), slash pine forests appear to be important in spring and early summer, and the edges of cypress swamps appear to be important in fall and early winter. However, this subspecies has been found in many different habitat types, including hammocks, mangrove swamps, and hardwood swamps. Only the interiors of cypress and hardwood swamps seem to be avoided. Since Big Cypress fox squirrels (as well as the other subspecies of fox squirrel) spend much of their time on the ground, an open understory is important regardless of the dominant tree species. Such habitat requirements are difficult to evaluate using the land-cover map.

Within the known range of the Big Cypress subspecies (Williams and Humphrey 1979, Humphrey and Jodice 1992), we consolidated the pineland and dry prairie land cover into a single land-cover class. Individual patches < 100 ha (247 acres) were eliminated to focus attention on large patches of habitat that might support a stable population. The contiguous patches of hardwood hammock, mixed hardwood-pine, cypress swamp, hardwood swamp, and mangrove land cover occurring within 300 m of the edges of these large patches of pine and prairie land cover were also incorporated as appropriate land cover.

The habitat distribution map (Figure 90) developed for this subspecies shows several large blocks of habitat in Glades, Hendry, Charlotte, and Collier counties. The largest contiguous patch of habitat on private land occurs around Devil's Garden in Hendry County, with two other large patches of habitat occurring in southwest Collier County (north of Belle Meade) and northeast Lee County (north of Lehigh Acres). Large portions of the habitat areas in Lee, Collier, and Charlotte counties are undergoing development. This habitat distribution map corresponds well with the range of the subspecies described by Humphrey and Jodice (1992).

Average densities of the Big Cypress fox squirrel are not well known (Humphrey and Jodice 1992). However, it is apparent that the species lacks an adequate habitat base in current conservation areas. Only five conservation areas currently provide habitat for distinct populations of this subspecies, and the population associated with the Corkscrew Sanctuary may be extirpated (Humphrey and Jodice 1992). A total of 1,676 km^2 of potential habitat was identified, with only 347 km^2 (21%) in current conservation areas. If densities of the Big Cypress fox squirrel are comparable to those reported for other subspecies, these acreage totals imply a population of about 1,000-4,000 individuals in current conservation areas.

Most of the major blocks of habitat described for the Big Cypress fox squirrel on private lands are incorporated in the Strategic Habitat Conservation Areas recommended for other species (see sections on Florida black bear, Florida panther, and red-cockaded woodpecker). The habitat conservation areas described for these other species will, to a large degree, umbrella the habitat requirements of fox squirrels. The Strategic Habitat Conservation Areas provided for other species will increase the quantity of fox squirrel habitat on conservation areas by 153% and establish at least three potentially secure populations. However, one area of extensive fox squirrel habitat may not be adequately conserved through conservation of habitat for other species. A large tract of fox squirrel habitat occurs in northern Lee County around Hickey Creek and southwest Charlotte County. This area (Area 1, Figure 90) was also identified as an important habitat area for the Florida scrub jay (Section 6.2.16). Because of its importance to these two unique components of Florida's biological diversity, a Strategic Habitat Conservation Area is proposed for this area totalling 3,104 ha (7,667 acres). We estimate that a habitat conservation area of this size is capable of supporting 155-310 fox squirrels, a population capable of long-term survival under favorable management conditions.

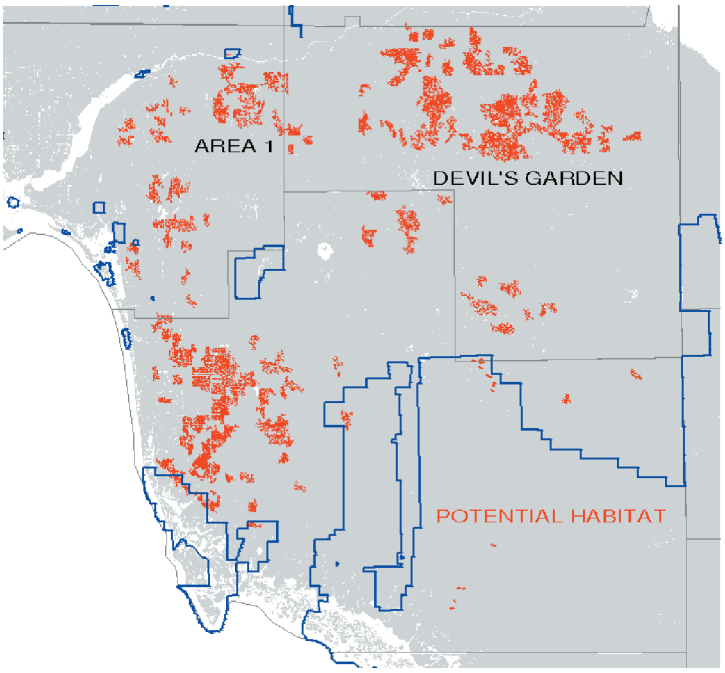


Figure 90. Potential habitat and proposed Strategic Habitat Conservation Area for the *avicennia* subspecies of fox squirrel.

Section 6.2.19. Gopher Tortoise

Although gopher tortoises occur in a variety of disturbed and natural areas, our model of potential gopher tortoise habitat emphasizes patches of "natural" habitat that have the capacity to support persistent populations. We isolated xeric land-cover types (sandhill, oak scrub, and sand pine scrub) in which gopher tortoises might occur. We also imposed a map of xeric soils over other land cover types (pineland, dry prairie, and mixed-hardwood pine) and added these to the map of xeric land-cover types to create an initial map of potential gopher tortoise habitat.

This initial map was then refined by identifying contiguous patches of appropriate land cover and eliminating patches < 20 ha (50 acres). This minimum size criterion resulted in moderately sized blocks of potential gopher tortoise habitat that have the potential of supporting stable populations (Cox et al. 1987). We then generated a 60-m zone surrounding these larger blocks of potential habitat and incorporated the smaller patches of potential habitat found within this distance and eliminated initially because of their small sizes. In the end, this model produces a map of moderately sized patches of potential gopher tortoise habitat and smaller patches of potential habitat that occur within 60 m of larger patches.

We used a density estimate of 3/ha (Cox et al. 1987) to determine the base of habitat provided by current conservation areas in Florida. There are an estimated 93 conservation areas with sufficient habitat to support populations > 200 individuals. While we do not believe that adequate protection is necessarily provided to species that utilize gopher tortoise burrows (Jackson and Milstrey 1989), and thus require stable populations of tortoises in order to survive, we conclude that the current system of conservation areas in Florida provides the minimum level of habitat protection required to maintain gopher tortoises.

Section 6.2.20. Limpkin

The map of potential limpkin habitat was created using information stored by the Florida Natural Areas Inventory and occurrences reported in the Atlas of Florida Breeding Birds (Kale et al. 1992). A small-radius circle (250 m) was generated around occurrence records stored by the Florida Natural Areas Inventory. Within the area defined around point data, and in atlas blocks where limpkins were recorded as "proba-

ble" or "confirmed" breeders, forested wetlands and freshwater marshes were isolated and contiguous patches larger than 2 ha (5 acres), an estimated territory size (Bryan 1982), were identified. The map of potential habitat (Figure 91) indicates that limpkins are widely distributed throughout the peninsula, but they become increasingly rare in the north and northwest regions of the state. The largest blocks of limpkin habitat (Figure 91) are found in the Everglades, along much of the St. Johns River south of Lake George, and along the western edge of Lake Okeechobee. We may have underestimated the quantity of habitat in many areas due to our reliance on known occurrence information.

Bryan (1982) estimated territory size for two populations in north Florida. Territory size at Wakulla Springs (Wakulla County) averaged 2.3 ha (+1.5 ha) while territory size at Alexander Springs (Lake County) averaged 2.1 ha (+0.7 ha). Territory size may vary greatly from year to year in relation to prey abundance and availability and social phenomena. The territory sizes estimated by Bryan (1982) also come from riverine areas bordered by forested wetlands. Territory size in more open and scattered wetlands (e.g., south Florida prairies and marshes) may be very different from those estimated by Bryan (1982) for forested wetlands. Hamel (1992), for example, reported a density of 1 territory per 40 ha in an Everglades marsh system.

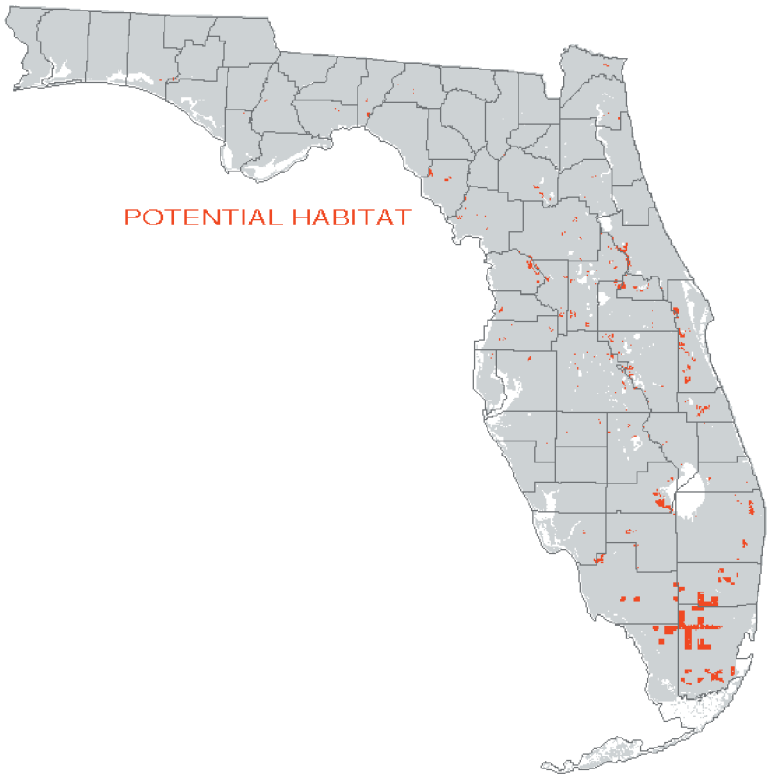


Figure 91. Habitat distribution map for the limpkin.

We use an estimate of 5-10 territories/km^2 in forested wetland systems and 2.5-5 territories/km^2 in open wetland systems to assess habitat capacity in current conservation areas. Approximately 1,981 km^2 (489,356 acres) of potential limpkin habitat is found throughout Florida with 49% (972 km^2 or 240,130 acres) occurring in current conservation areas. Most (76%) of the potential habitat on conservation lands consists of open wetland types. These figures suggest a statewide population of about 3,000-6,000 territories in current conservation areas. The distribution of potential habitat among contiguous management areas suggests the presence of four potentially secure populations (> 100 territories), 11 insecure populations (25-100 territories), and > 30 imperiled populations (< 25 territories). The largest populations estimated for current conservation areas are in the Everglades (including Everglades National Park, water conservation areas, Big Cypress National Preserve, Fakahatchee Strand State Preserve, and Loxahatchee National Wildlife Refuge), water management district lands along the western edge of Lake Okeechobee, forested wetlands on and near the Ocala National Forest (including Lake Woodruff National Wildlife Refuge and Cross-Florida Barge Canal lands), and water management district lands along the upper St. Johns River.

Conservation areas in Florida do not appear to provide the recommended minimum base of habitat for limpkins. However, the species is probably more secure than other species estimated to share this status. Limpkins disperse great distances (Nesbitt 1978) and may range in a nomadic fashion as they follow the changing abundance and availability of apple snails, their primary prey. This characteristic enhances movement among conservation areas. Limpkins also appear to have a large total population size on conservation areas throughout Florida even though there is not sufficient habitat to support at least 10 populations of 200. Even so, the conservation of additional habitat areas seems warranted and would enhance the security of the statewide population. Furthermore, the conservation of limpkin habitat can be accomplished by identifying important wetland areas where wetland regulations may offer some degree of habitat protection.

Our evaluation of important habitat areas on private lands takes three considerations into account. First, we consider the possibilities of expanding the habitat base available for some of the larger insecure populations (25-100 territories) on existing conservation areas in Florida. Such additions could quickly increase the total number of potentially secure populations (> 100 territories). Second, we also look at potential habitat areas that occur some distance away from protected populations. This evaluation helps to expand the geographic distribution of conserved habitat areas, which in turn will provide a safeguard against sudden crashes in local food abundances. A final evaluation looks at areas outside of current conservation lands with concentrations of breeding bird atlas records. Concentrations of atlas records might indicate areas with peak abundances or higher quality habitat.

Seven conservation areas have > 10 km^2 but < 30 km^2 of potential limpkin habitat with estimated populations in the range of 25-100 territories. Additions to these conservation areas could help quickly to bring the number of potentially secure populations throughout Florida to 11. The seven conservation areas are Aucilla Wildlife Management Area and St. Marks National Wildlife Refuge (Wakulla and Jefferson counties), Richloam Tract (Withlacoochee State Forest) and

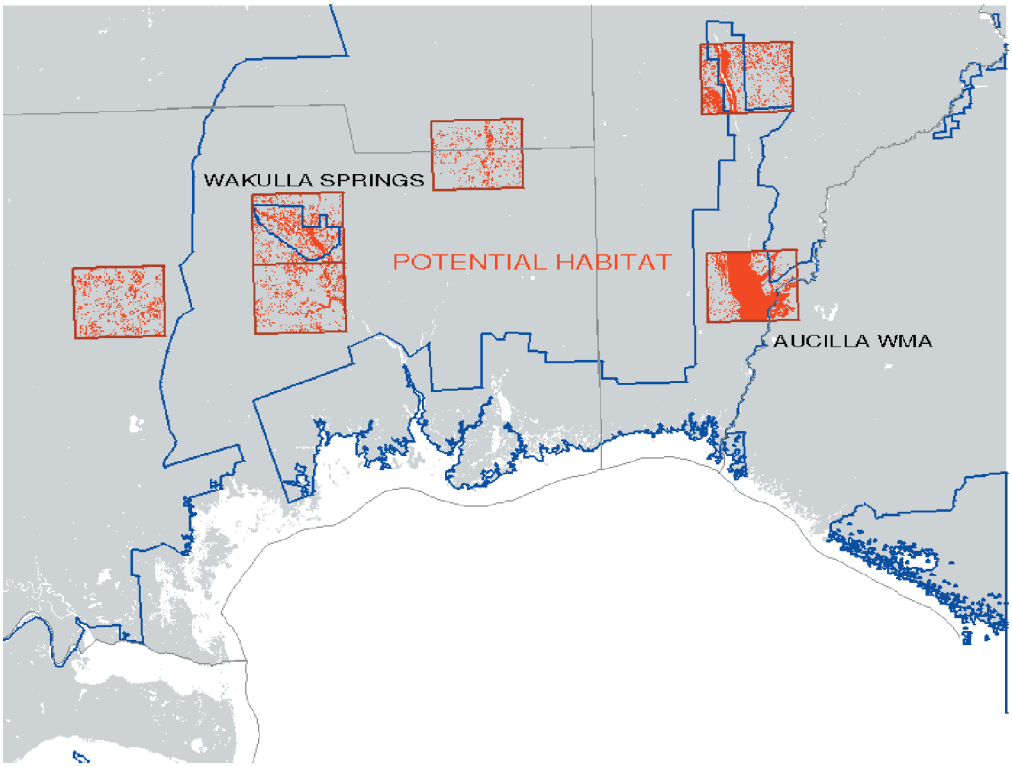


Figure 92. Limpkin habitat near St. Marks National Wildlife Refuge, Wakulla County.

nearby water management district lands in the Green Swamp (Lake, Pasco, Polk, and Sumter counties), Flying Eagle Wildlife Management Area (Citrus and Sumter counties), Carlton Halfmoon Ranch Wildlife Management Area (Citrus and Sumter counties), Tosohatchee State Reserve (Orange County), J. W. Corbett Wildlife Management Area (Palm Beach County), and Corkscrew Swamp Sanctuary (Collier County).

Several large blocks of potential habitat occur outside of St. Marks National Wildlife Refuge and Aucilla Wildlife Management Area (Figure 92) in Jefferson and Wakulla counties. Potential limpkin habitat at Wakulla Springs State Park is within 30 km of these existing conservation areas and likely forms part of a larger regional population covering all three managed areas. The quantity of potential habitat across all managed areas is estimated to be 19 km^2 (4,693 acres). The largest blocks of unprotected habitat are found east of the Aucilla Wildlife Management Area (Wacissa River swamp), north of St. Marks National Wildlife Refuge (St. Marks River), and south of Wakulla Springs State Park (Wakulla River). Much of the potential habitat found south of Wakulla Springs State Park is being developed.

Limpkin habitat associated with wetland areas comprising the Green Swamp, Withlacoochee and Hillsborough rivers, and lakes Tsala, Apopka, and Panasofkee (Figure 93) is distributed among several current conservation areas (Richloam and Croom tracts of the Withlacoochee State Forest, Flying Eagle Wildlife Management Area, Carlton Halfmoon Ranch Wildlife Management Area, and Cross-Florida Barge Canal lands). These conservation areas form part of a large regional population and provide a total of 50 km^2 (12,350 acres) of potential habitat in Sumter, Hernando, and Citrus counties. One of the larger blocks of unprotected habitat occurs to the west and north of Carlton Halfmoon Ranch Wildlife Management Area (Figure 93) and would provide an additional 30 km^2 (7,410 acres) of managed habitat. A small area north

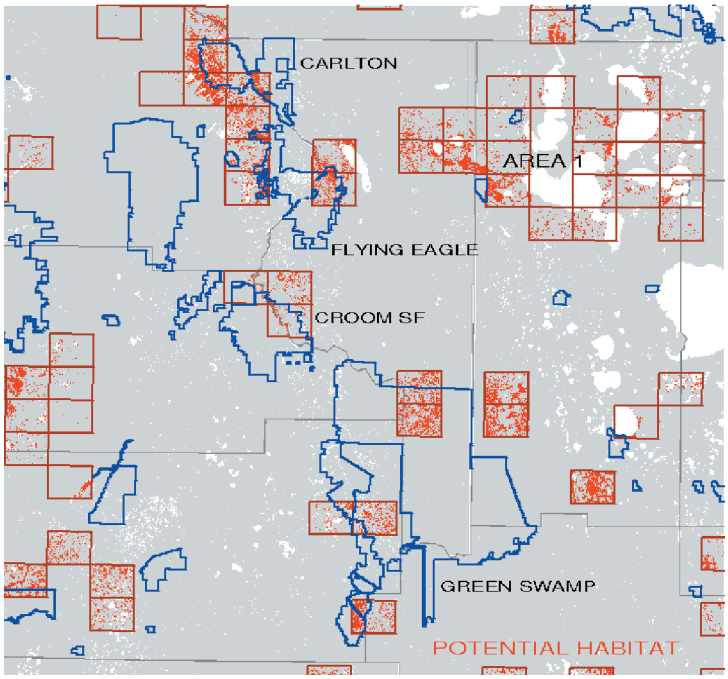


Figure 93. Limpkin habitat along the Withlacoochee River in Citrus, Hernando, Pasco, and Sumter counties.

of the Croom Tract of the Withlacoochee State Forest contains an additional 5 km^2 (1,235 acres) of habitat. Several blocks of potential habitat on unprotected areas around the Richloam Tract of the Withlacoochee State Forest and nearby water management district lands total to about 40 km^2. Unprotected limpkin habitat (Area 1, Figure 93) to the west of Lake Harris (Lake Denham) totals to about 30 km^2 (7,410 acres).

Limpkin habitat surrounding the Tosohatchee State Reserve (Figure 94) in Orange County extends east and south over a very large area and is contiguous with water management district lands beginning at Lake Poinsett and extending south of Blue Cypress Lake. A total potential habitat base of 15 km^2 (3,705 acres) exists on Tosohatchee State Reserve, but the total area of herbaceous and forested wetlands surrounding Tosohatchee State Reserve is 190 km^2 (46,930 acres).

The largest block of unprotected habitat near J. W. Corbett Wildlife Management Area (Figure 95) lies to the southeast around Loxahatchee Slough, a portion of which is owned by the South Florida Water Management District. There are 22 km^2 (5,434 acres) of potential habitat on Corbett and an additional 20 km^2 (4,940 acres) on water management district lands around Loxahatchee Slough. Potential habitat surrounding Loxahatchee Slough could add approximately 20 km^2 of potential habitat to this regional population.

Corkscrew Swamp Sanctuary (Lee and Collier counties) contains 24 km^2 (5,925 acres) of potential habitat (Figure 96) with an additional 70 km^2 (17,290 acres) found on nearby private lands. The largest block of unprotected habitat is

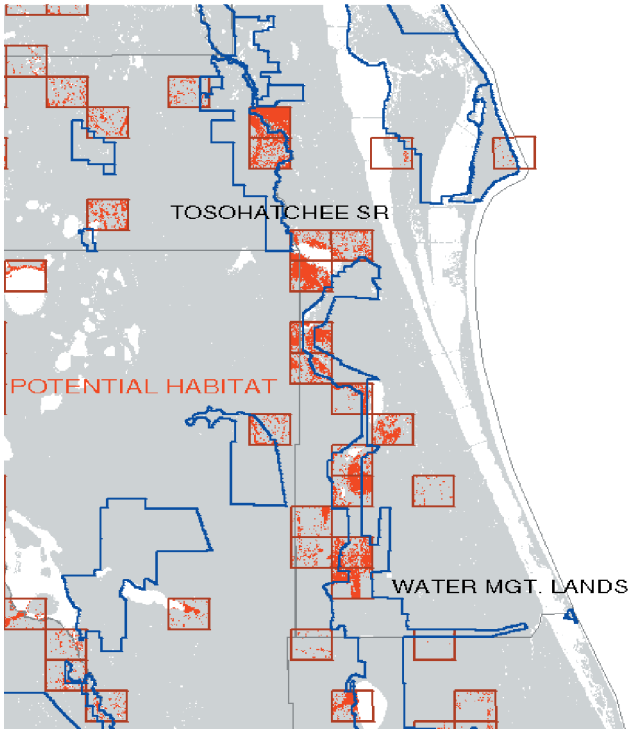


Figure 94. Limpkin habitat near Tosohatchee State Reserve, Brevard County.

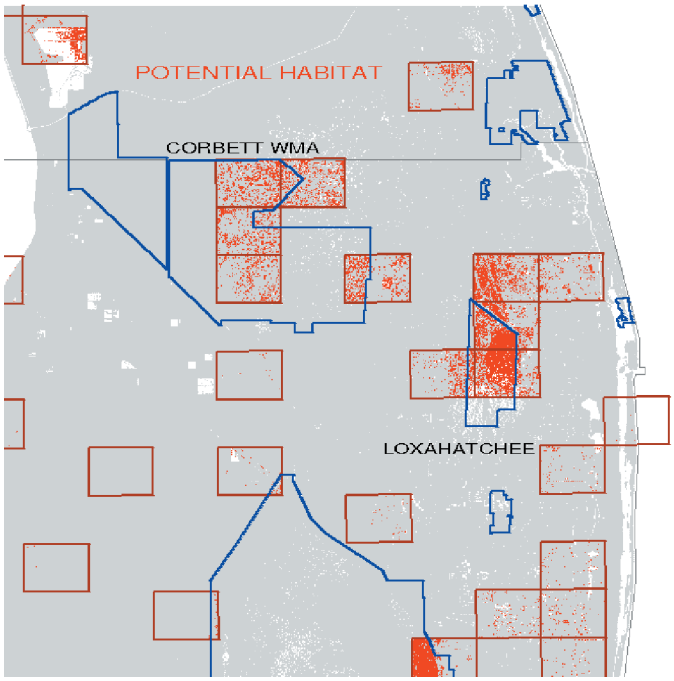


Figure 95. Limpkin habitat near J.W. Corbett Wildlife Management Area, Palm Beach County.

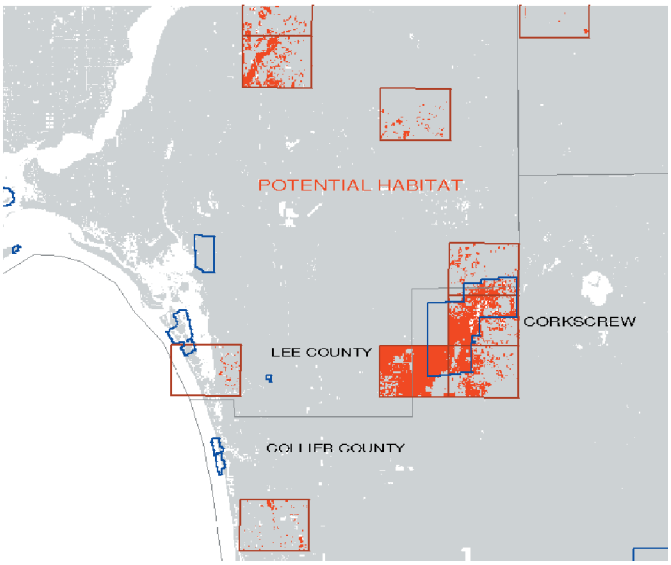


Figure 96. Limpkin habitat near Corkscrew Swamp Sanctuary, Lee County.

found southwest of this conservation area and adds 40 km^2 (9,880 acres) of habitat to the habitat base available on this conservation area.

To evaluate habitat conservation options in geographically distinctive areas (with the rationale being to maintain a broad geographic distribution of conservation areas), we searched the area 30 km beyond the limpkin habitat in current conservation lands and identified large (> 10 km^2, 2,470 acres) tracts of potential habitat falling outside the 30-km zone. Only a few patches of potential habitat satisfied these conditions. One such habitat area is along Econfina Creek south of Gainer Springs in Bay County (Figure 97). There are approximately 10 km^2 (2,470 acres) of potential habitat in this general area that could help to sustain limpkins in the extreme western portion of their current range in Florida. Another large block (18 km^2, 4,446 acres) of habitat satisfying this condition occurs in northeast Florida (Figure 98) around Durbin Swamp and Durbin and Pablo creeks (Duval and St. Johns counties). A final large area

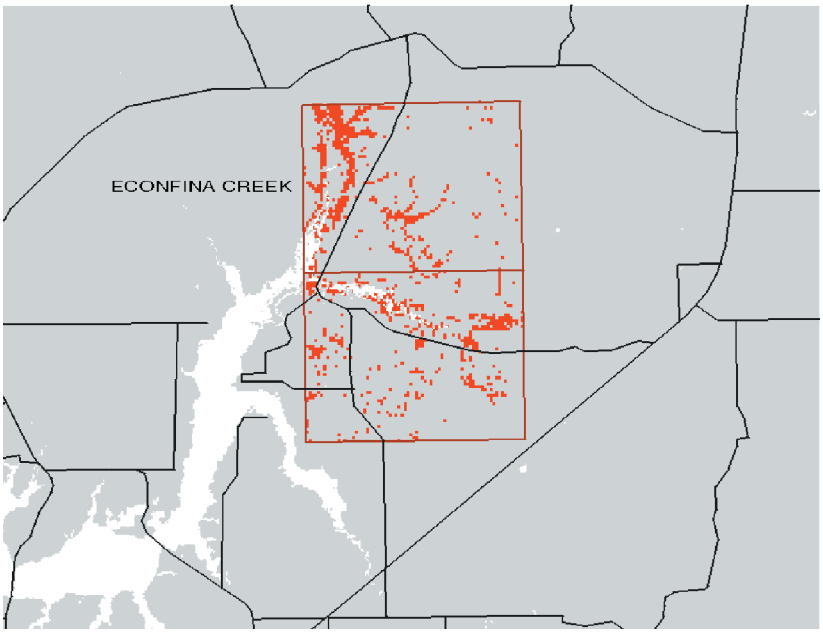


Figure 97. Limpkin habitat near Econfina Creek and Gainer Springs, Bay County.

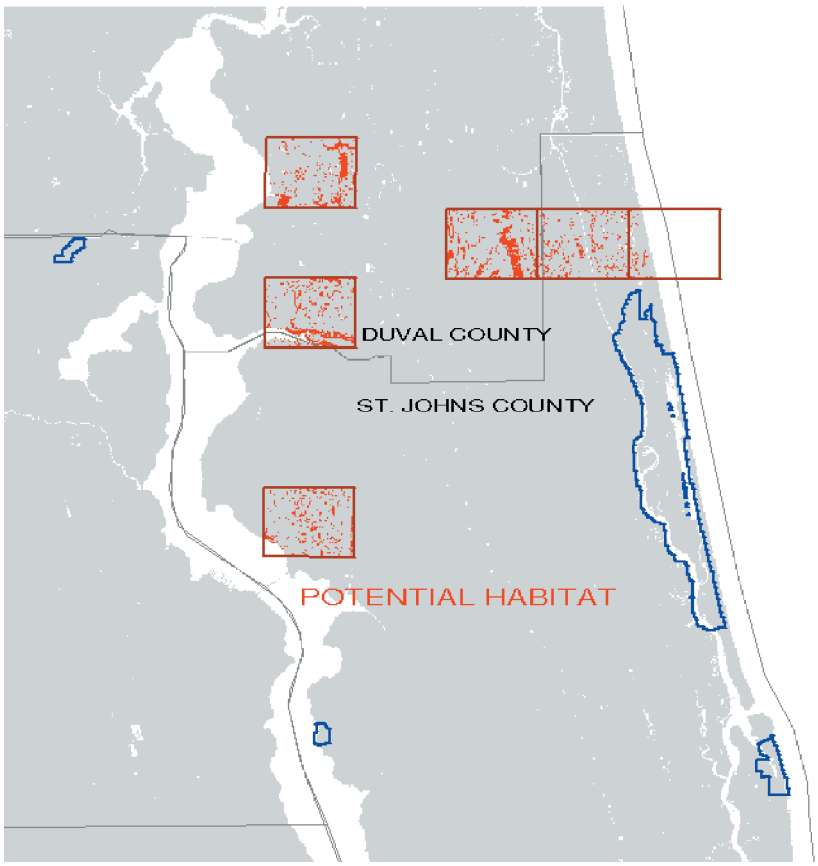


Figure 98. Limpkin habitat near Pablo and Durbin creeks, St. Johns and Duval counties.

Figure 99. Limpkin habitat in southwest Florida.

(Figure 99) of potential habitat (20 km^2, 9,880 acres) satisfying this condition was found in southwest Florida around Graham Marsh, Devil's Garden, and Collins Slough (Hendry County).

Figure 100 shows regions of Florida where limpkins were recorded within five or more contiguous atlas blocks. This figure also shows current conservation areas, which helps to indicate some of the private lands where limpkins are frequently recorded. There are several notable concentrations of atlas records that were not discussed previously. Many records north and south of Avon Park Air Force Range (Area 1, Figure 100) suggest the importance of available habitat in this area. Similar aggregations south of the Ocala National Forest and along the St. Johns and Wekiva rivers (Area 2, Figure 100) point to the importance of these areas to limpkins. Another potentially important cluster of records occurs west of Lake Okeechobee (Area 3, Figure 100).

Many of the areas identified as important to limpkins were also highlighted in analyses of wading bird communities (see Section 6.3.10), Florida sandhill crane, southern bald eagle (see

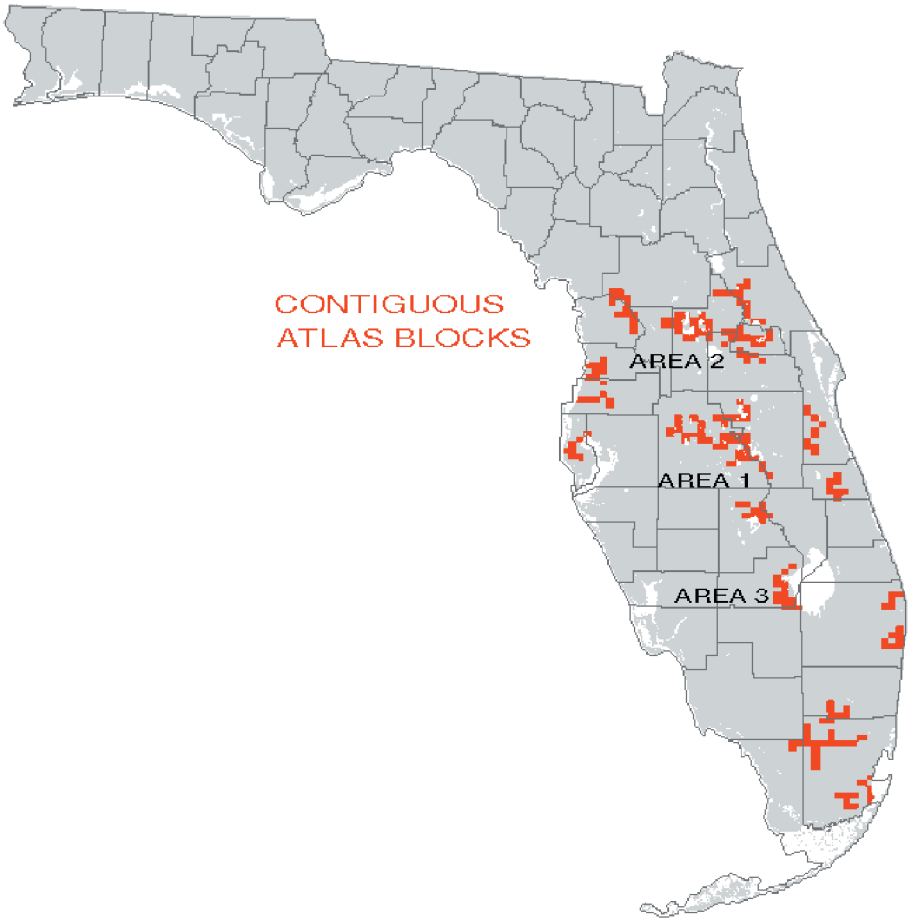


Figure 100. Regions where limpkins were recorded within five or more contiguous atlas blocks.

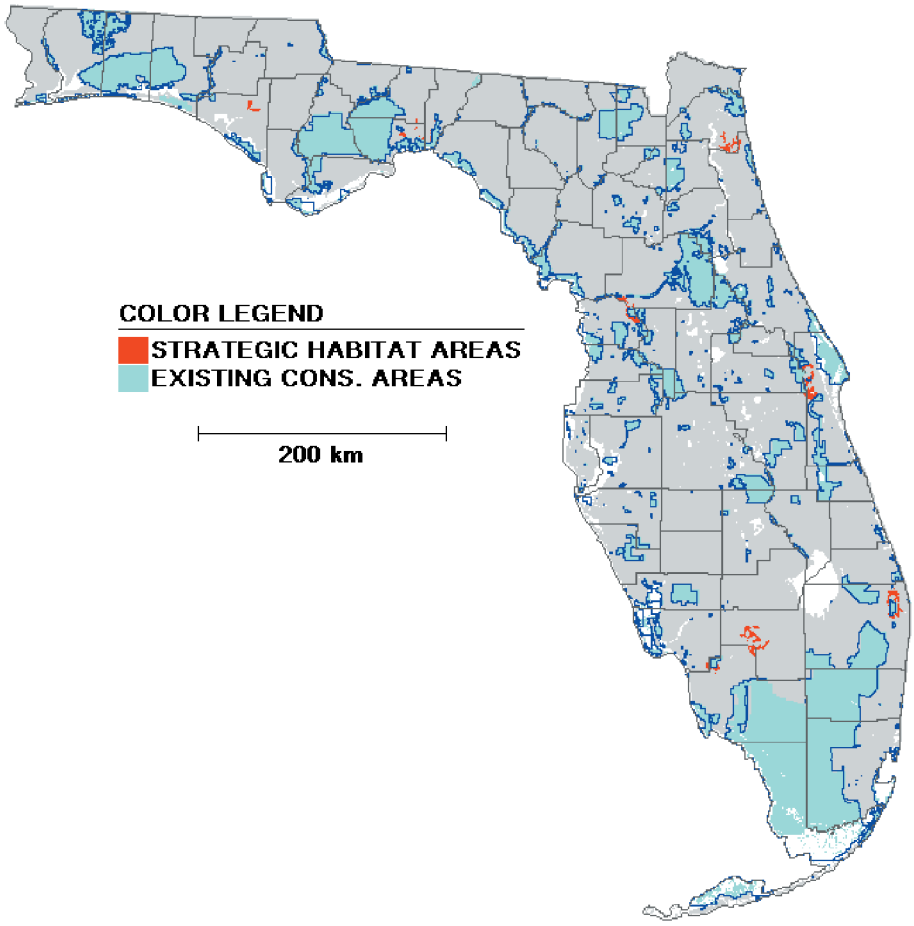


Figure 101. Strategic Habitat Conservation Areas proposed for limpkin populations in Florida.

below), Audubon's crested caracara, and snail kite. Based on the importance of these areas to limpkins and these other rare species and their regulatory status as wetlands, we propose areas shown in Figure 101 as Strategic Habitat Conservation Areas for limpkins. Only the habitat areas described in Bay, Brevard, Citrus, and Sumter counties were not included in recommendations for these other species. The Strategic Habitat Conservation Areas that provide habitat for both limpkins and other rare species may warrant protection through fee-simple acquisition.

Section 6.2.21. Mangrove Cuckoo

The map of potential habitat for the mangrove cuckoo was created using the land-cover map, data points stored by the Florida Natural Areas Inventory, and results from the breeding bird atlas project (Kale et al. 1992). Unfortunately, so little is known about the biology of this species that estimates of potential habitat, even when based on known occurrence information, must be considered tentative and coarse. The primary habitat is inferred to be coastal mangrove swamps (Robertson 1978), but shrub and brush, scrub, and hardwood hammock land cover adjacent to mangrove swamps may also be used (Robertson 1978). Within atlas blocks where mangrove cuckoos were recorded, we isolated the mangrove swamp land cover and the shrub and brush, oak scrub, tropical hammock, and upland hardwood hammock within 100 m of mangrove land cover. We isolated similar land-cover compositions within 500 m of occurrence records stored by the Florida Natural Areas Inventory. The habitat patches resulting from these procedures are generally too small to see on a statewide map. Figure 102 therefore includes the atlas data and point data used to construct this map.

Mangrove cuckoos occur throughout extreme south Florida and extend along the west coast as far north as Tampa Bay. There appear to be four more-or-less distinct habitat areas within this broader range: Tampa Bay, Charlotte Harbor, the Lower Keys, and a large region extending across the southern peninsula from Naples to Miami (and including the upper keys). Robertson (1978) suggested that densities of mangrove cuckoos were highest in the Lower Key, but there is no quantitative information available from any of these areas to use as a standard reference.

We calculated the percentage of "protected" versus "unprotected" habitat for the four regions described above. Such calculations could help to estimate where additional habitat protection might prove most effective in terms of enhancing protection of regional or local populations. A total of 585 km^2 (144,495 acres) of potential habitat is estimated to occur statewide with 83% found within currently defined conservation areas. The Everglades National Park accounts for approximately 86% of the potential habitat estimated to occur in current conservation areas. Among the four more specific

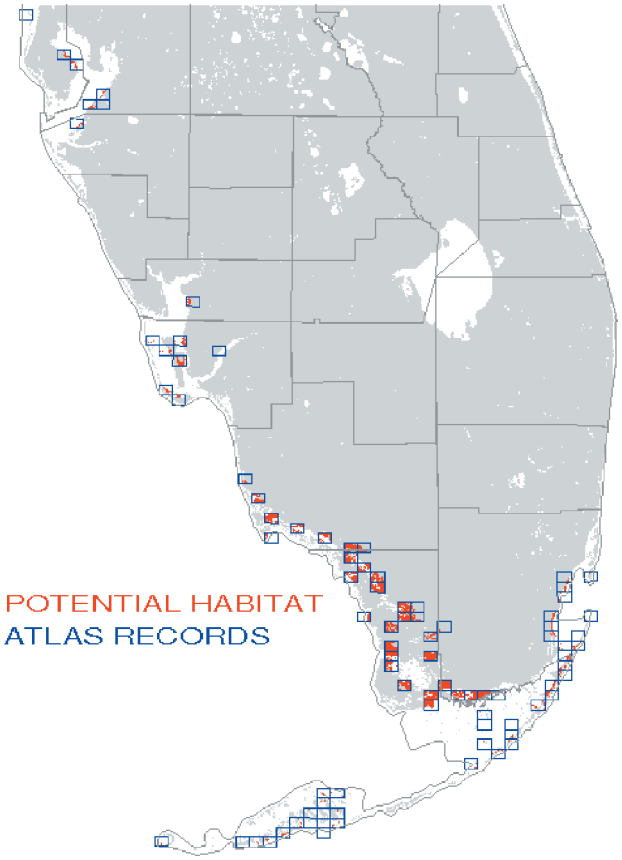


Figure 102. Habitat distribution map for the mangrove cuckoo.

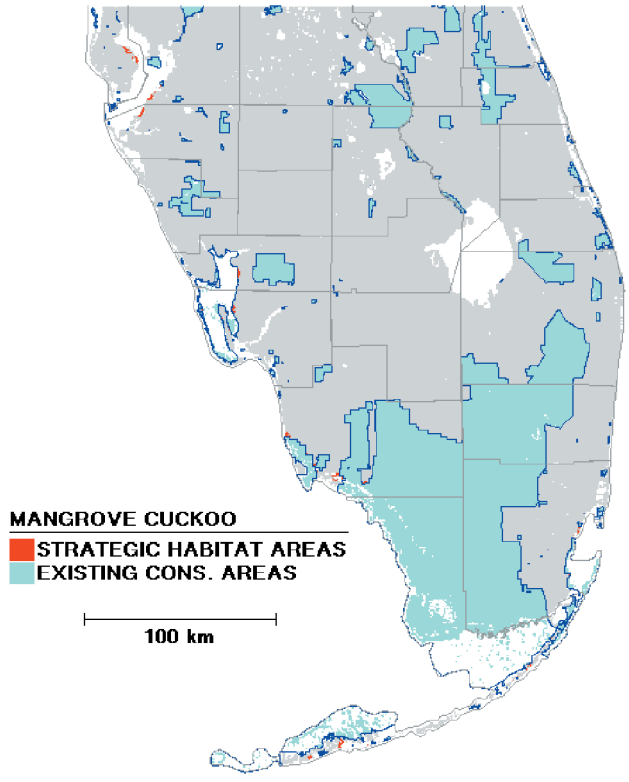


Figure 103. Strategic Habitat Conservation Areas proposed for mangrove cuckoo.

regions defined above, the Tampa Bay region has the smallest percentage of currently protected habitat with only 4% of the potential habitat occurring in some type of formal conservation area (out of a total of 17 km^2, 4,199 acres). The Lower Keys region has the next smallest percentage with approximately 42% of the potential habitat occurring within a formally recognized conservation area (out of a total of 22 km^2, 5,434 acres). The Charlotte Harbor region has 58% of the potential habitat in some formal conservation area (out of a total of 22 km^2, 5,434 acres). The southern peninsula region, stretching from Naples to Miami, has the largest percentage with approximately 90% of the potential habitat occurring within formal conservation areas (out of a total of 505 km^2, 124,735 acres).

Conservation of additional habitat areas in the Lower Keys, Tampa Bay, and around Charlotte Harbor is important to maintaining the current geographic distribution of mangrove cuckoos throughout Florida. Large portions of the available habitat areas in these regions are not formally protected by a designated conservation area. Furthermore, Bancroft et al. (in prep.) found that mangrove cuckoos were not found in forest fragments < 2.3 ha, suggesting that continued habitat loss and fragmentation may eliminate cuckoos in the these areas. Among the three regions described above, conservation of appropriate habitat areas in the Lower Keys is likely to be of greatest importance due to the number of other rare species associated with mangrove swamps in the region (see Sections 6.3.3 and 6.3.9) and the higher densities of mangrove cuckoos reported for this region (Robertson 1978). We designated the potential habitat areas outside of public lands as Strategic Habitat Conservation Areas for mangrove cuckoos (Figure 103). These conservation areas total 95.5 km^2 (23,000 acres) and will help to protect habitat for several other species. Sixty-five occurrence records processed by the Florida Natural Areas Inventory were located in proposed conservation areas for mangrove cuckoos. These records included American crocodile, black-whiskered vireo, roseate spoonbill, wood stork, white-crowned pigeon, Key Largo woodrat, and several rare plants.

Section 6.2.22. Mottled Duck

The mottled duck occurs throughout the prairies and freshwater marshes of south central Florida (Bellrose 1976, Johnson et al. 1991). In past years, mottled ducks were abundant along the St. Johns and Kissimmee River valleys in central Florida (Chamberlain 1960, Lotter and Cornwell 1969), but habitat conditions have deteriorated as a result of ditching, draining, and heavy grazing by cattle and wild hogs. These activities alter natural hydroperiods and plant composition dramatically (Winchester et al. 1985, Winchester 1987). Johnson et al. (1984) provide more recent evidence of declining mottled duck numbers.

Our estimate for the current status of mottled ducks on public conservation areas is based on data presented in Johnson et al. (1991), breeding bird atlas data, and the current land-cover map. We selected the wet prairie and freshwater marsh land-cover types found in breeding bird atlas blocks where mottled ducks had been recorded. We also used a density of 0.639 birds/km^2 for estimating population sizes from this map of potential habitat (Johnson et al. 1991).

The habitat areas important to this species are not adequately protected by current conservation lands in Florida.

Although we estimate that there are five insecure (50-200) and nine imperiled (< 50) populations in current conservation areas, the dispersal capabilities of the species argue for treating the statewide population as a single panmictic population. As such, the current population on conservation areas is estimated to number only about 800 individuals based on the presence of 1344.5 km^2 of potential habitat and a density of 0.63/km^2. Given the small size of the protected population, conservation of additional habitat areas is warranted.

Conservation lands managed by the St. Johns River Water Management District in Indian River County, the Corbett Wildlife Management Area, Lake Okeechobee, and the Water Conservation Areas currently appear to support the largest habitat area for mottled ducks on public lands. To identify the important habitat areas on private lands, we utilized mottled duck survey data collected from 1987-1990 (see Johnson et al. 1991). These surveys include estimates of the number of mottled ducks observed at specific points along survey transects. An interpolation of these point data was developed (Figure 104) to estimate the density of mottled ducks across the survey area, and a Voronoi tessellation was constructed and reclassified to show areas where high densities and frequent occurrences were observed. Areas with densities of four or more ducks per point, and Voronoi polygons < 810 ha (2,000 acres), were classified as frequent high-use regions. The resulting map of high-use regions is shown in Figure 105. The more important areas appear in Okeechobee, Hendry, DeSoto, Glades, and Osceola counties (Figure 105). Most of the regions fall outside the boundaries of current conservation lands.

Important mottled duck habitat conservation areas on private lands were estimated by isolating the wet prairie and freshwater marsh land-cover type within the frequent high-use areas outside of public ownership. We also incorporated agricultural land cover within 200 m of the boundaries of the wet prairie and marsh land-cover types in an effort to estimate some of the rangeland areas that might be used by mottled ducks during years with high rainfall. Although mottled ducks will nest as much as a mile from water and will feed far from established wetlands following major rainfall events (P. Gray pers. comm.), the coarseness of the grassland and agriculture land-cover class forced us to use the more conservative distance of 200 m to estimate the distribution of mottled duck habitat. Elevation data, which are needed to estimate rangeland areas of potential importance to mottled ducks more accurately, were not available at the time this model was performed.

The proposed Strategic Habitat Conservation Areas for mottled duck are shown in Figure 106 and total 462 km^2 (114,000 acres). These areas fall within the frequent high-use areas and include wet prairie and freshwater marsh habitats, and some dry prairie and rangeland. We estimate that these areas will increase the size of the manageable population by at least 400-600 individuals. Other rare species that would benefit from these proposed management zones are Audubon's crested caracara (portions of five territories); wading bird colonies that include little blue heron, great egret, anhinga, and wood stork; and bald eagle (one nest record).

Mottled duck habitat conservation and management within these areas should focus on the conservation of freshwater marshes, dry prairie, and rangeland cover (Johnson et al. 1991). Agricultural land uses such as cattle grazing and rice

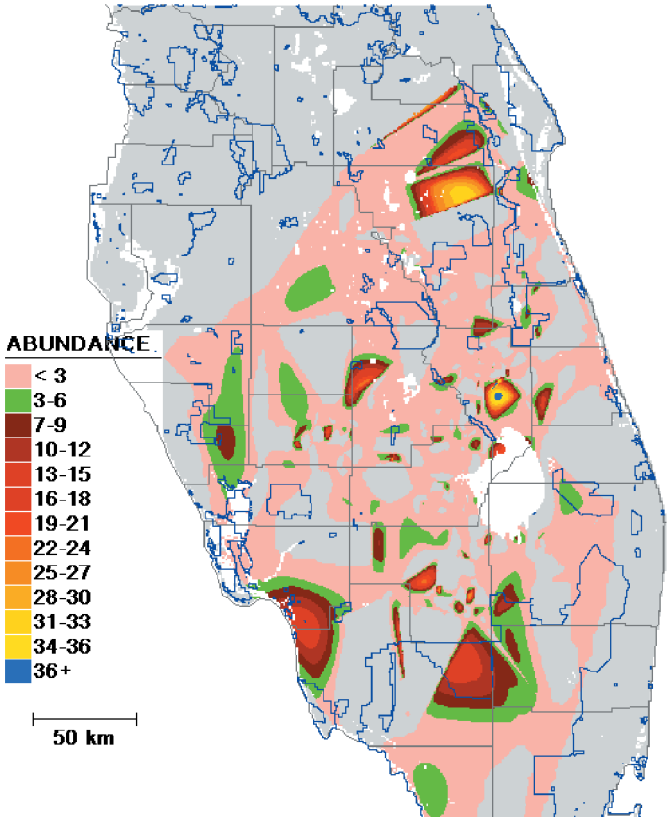


Figure 104. Abundance of mottled ducks in south central Florida as estimated from transect surveys performed by the Florida Game and Fresh Water Fish Commission.

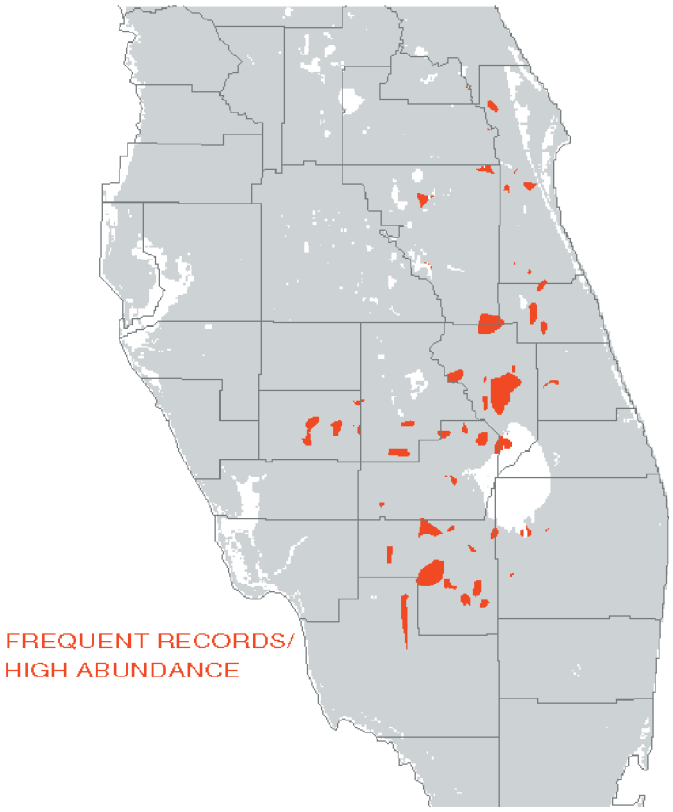


Figure 105. Areas with high abundances and frequent sightings of mottled ducks.

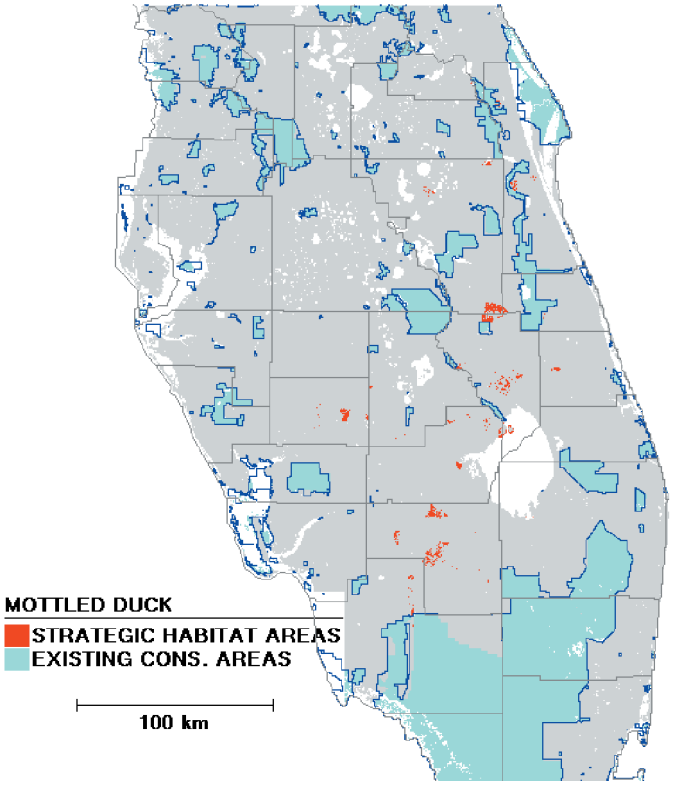


Figure 106. Strategic Habitat Conservation Areas for the mottled duck.

production may be compatible with mottled duck habitat conservation (depending on the intensity of the activity). Steps to restore mottled duck habitat on agricultural lands surrounding Lake Okeechobee are under consideration (Johnson et al. 1991). Restoration of habitat along the Kissimmee River has been initiated as part of the Save Our Everglades campaign (Johnson et al. 1991). In combination with the conservation of habitat areas identified above, these measures will help to establish a secure population of ducks in the Kissimmee and Upper St. Johns river basins.

Section 6.2.23. Pine Barrens Treefrog

The pine barrens treefrog inhabits hillside seepage bogs in four counties of northwest Florida (Means 1992). The habitat distribution map for this species was created using data records processed by the Florida Natural Areas Inventory, survey information provided by P. Moler referenced to quarter sections (65 ha, or 160 acres) of the township-section-range survey system, and the land-cover map. A small-radius circle (250 m) was created around the occurrence records mapped by the Florida Natural Areas Inventory. Within these circles and the quarter sections with documented occurrences, the shrub swamp, hardwood swamp, and shrub and brush land-cover types were isolated.

The distribution of potential habitat (Figure 107) covers 3,316 ha (8,190 acres). Eglin Air Force Base and Blackwater River State Forest provide the largest blocks of habitat on existing conservation areas with totals of 1,277 ha (3,154 acres) and 1,119 ha (2,763 acres), respectively. These acreage estimates are likely low since the survey data used to define potential habitat were not exhaustive (P. Moler pers. comm.). An estimated 72% of the available habitat occurs in conservation areas.

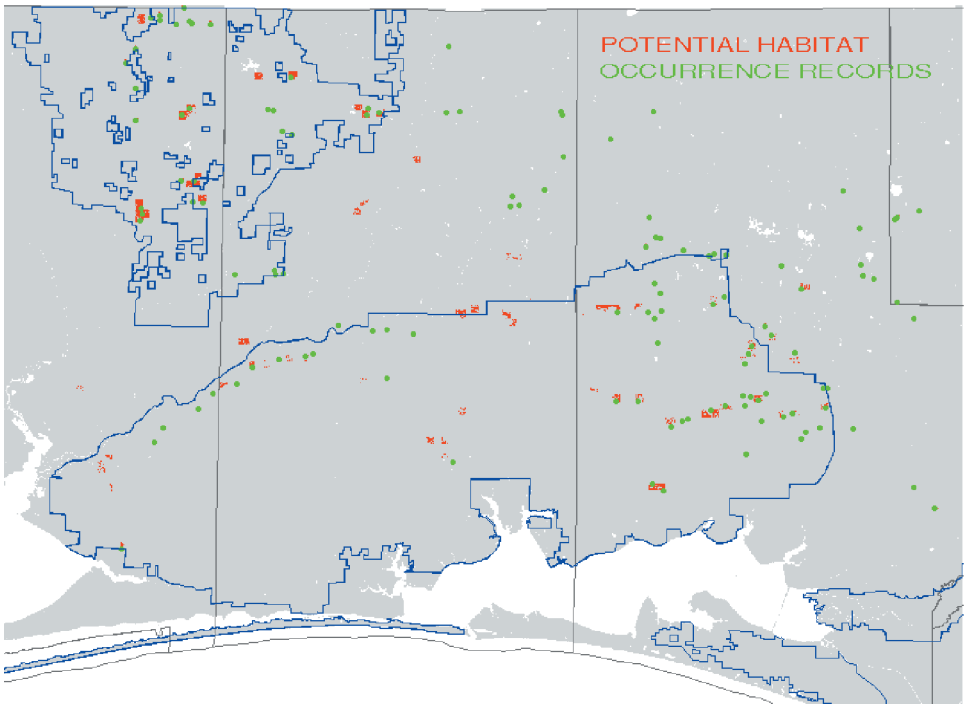


Figure 107. Habitat distribution map for the pine barrens treefrog.

Although the size of populations on existing conservation areas appears to be large, conservation of additional habitat areas might be justified to maintain a broad geographic distribution of protected populations. However, the distribution of habitat patches on public lands seems to accomplish this objective since habitat patches within conservation areas are broadly distributed across several discrete streams. This distribution will provide security against many environmental perturbations.

Conservation of additional treefrog habitat might also be justified based on the importance of habitat areas to other rare species. To evaluate the potential importance of treefrog habitat to other species, we isolated the potential habitat on private lands and tallied up the occurrence records for each unique area processed by the Florida Natural Areas Inventory and Florida Game and Fresh Water Fish Commission. Forty-nine records were found in patches of habitat outside of existing conservation areas, but only two sites (Areas 1 and 2, Figure 107) had records for rare species other than the pine barrens treefrog. Both areas are very close to the boundaries of existing conservation areas. Given the small scale problems associated with maps of conservation areas, occurrence records, and land-cover developed at different scales of resolution, these areas may lie within existing conservation areas and represent an artifact of computer mapping techniques. Other private lands that support geographically distinct populations of the pine barrens treefrog are not known to support other rare species.

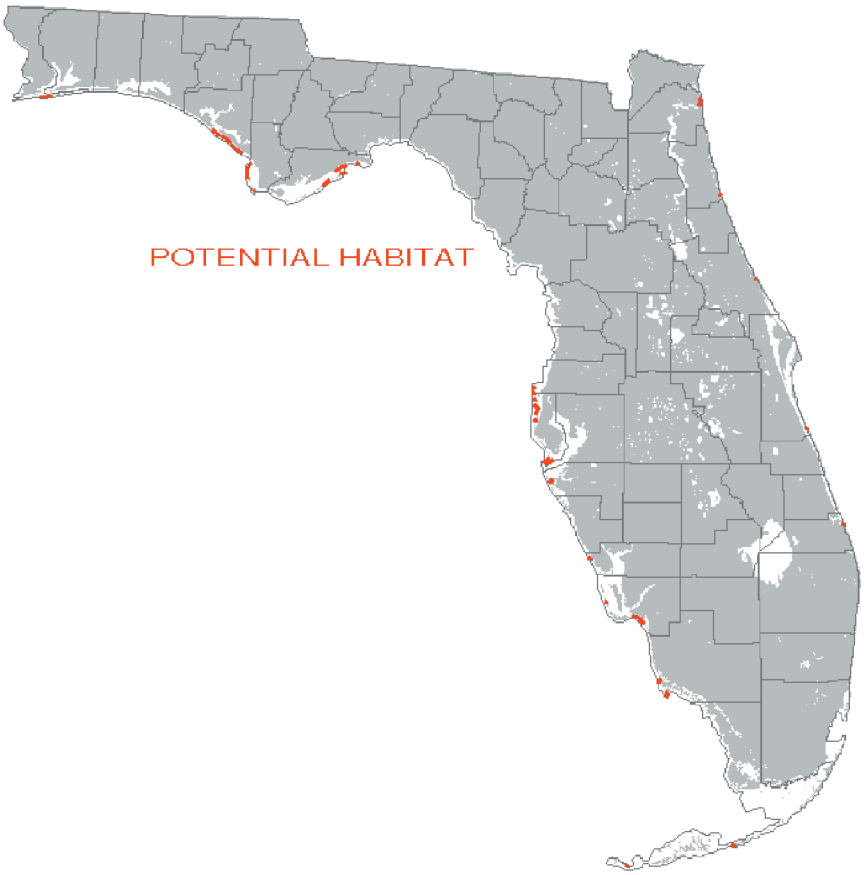


Figure 108. Habitat distribution map for the piping plover.

These analyses lead us to propose that the pine barrens treefrog has adequate representation on the existing system of conservation areas in Florida. Additional survey information may point to distinct habitat areas on private lands that are important to treefrogs and other rare species, but the available information suggests that conservation of habitat areas on private lands will not significantly expand the habitat base for this species nor provide protection for other rare species.

Section 6.2.24. Piping Plover

The habitat distribution map for piping plovers (Figure 108) was developed using maps prepared by participants in a U.S. Fish and Wildlife Service winter survey (Haig and Plissner 1993). We also incorporated point data from the Florida Natural Areas Inventory and Nongame Wildlife Program Wildlife Observation databases that were not included in the information provided by survey participants. The coastal salt marsh, coastal strand, and barren land cover (sandy beaches) within the areas identified by survey participants were included as potential habitat areas. For other locations not specifically mapped by survey participants, we isolated coastal strand and coastal salt marsh. Since some barren land cover consists of sandy beaches that are also appropriate habitat areas, we also included barren land that occurred within 60 m (2 pixels) of the salt marsh and coastal strand areas identified above.

Piping plovers reach their greatest densities along coastal areas of the panhandle and in southwestern Pasco and Pinellas counties. Ohio Key (Monroe County), Ward's Bank (Duval County), and Ponce Inlet (Volusia County) are also known to support important wintering populations of piping plovers (Haig and Plissner 1993). Managing human activities on these important wintering grounds is one of the most important conservation activities that can be pursued for piping plovers in Florida (Haig and Plissner 1993), but conservation of the few habitat areas existing outside of current conservation areas is also important. Some potentially important blocks of unprotected habitat not mentioned above include: Philips Inlet (Bay County); portions of Charlotte Harbor, Estero Island, and Tigertail Beach (Marco Island) in southwest Florida; Floridana, Wabasso Beach, and Hutchinson Island; Boot Key (Monroe County); and Perico Island, Clearwater Beach, and other areas around coastal Pinellas, Pasco, Hillsborough, and Manatee counties.

We do not have a specific goal developed for this wintering species in terms of numbers and distributions of populations and habitat. However, we believe the rarity of the species, coupled with the imperiled status of the coastal areas the species inhabits, warrant conservation of the known wintering habitat areas outside of current conservation areas.

Section 6.2.25. Red-cockaded Woodpecker

The map of potential habitat for red-cockaded woodpeckers relied heavily upon known occurrence information. The land-cover map alone cannot be used to identify the stands of

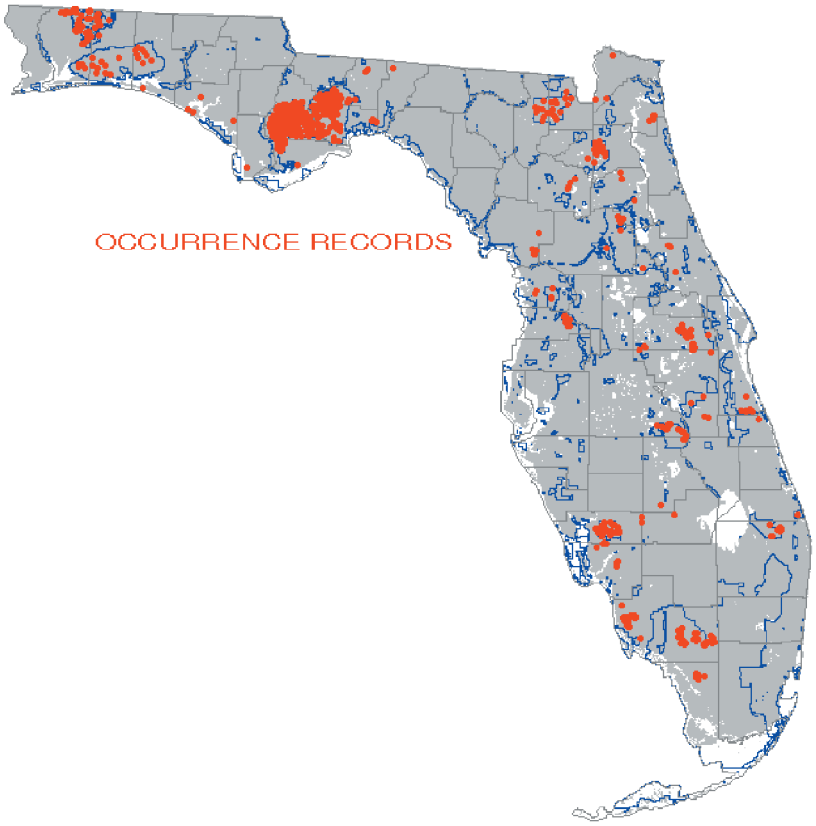


Figure 109. Habitat distribution map for the red-cockaded woodpecker.

mature pines required by this species. Thus, our map shows areas where red-cockaded woodpeckers are known to occur, but it does not include all areas where red-cockaded woodpeckers might occur. The specific data sets incorporated in our map of potential red-cockaded woodpecker habitat included:

(1) locations of 800+ colonies on the Apalachicola National Forest digitized from a 1:126,720 scale U.S. Forest Service map;

(2) locations of active and inactive colonies on Blackwater River State Forest obtained from D. Hardin;

(3) locations of active and inactive colonies on Camp Blanding Military Reserve obtained from J. Garrison;

(4) locations of active colonies on Avon Park Air Force Range obtained from B. Progulske;

(5) locations of active colonies in northeast Florida obtained from W. Baker and M. Allen;

(6) locations of active colonies in central Florida obtained from R. DeLotelle;

(7) locations of colonies on the Withlacoochee State Forest obtained from C. Smith;

(8) locations of colonies in southwest Florida obtained from K. Dryden, J. Beever, and D. Jansen; and

(9) data records stored by the Florida Natural Areas Inventory.

We isolated the pineland, sandhill, dry prairie, and mixed hardwood-pine land-cover types within 500 m of these data sets to identify core habitat areas (DeLotelle et al. 1983, Nesbitt et al. 1983). We also consulted breeding bird atlas records (Kale et al. 1992) of red-cockaded woodpeckers to determine areas where specific colony location information was lacking. Within atlas blocks lacking corresponding point data, we isolated the contiguous patches of the aforementioned land-cover types.

The habitat distribution map for red-cockaded woodpecker (Figure 109) indicates that few large patches of habitat are known outside of public lands. The largest patches of potential habitat mapped outside of public lands are found in Orange, Glades, Collier, and Hendry counties. Private lands in Florida support less than 10% of the known population (Cox et al. 1993), and < 1% of the pine stands in Florida (Bechtold et al. 1990) are old enough (70+ years) to be considered suitable as colony sites (Wood and Wenner 1983). Some of the small populations on private lands have limited chances of long-term survival.

Our review of protective options for red-cockaded woodpeckers focuses initially on the smaller populations on public and private lands that might benefit from additional habitat protection. We believe the area of potential and restorable habitat on Eglin Air Force Base and the Apalachicola National Forest is sufficient to sustain these populations over time. Furthermore, if these populations decline as a result of unfavorable habitat management, the protection of an additional 20,000-40,000 ha (50,000-100,000 acres) is not likely to improve the stability of either population. The persistence of red-cockaded woodpeckers in both areas hinges on habitat management more than habitat acquisition. We also consider how the protection of habitat for red-cockaded woodpeckers might benefit some of the other species analyzed here.

To analyze the potential dispersal of red-cockaded woodpeckers among nearby management areas, we created zones extending 3, 6, and 12 km from the edge of potential habitat areas. These boundaries reflect "frequent," "infrequent," and "very infrequent" dispersal distances (as defined in Cox et al. 1993) and are based on information presented in Walters et al. (1988a). Areas that occurred within 6, 12, and 24 km of each other would appear to be "connected" by these distances. However, the use of 12 and 24 km probably overestimates dispersal capabilities. Walters et al. (1988b) described the long-distance dispersal (90 km) of a single female, but this was an extremely rare event that constituted less than 0.5% of the total number of dispersing individuals. Walters et al. (1988a) showed that most dispersal occurs over a much more limited distance. Average dispersal among males is

only 2.5 km; dispersal in females averages about 10 km (Walters 1988a). However, greater average dispersal distances have been recorded for some populations where the intervening habitat is less suitable (W. Baker pers. comm.).

One of the largest clusters of known active sites (a cluster of cavity trees that might support a breeding pair) on private lands in Florida is located west of the Big Cypress National Preserve and Fakahatchee Strand State Preserve (Area 1, Figure 110). The 14 active sites located here are some 60 km from populations on Big Cypress National Preserve, which means that natural exchanges are unlikely to occur very frequently unless there are additional unknown active sites between these populations. However, this isolated group of woodpeckers is sufficiently large to sustain the population for many generations, and occasional translocations from other populations in the region could alleviate the long-term threats facing this small population. A land acquisition proposal (Anon. 1993) reviewed by the Florida Conservation and Recreation Lands Acquisition Advisory Council would incorporate roughly half of the active sites in this area. This proposed acquisition site, as well as areas just to the north of the site, are among the most important options available for unprotected populations of red-cockaded woodpeckers in Florida.

Another region with several unprotected active sites occurs in Lee, Charlotte, Glades, and Highlands counties in southwest Florida (Area 2, Figure 110). Protection of areas to the south and southwest of the Cecil Webb Wildlife Management Area could increase the size of the protected population to approximately 40 active cavity sites. The distance to the cluster of active cavity sites south of the Cecil Webb Wildlife Management Area is 10 km, and, based on the land-cover map, much of this area appears to consist of potentially suitable habitat. Dispersal between these two areas could occur fairly regularly. There are also records of red-cockaded woodpeckers some 20 km east of the Cecil Webb Wildlife Management Area, but a thorough inventory of woodpeckers in these areas has not been performed. The land-cover map shows extensive areas of potential habitat throughout this region, and a more thorough inventory is needed. Farther to the north and east, R. Bowman (pers. comm.) found approximately 5 active sites at the southern edge of the Lake Wales Ridge (Area 3, Figure 110). S. Gatewood (pers. comm.) reports an unspecified number of active sites along Fisheating Creek (Area 4, Figure 110). This area potentially may have one of the larger populations remaining on private lands in Florida, and the relatively close proximity of these sites suggests that they may be part of a larger regional population of great significance.

The broad region extending from southern Orange County to Avon Park Air Force Range (Figure 111) contains approximately 60 active sites

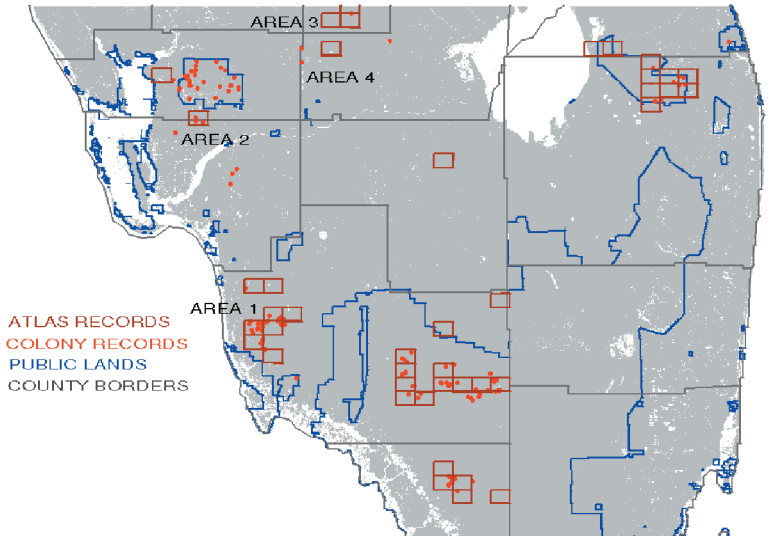


Figure 110. Red-cockaded woodpecker records for southwest Florida.

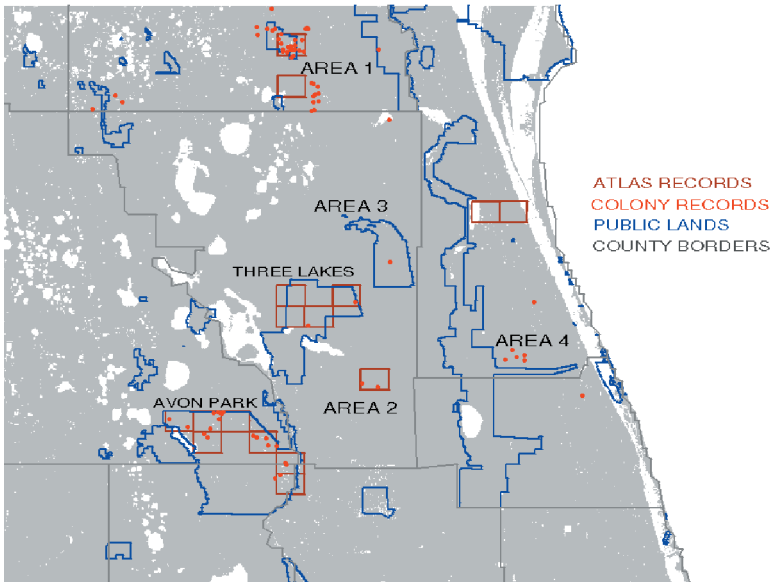


Figure 111. Red-cockaded woodpecker records for south central Florida.

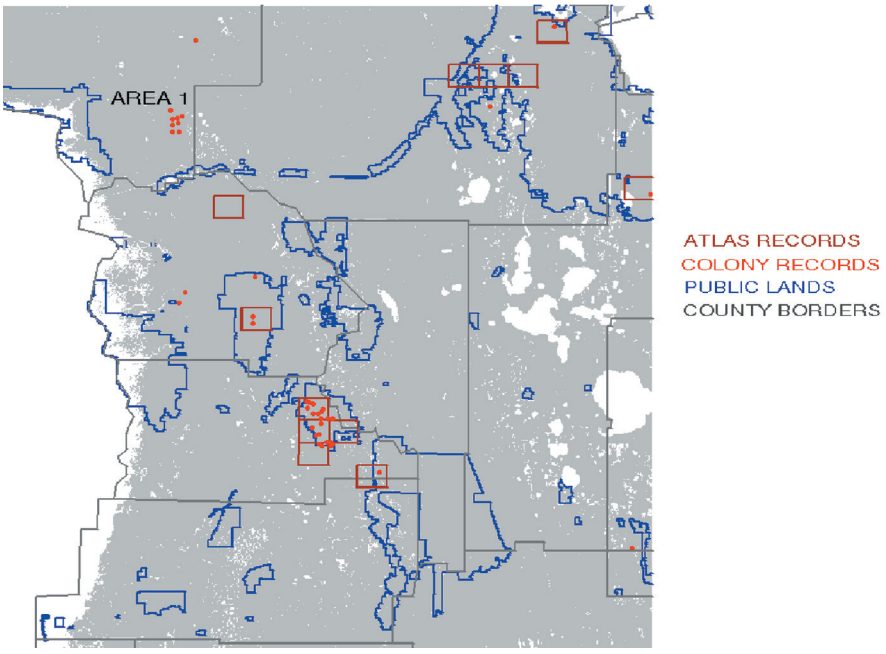


Figure 112. Red-cockaded woodpecker records for west central Florida.

in public ownership and an additional 32 known active sites on private lands. Protection of red-cockaded woodpecker habitat in Orange County (Area 1, Figure 111) would secure yet another population in the range of the insecure population sizes defined earlier. Populations of these general sizes have reasonable chances of long-term persistence, but attention needs to be given to population and habitat management. The two clusters of colonies shown in Area 1 (Figure 111) are sufficiently close that frequent natural interchange is likely. Protection and restoration of habitat in this area would bring the population size into the range of an insecure population and significantly improve the chances of long-term persistence. The protection of habitat in this region would also help to maintain a geographically distinct population.

Land cover north of the Avon Park Air Force Range consists of older pines and may be suitable for red-cockaded woodpeckers. Lack of access to this area has hampered attempts to collect additional information. R. Bowman (pers. comm.) has conducted detailed surveys on Avon Park and estimates a total of approximately 50 active sites on public and private lands in this area. In addition, a known active site occurs on Kicco Wildlife Management Area, which is contiguous to Avon Park Air Force Range.

The southern edge of Three Lakes Wildlife Management Area is approximately 14 km from the northern edge of Avon Park Air Force Range, a dispersal distance towards the extremes reported for red-cockaded woodpeckers. Protection of potential habitat areas extending north of Avon Park to approximately Lake Kissimmee (Figure 111) could also bring the boundaries of these managed areas to within 7 km of one another. This distance approximates the frequent dispersal distances reported for red-cockaded woodpeckers. Conservation of the habitat in this area would also benefit many other rare species (see Section 6.3.6).

Two additional habitat protection options are considered for this broad region. First, areas where red-cockaded woodpeckers have been reported on private lands to the south of Three Lakes Wildlife Management Area (Area 2, Figure 111) warrant consideration, as well as the appropriate land-cover types on private lands that lie between Three Lakes and these records. There also exists a large area of old-growth pines surrounding Bull Creek Wildlife Management Area that may support red-cockaded woodpeckers and could, over time, bring the Three Lakes and Bull Creek wildlife management areas in closer proximity and potentially help bolster the populations on each.

The archipelago of conservation areas comprising the Withlacoochee State Forest (Figure 112) supports approximately 20 active red-cockaded woodpecker cavities. More active sites may be recorded in these areas as a result of surveys in progress (C. Smith pers. comm.). The largest number of active sites occurs on the Croom Tract. However, the Citrus Tract has the largest total area of potential red-cockaded woodpecker habitat. Both areas can support many more active sites than they currently support, and improvement of habitat conditions on these managed areas should be a top priority in red-cockaded conservation efforts in Florida.

The midpoints of these two managed areas are approximately 26 km apart with two smaller conservation areas lying between. Some of the private lands lying between existing conservation areas contain blocks of potential and restorable habitat. The distance between the midpoints of the Croom and Richloam tracts of the Withlacoochee State Forest is also about 25 km, but the intervening habitat in this case is not appropriate for red-cockaded woodpeckers. The only record of red-cockaded woodpeckers immediately north of the Citrus Tract occurs in a large area of suitable habitat where permits for large-scale development have been granted. Conservation of the habitat in this area will be difficult. The cluster of active sites shown farther to the north (Area 1, Figure 112) was recently purchased through Florida's Conservation and Recreation Lands program. However, a proposed extension of the Florida Turnpike (T. Gilbert pers. comm.) runs through this area and may pose a threat to the future security of the population in this area.

The Osceola National Forest, Pinhook Swamp, and Okefenokee National Wildlife Refuge contain a total of approximately 110 active red-cockaded sites (Baker 1993, Cox et al. 1993). Acquisition and restoration of appropriate habitat conditions on private lands between these two areas has been proposed as a means of connecting the red-cockaded woodpecker population on the Osceola National Forest with the red-cockaded woodpecker population on the Okefenokee National Wildlife Refuge (Baker 1993). However, restoration of appropriate habitat conditions throughout large portions of both of these public land holdings will likely improve

the security of red-cockaded woodpecker populations more than additional habitat protection. Almost all known active sites on the Osceola National Forest are south of Interstate 10 (Cox et al. 1993), which means that very long-distance dispersal will be needed for red-cockaded woodpeckers to move from the Osceola to the Okefenokee.

Several private lands near to the Apalachicola National Forest support small populations of red-cockaded woodpeckers, but none of these appears to be sufficiently close to allow for frequent exchanges to occur unless appropriate habitat conditions are established in the intervening areas. The area in Wakulla County (Area 1, Figure 113) has the largest number of active clusters, but commercial timber operations are quickly eliminating the habitat in this area (J. Cox pers. obs.). A sizeable population of approximately 170 active red-cockaded woodpecker sites is found on private lands in southern Georgia just north of Tallahassee. However, this population is some distance from the population on the Apalachicola National Forest, and the intervening areas are dominated by urban land uses.

The proximity of Eglin Air Force Base to Blackwater River State Forest would allow frequent exchanges to occur if the habitat lying between these areas were restored (Figure 114). The Conecuh

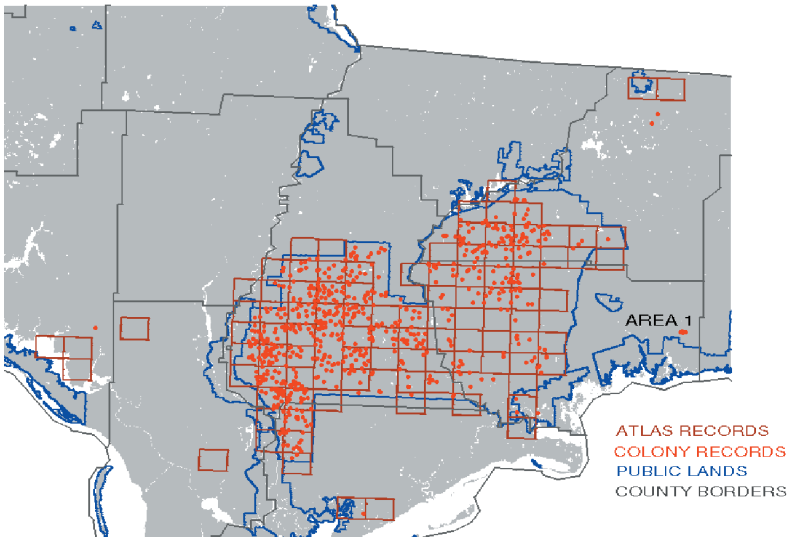


Figure 113. Red-cockaded woodpecker records in or near the Apalachicola National Forest.

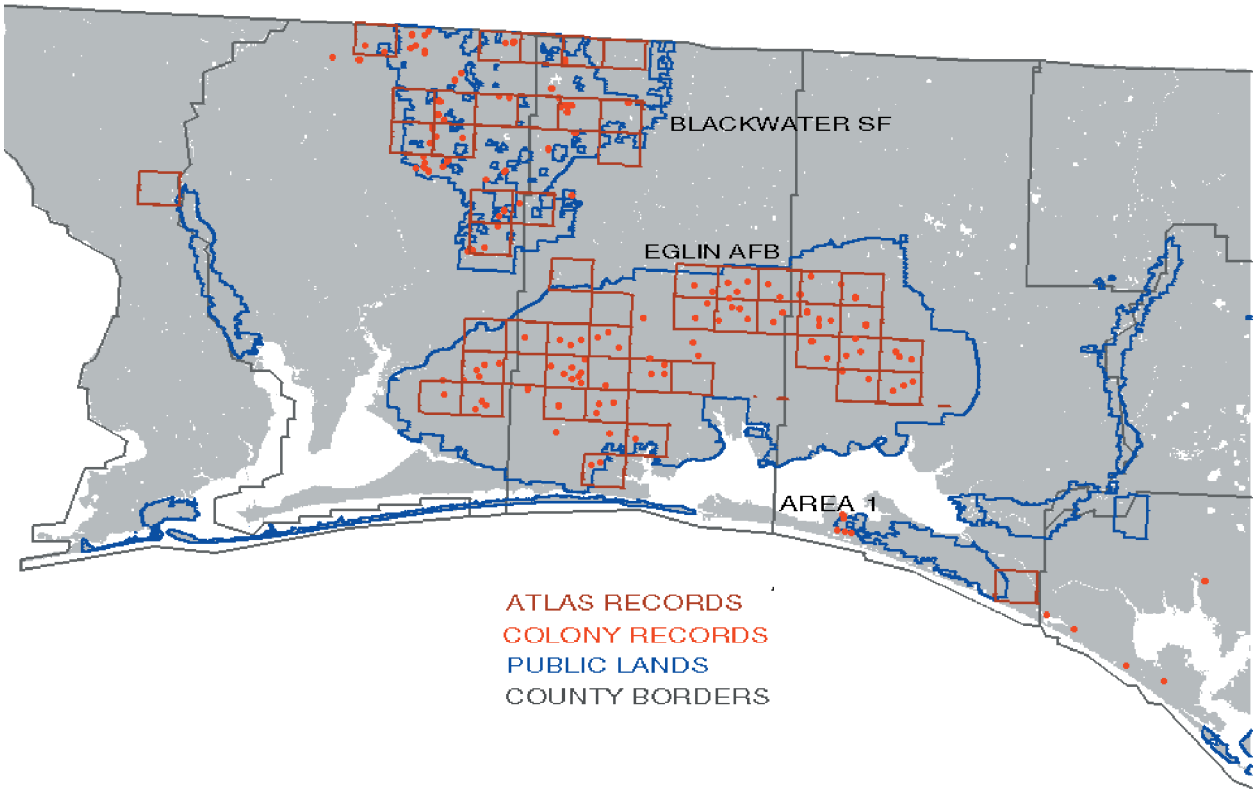


Figure 114. Red-cockaded woodpecker records in or near Eglin Air Force Base and Blackwater State Forest.

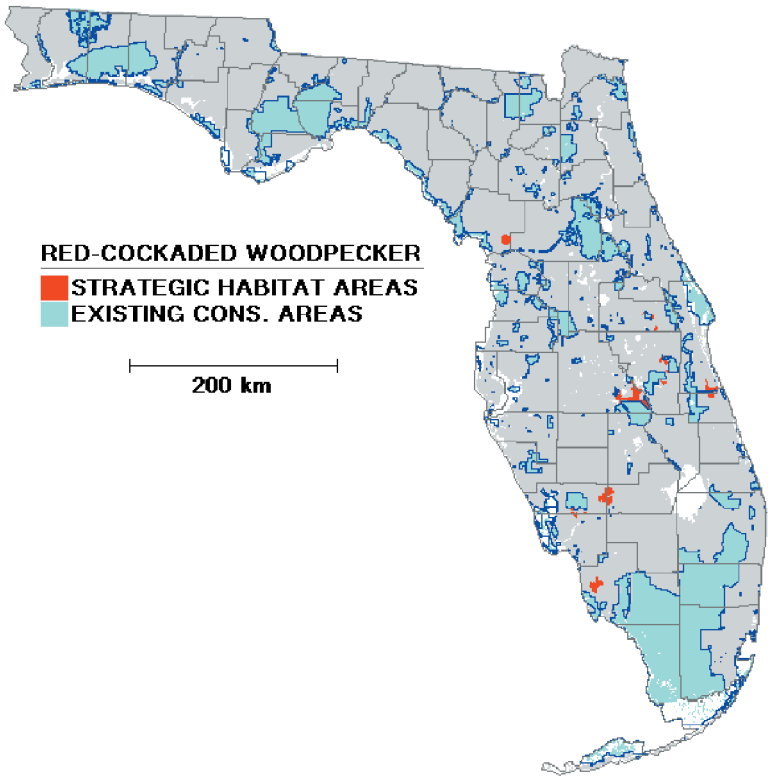


Figure 115. Strategic Habitat Conservation Areas proposed for the red-cockaded woodpecker.

National Forest in Alabama is also very close to the Blackwater River State Forest, and together all three managed areas currently support approximately 270 active sites. Connecting these three areas is a logical proposition (Harris 1985, Anon. 1988), but, as in the case of a proposed Osceola-Okefenokee connection, proper habitat management on existing lands must be viewed as the foremost concern of woodpecker management. It seems unlikely that these areas will produce a surplus of dispersing individuals given that the populations on all three areas are below their carrying capacity and apparently are declining (Green 1993, James 1993). A large cluster of active colonies occurs on private lands in Area 1 (Figure 114, portions of which are now owned by the State.

As demonstrated by Hurricane Hugo in South Carolina (Cely 1993) and Hurricane Andrew in Florida (Jansen 1993), major storms can have a devastating impact on populations of red-cockaded woodpeckers. Thus, a primary consideration should be the maintenance of several secure red-cockaded woodpecker populations throughout a broad geographic area of Florida to guard against the threat of catastrophes striking several populations within a short time period.

We propose Strategic Habitat Conservation Areas for the red-cockaded woodpecker for the known populations in Orange, Collier, and Lee counties, and also for areas of favorable or restorable habitat surrounding Avon Park Air Force Range, Three Lakes Wildlife Management Area, and Bull Creek Wildlife Management Area (Figure 115). Additional areas in south Florida with apparently appropriate habitat conditions may support additional colony sites (Cox et al. 1993), but more information is needed from many of these areas before specific conservation plans can be developed. In particular, areas in Glades and southern Highlands counties are suspected of having larger populations that warrant protection. These areas are included in proposed Strategic Habitat Conservation Area for other species. The habitat requirements of red-cockaded woodpeckers are such that population management will likely be effective only on areas that receive total protection via acquisition. Attempts to conserve additional red-cockaded woodpecker habitat through conservation easements and other less-than-fee techniques will not likely permit a sufficiently broad range of private land uses to make such easements attractive.

Red-cockaded woodpecker populations on many publicly owned areas are not particularly secure. Cox et al. (1993) found that only two public land holdings have potentially secure populations (using definitions provided above): Apalachicola National Forest and Eglin Air Force Base. Both of these populations show signs of declines (Green 1993, James 1993). The Osceola National Forest, J. W. Corbett Wildlife Management Area, Blackwater River State Forest, Big Cypress National Preserve, and Avon Park Air Force Range support insecure populations, and all other conservation areas support imperiled populations totalling fewer than roughly 20 active colony areas. Baker (1983) described the rapid decline and eventual extirpation of a red-cockaded woodpecker population whose initial size was in the range of our definition for an imperiled population. Thus, the continued existence of imperiled populations may be in jeopardy without a new focus on proper management of the areas on which they occur.

Section 6.2.26. Seaside Sparrows

The habitat distribution maps prepared for various geographic races of seaside sparrows were based on distributional information presented in Stevenson and Anderson (1992), breeding bird atlas records (Kale et al. 1992), and the land-cover map. Within atlas blocks where seaside sparrows were reported as "confirmed" or "probable" breeders, we isolated the salt marsh land cover. We also created a 100-m zone around the salt marsh land cover and isolated the freshwater marsh habitat in this zone. This procedure identified transitional marshes that might be occupied by seaside sparrows yet were mapped as freshwater marsh by the classification procedures used.

The quantity of habitat provided by current conservation areas varies greatly for different races of seaside sparrows. Large portions (> 70%) of the habitat available to Wakulla and Cape Sable seaside sparrows occur on conservation lands. On the other hand, distinctive populations found in the panhandle (approximately St. Joseph Peninsula to Pensacola, including the Louisiana seaside sparrow, in part), central Gulf coast (Scott's seaside sparrow), and northeast Florida (Smyrna seaside sparrow) are less adequately protected. The proportion of protected habitat for each of these populations is: 40% for the northeast region (Ft. Matanzas to Amelia Island), 25% for the central Gulf coast (Tampa Bay to Pepperfish Key, Dixie County), and 10% for the panhandle region (St. Joseph Peninsula to Pensacola). Because of their limited geographic distributions in Florida and the small

Figure 116 (a-c). Strategic Habitat Conservation Areas proposed for subspecies of the seaside sparrow.

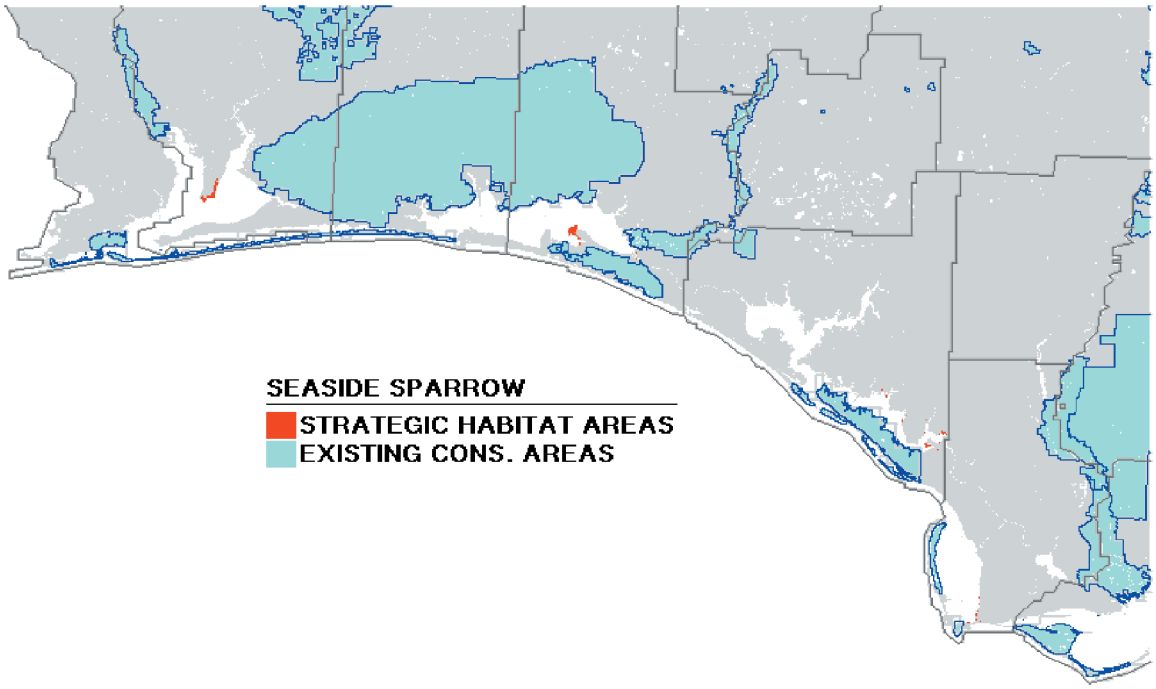


Figure 116a. Louisiana and Wakulla seaside sparrow populations of the Florida panhandle and Big Bend regions.

percentage of occupied habitat in current conservation areas, we consider these latter subspecies in need of habitat conservation efforts.

Unprotected habitat in Pensacola, Choctawhatchee, St. Andrews, and St. Joseph bays sustain distinct seaside sparrow populations (Stevenson and Anderson 1992). Coastal marshes around Ft. Pickens State Park and Garcon Point (private lands) support the seaside sparrow population in Pensacola Bay. Coastal marshes along the eastern edge of Choctawhatchee Bay and at Live Oak Point support seaside sparrows in this geographically distinct area. In St. Andrews Bay, seaside sparrows are known along East Bay from approximately Laird Point to Sandy Creek. The population in St. Joseph Bay is associated with coastal marshes around the southern edge of the bay from approximately Pig Island (St. Vincent's National Wildlife Refuge) to Oak Grove. Because there appear to be at most only three more or less isolated populations across the panhandle, the occupied habitat in all of these areas is proposed as a Strategic Habitat Conservation Area (Figure 116a).

Breeding season records of seaside sparrows in the range of Scott's seaside sparrow (central Gulf coast) are known immediately north and south of Chassahowitzka National Wildlife Refuge, around the mouth of the Withlacoochee River in Levy and Citrus counties, and along Waccassa Bay. Portions of these tidal systems fall within the boundaries of aquatic preserves, but most of the identified habitat lies outside of current conservation areas. We categorize the known occupied habitat areas as a Strategic Habitat Conservation Area for this subspecies (Figure 116b).

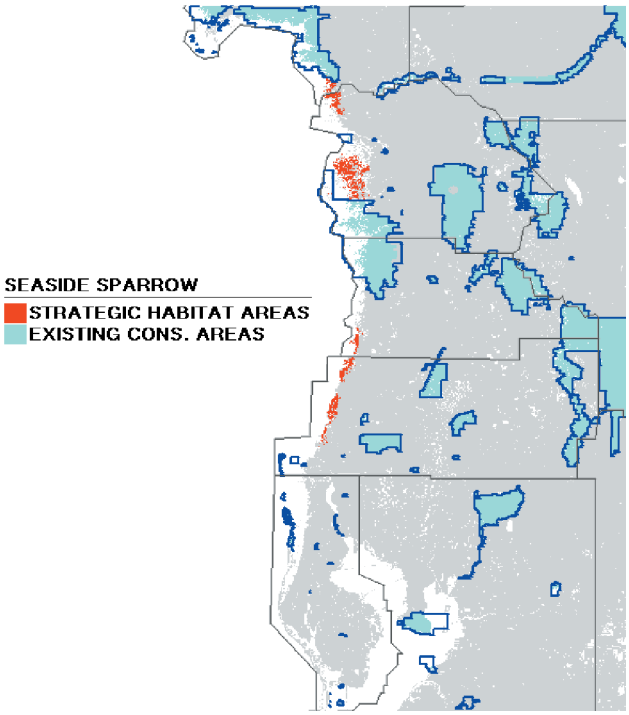


Figure 116b. Scott's seaside sparrow, central Gulf coast.

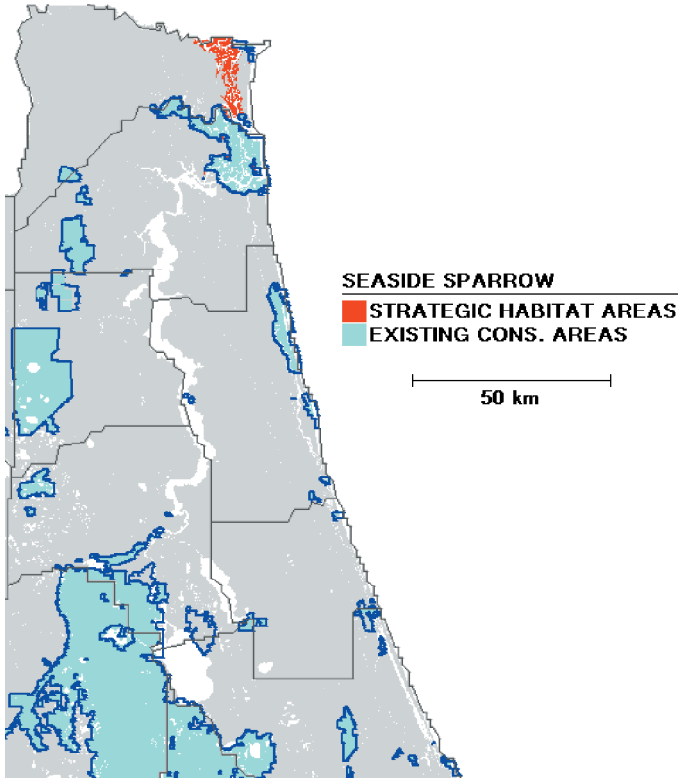


Figure 116c. Smyrna seaside sparrow, northeast Atlantic coast.

Several large blocks of habitat occur within the range of the Smyrna seaside sparrow (St. Johns River to Amelia Island). The largest expanses of coastal marshes are found along Sister Creek, Ft. George River, Pumpkin Hill Creek, Nassau River, and St. Marys River. Portions of these tidal systems fall within the boundaries of aquatic preserves, but the protection offered by aquatic preserves is poorly defined. We categorize the known occupied habitat as a Strategic Habitat Conservation Area (Figure 116c).

Conservation efforts for this species may not require additional acquisition. Current regulations pertaining to wetlands have the potential to provide adequate conservation of the habitat features important to these focal species.

Section 6.2.27. Short-tailed Hawk

The habitat distribution map for the short-tailed hawk was developed using occurrence information in the Florida Game and Fresh Water Fish Commission Wildlife Observation database and breeding bird atlas records (Kale et al. 1992). Habitat requirements for this species are poorly understood; however, the occurrence information alone (Figure 117) provides ample proof that this species lacks adequate representation in current conservation areas in Florida. A total of about 30 occurrence records exists, and only about half of these are associated with current conservation areas.

The rarity of this species, coupled with limited distribution information, provides little guidance on new protective strategies. Most areas where this species has been recorded

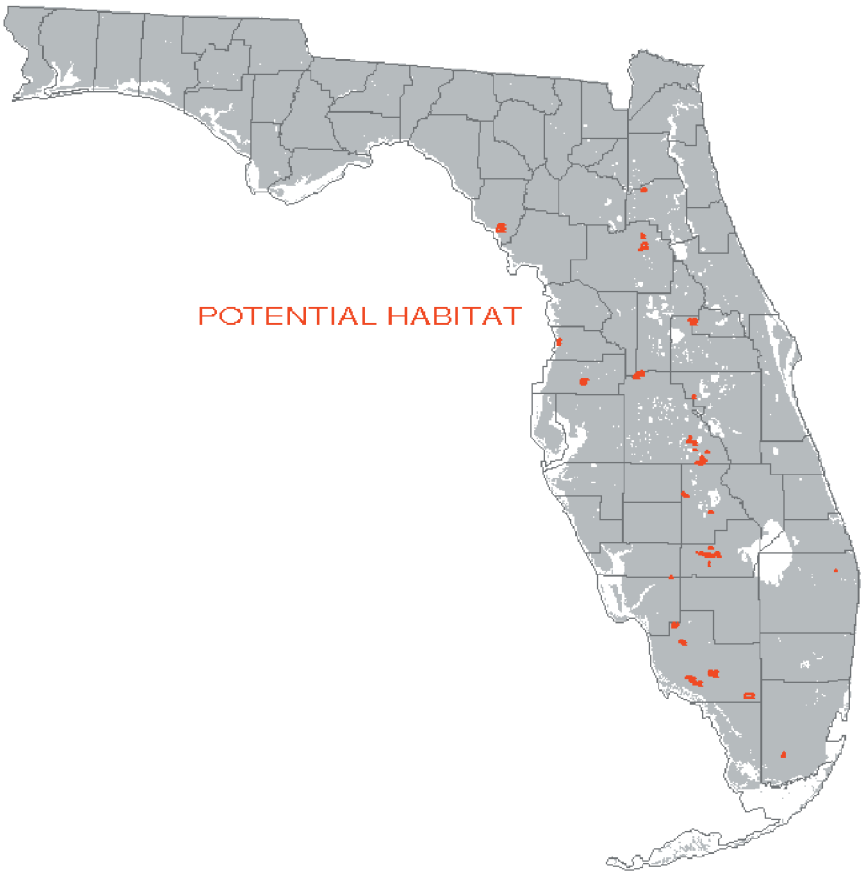


Figure 117. Habitat distribution map for the short-tailed hawk.

consist of a mix of large forested tracts, which are used for nesting, and nearby open areas, which serve as foraging areas (B. Millsap pers. comm.). Forested wetlands and upland hardwood hammocks around Big Cypress Swamp, Fisheating Creek, Green Swamp, Wekiva River, and California Swamp seem to provide appropriate nesting conditions. The largest aggregation of occurrence records comes from along Fisheating Creek in Glades County.

Securing an adequate base of habitat for this species may be achieved by protecting habitat for other species (e.g., black bear and Florida panther), but several areas where this species was recorded are not prime areas for either black bears or Florida panthers (e.g., Arbuckle Creek in Polk County). Perhaps the best habitat conservation strategy is simply to conserve the forested habitat, open rangeland, and natural cover in areas where this species has been recorded nesting. We developed Strategic Habitat Conservation Areas that consisted of 810 ha (2,000 acres) of forested lands around all recent occurrences (Figure 118).

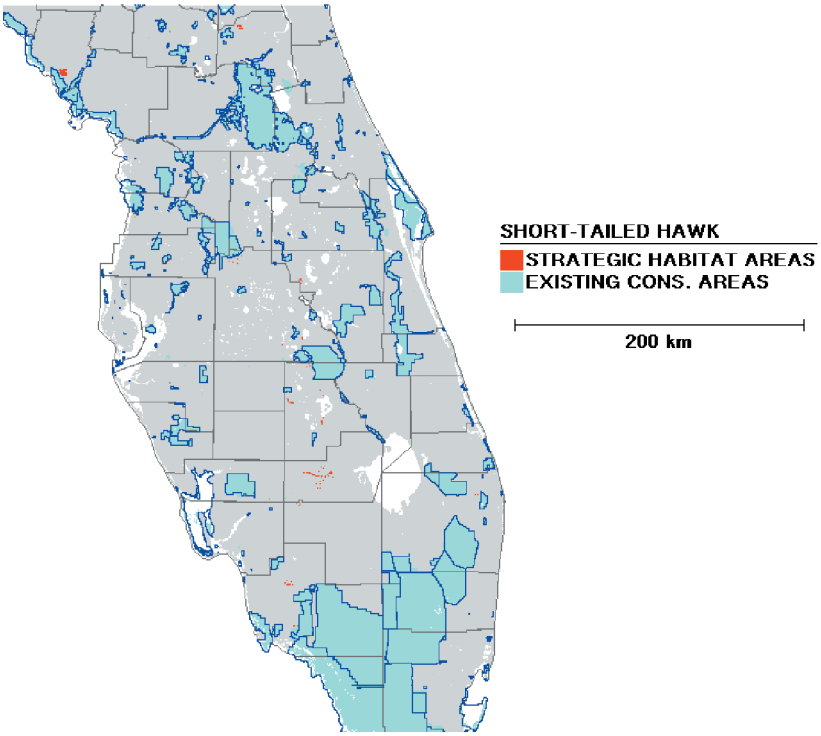


Figure 118. Proposed Strategic Habitat Conservation Areas for the short-tailed hawk.

Section 6.2.28. Snail Kite

The habitat distribution map for the snail kite was developed using a variety of polygonal and point data sets. Based on information presented in Sykes (1984), Rodgers et al. (1988), Takekawa and Beissinger (1989), and Rodgers (1992), we digitized nesting and foraging sites throughout Florida and isolated the freshwater marsh, shrub swamp, and open water found within these areas. We then generated a 0.5-km zone around these habitat patches and also highlighted the dry prairie and grassland areas that fell within this distance and may constitute appropriate habitat areas in very wet years (particularly along the Kissimmee River).

The total size of the Florida snail kite population has been estimated at < 800 individuals for many years (Rodgers 1992). This species lacks an adequate base of habitat in current conservation areas. The information available on snail kites (Sykes 1984, Takekawa and Beissinger 1989, Rodgers 1992) points to a few important habitat areas (Figure 119) outside of current conservation areas. Among the more important freshwater marshes are those associated with East Lake Tohopekaliga, Lake Kissimmee, Lake Tohopekaliga, Able Canal Marsh (Lee County), and the Upper St. Johns River (Rodgers 1992). These areas provide critical nesting habitat for snail kites (Rodgers in press), and may also serve as important winter refugia (Rodgers 1992).

There is considerable variation in the number of snail kites observed at these marsh systems each year. For example, East Lake Tohopekaliga and Lake Tohopekaliga supported few nesting snail kites from 1986-1988.

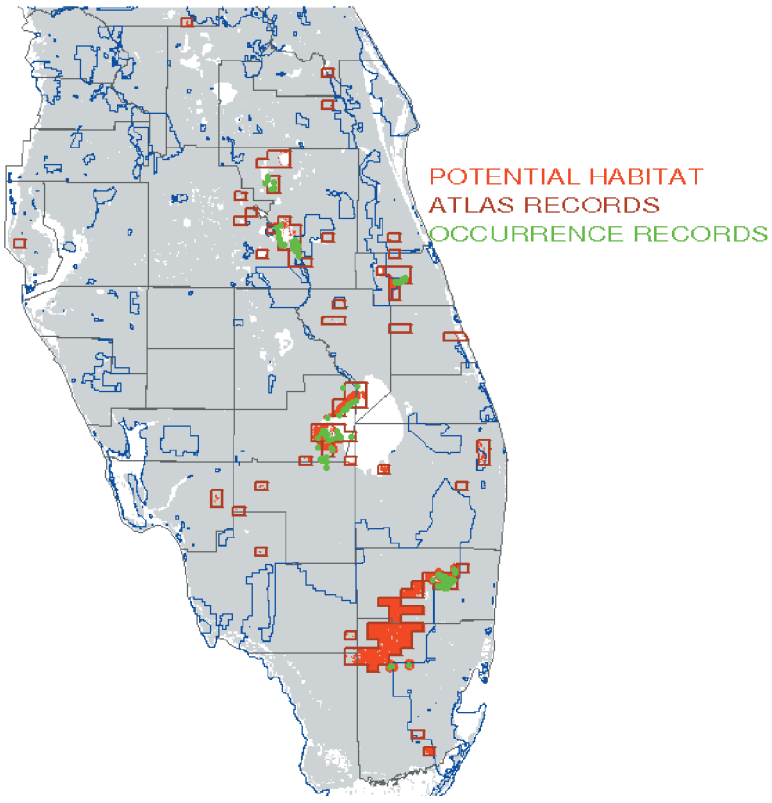


Figure 119. Habitat distribution map for the snail kite.

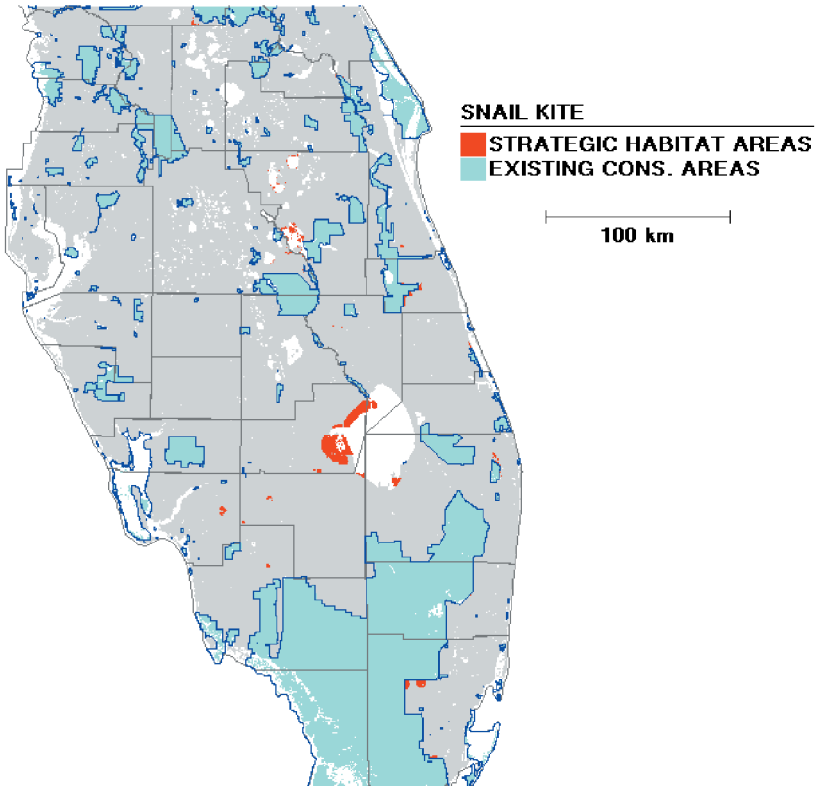


Figure 120. Strategic Habitat Conservation Areas for the snail kite.

However, in 1990 these two lakes supported 25% of the known nesting population (Rodgers 1992). This variation results from specific hydrologic conditions that vary over a large spatial scale and yet are critical to nest-site selection. The appropriate hydrologic conditions are not repeated in each area year after year (Takekawa and Beissinger 1989), and kites become nomadic when conditions in "traditional" nesting areas are not appropriate, usually venturing to marshes north of the Everglades along the Kissimmee Lakes, to marshes associated with the Upper St. Johns River, and to marshes along the Caloosahatchee River west of Lake Okeechobee.

This nomadic characteristic is predictable (Takekawa and Beissinger 1989, Rodgers in press) and requires that habitat management and conservation efforts be extended to areas outside the boundaries of current water conservation areas of the Everglades. We categorize the known nesting locations outside of current conservation areas as Strategic Habitat Conservation Areas (Figure 120). Not all of these areas are recognized in the snail kite recovery plan (U.S. Fish and Wildlife Service 1986b), but each is critical to maintaining the broad geographic habitat areas required to support this species.

Several management considerations could enhance the survival potential of snail kites (Rodgers in press). Discharge of nutrient-laden water from agricultural and dairy sources into Lake Okeechobee and the Water Conservation Areas has contributed to the loss of foraging habitat and die-offs of snails (Rodgers in press). Non-native species such as water hyacinth, water lettuce, torpedo grass, and hydrilla have proliferated in some areas and reduced the available foraging area (Rodgers in press). Herbicide application has in some cases caused nests built in cattails and bulrushes to collapse (Rodgers in press). Herbicide application in these areas must be carefully coordinated.

Section 6.2.29. Southeastern American Kestrel

The habitat distribution map for the southeastern American kestrel was created using point data stored by the Florida Natural Areas Inventory and breeding bird atlas records (Kale et al. 1992). We isolated sandhill, dry prairie, grass and agriculture, and mixed hardwood-pine land cover within 500 m of Florida Natural Areas Inventory data points documenting known occurrences. This distance reflects an estimated territory size (Stys 1993). Within atlas blocks where kestrels were recorded as "confirmed" or "probable" breeders (Kale et al. 1992), we isolated the sandhill, mixed hardwood-pine, and dry prairie land cover and generated a 200 m buffer around these cover types. The grass and agriculture land cover within this 200 m zone was also included as potential kestrel habitat. This latter map does not include many areas with rangeland and agriculture land cover that might support southeastern American kestrel (Stys 1993), but it does emphasize natural land cover where kestrels have been reported.

Open ground cover is an important factor that determines suitability of foraging habitat (Stys 1993), but the location of nest sites may occur in less open areas with appropriate nesting structures. Assessing the suitability of ground cover using the land-cover map was impossible, and any discussion of potential habitat areas should note that some areas may not currently be in an appropriate condition for kestrels. Some of the areas will require restoration through prescribed fire or mechanical treatment.

The largest contiguous patches of potential kestrel habitat remaining in Florida (Figure 121) occur along a sand ridge that extends from Hernando County north to Gilchrist, southern Suwannee, and Columbia counties. Other large blocks of potential habitat are found in southwestern Clay County, and central Walton and Santa Rosa counties in the panhandle. The prairie and scrub lands along the Lake Wales ridge of south central Florida also support a significant population of southeastern kestrels as indicated by the number of atlas records for this area. These areas also coincide with the areas of highest density for the species as determined from breeding bird survey data (Hamel 1992).

Stys (1993) summarized information on densities of southeastern kestrels in a range of land-cover types. We used a density of 0.8/km^2 (1 territory/300 acres) to estimate the size of populations of southeastern kestrels on conservation areas in Florida. Based on this estimate, there are approximately three insecure populations (50-200 individuals) and approximately 52 imperiled populations (< 50 individuals) on conservation lands in Florida. The largest habitat areas on existing conservation areas are estimated to occur on Eglin Air Force Base (168 km^2 of potential habitat), Ocala National Forest (101 km^2 of potential habitat), Citrus and Croom tracts of the Withlacoochee State Forest (61 and 42 km^2, respectively, of potential habitat), Camp Blanding Military Reserve (33 km^2 of potential habitat), and Apalachicola National Forest (30 km^2 of potential habitat). We conclude that southeastern kestrels are not adequately represented in current conservation areas in Florida.

The close proximity of several of the conservation areas mentioned above to one another raises questions about the degree to which kestrels might disperse among these areas. Current conservation areas may actually contain sufficient habitat to support a much larger regional population when dispersal capabilities are taken into account. To evaluate broader regions over which southeastern kestrels might frequently disperse, we generated 10-km buffers around the potential habitat found within public lands to show broader areas where interchange might occur as a result of dispersal. Data from south central Florida (J. Layne pers. comm., in Stys 1993) indicate that 10-km dispersal events occur regularly with occasional long-distance dispersal reported up to approximately 30 km.

This analysis shows the possibility of there being at least one much larger regional population. The potential habitat areas on Camp Blanding Military Reserve, Ocala National Forest, Croom and Citrus tracts of the Withlacoochee State Forest, and other smaller conservation lands (Figure 122) fall within the estimated dispersal capacity of this species, and frequent interchanges among these areas seem likely. The Ocala National Forest is at the center of this extended area, and the total habitat area is 410 km^2 (101,270 acres) of potential habitat across all current conservation areas. We estimate these conservation areas have sufficient habitat to support a potentially secure population (> 200 individuals).

Given the presence of this larger regional habitat area, our analyses generally focus on habitat areas outside this region in an effort to help maintain the geographic distribution of the subspecies. However, as indicated by breeding bird atlas records (Figure 121), there appear to be only two

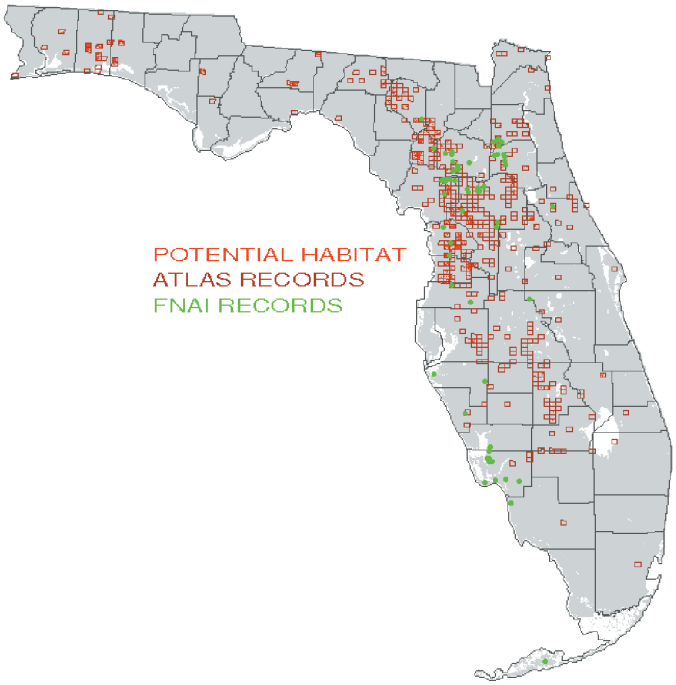


Figure 121. Habitat distribution map for the southeastern American kestrel.

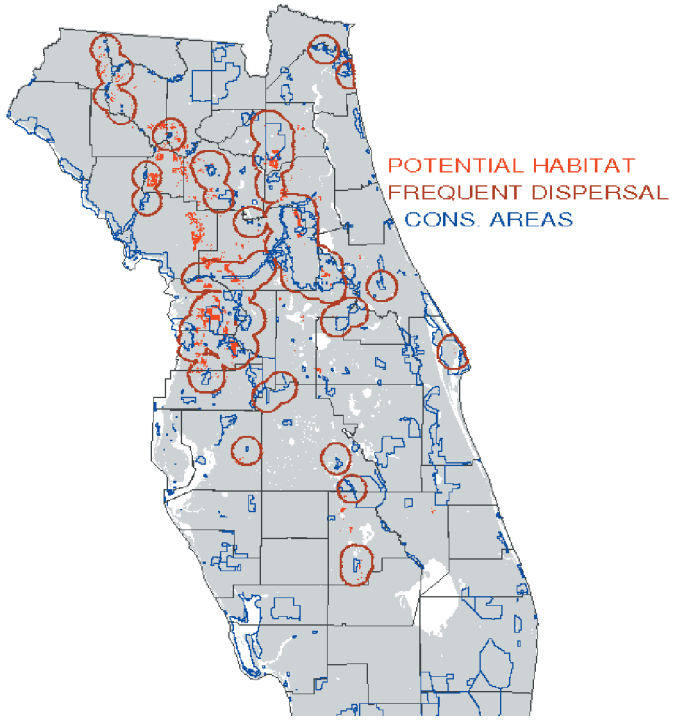


Figure 122. Higher level organization of southeastern American kestrel habitat based on proximity of habitat within current conservation lands.

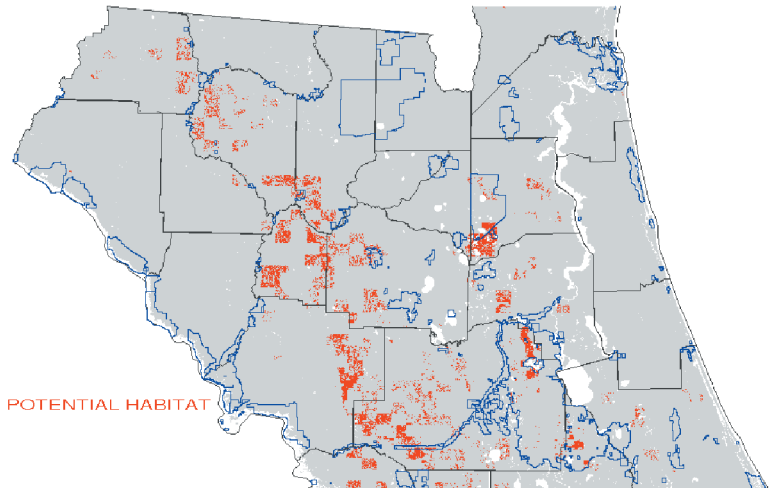


Figure 123. Distribution of kestrel habitat in north central Florida.

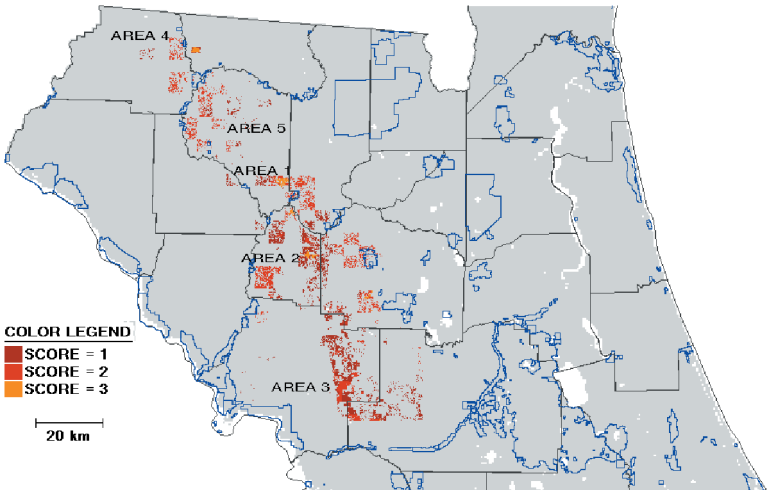


Figure 124. Qualitative scoring of kestrel habitat in north central Florida. Scores reflect the size of habitat patches and their occurrence on large landownerships.

broader regions in Florida where numerous breeding bird atlas records and appropriate land-cover types coincide. These are the region around the central Lake Wales ridge (Polk and Highlands counties) extending west to southern Hillsborough County, and a large sandhill ridge system extending from Hernando to Hamilton County. We discuss the habitat conservation options available within each of these regions separately.

Figure 123 shows the distribution of southeastern kestrel habitat along the ridge system extending from Hernando County to Hamilton County. Some of the largest blocks of potential habitat are found in eastern Levy County, western Alachua County, southern Suwannee and Columbia counties, and northwestern Suwannee and eastern Madison counties. We estimate a total of 22 km^2 (5,434 acres) of potential habitat currently occurs on conservation areas in this broad area, and another 738 km^2 (179,816 acres) occurs on private lands. Conservation of an additional 180 km^2 (44,460 acres) of potential habitat would establish a regional population of approximately 100-200 territories, and the placement of conservation areas could be such that they enhance movement among all conservation areas.

We developed additional qualitative measures for the remaining patches of potential kestrel habitat using information on landownerships and the proximity of habitat patches to existing conservation areas. First, we isolated the potential habitat found on large private landownerships in this region and assigned these areas a score of 1. We also isolated the kestrel habitat within 10 km of current conservation areas in the region that contained southeastern kestrels and assigned these areas a value of 1.

When these maps were added to the original map of potential kestrel habitat (Figure 123), a map with index scores from 1-3 is produced (Figure 124). The highest scoring areas (Figure 124) occurred in Gilchrist County, eastern Alachua County, Levy County, and southern Suwannee County. Several high-scoring areas occurred around Ichetucknee Springs State Park (Suwannee County), and they might serve to establish a larger regional habitat conservation area for southeastern kestrels that is centered around this state park. A high-scoring area to the northwest of Ichetucknee Springs State Park (Area 1) is contiguous to the state park by virtue of a powerline corridor (used for nesting and foraging, J. Cox pers. obs.) that intersects both areas. Another high ranking area (Area 2) near Ichetucknee Springs State Park is near Wilson's Spring Road near the Sante Fe River in Gilchrist County. Other high-scoring areas in eastern Alachua County are near Kanapaha Prairie and Watermelon Pond.

The extensive tracts of potential habitat in eastern Levy County along State Road 337 (Area 3) present many options for enhancing kestrel habitat conservation. A particularly high ranking site occurs within the triangle defined by state roads 121, 337, and 326. Residential development is expanding into much of this area, but there are yet several large tracts of sandhill and rangeland cover that would be important to kestrel conservation efforts. Other high scoring tracts found in Madison, Hamilton, and Suwannee counties (Areas 4 and 5) would help maintain kestrels in the northern portion of this formerly extensive ridge system.

Based on field surveys of the high ranking areas described above (J. Cox pers. obs.), Strategic Habitat Conservation Areas are proposed as shown in Figure 125. These proposed kestrel conservation areas total 182 km^2 and are dominated by sandhill and mixed hardwood-pine land cover, and they include nearby grass and agriculture land cover. Conservation of these areas would also benefit such species as gopher tortoise, Sherman's fox squirrel, and Florida pine snake.

Concentrations of records of southeastern kestrels in central and southwest Florida (Figure 126) also point to several important habitat areas in a region extending from eastern Hillsborough County to Glades County. Conservation of kestrel habitat in this broad area is needed to help bolster

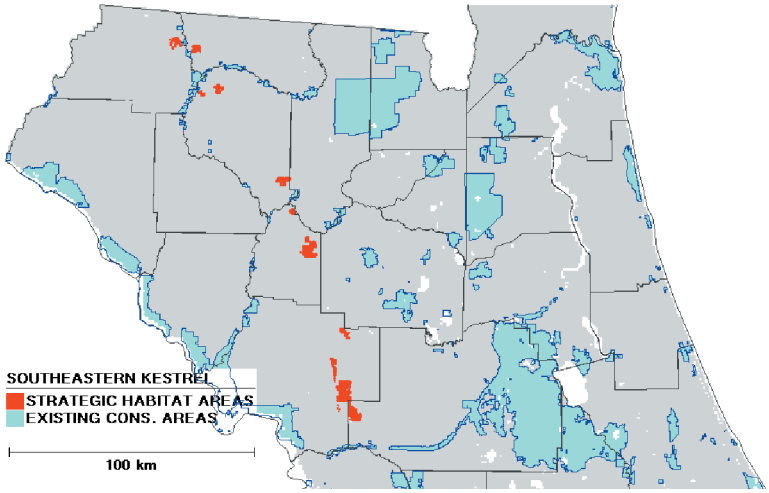


Figure 125. Strategic Habitat Conservation Areas for the southeastern American kestrel in north central Florida.

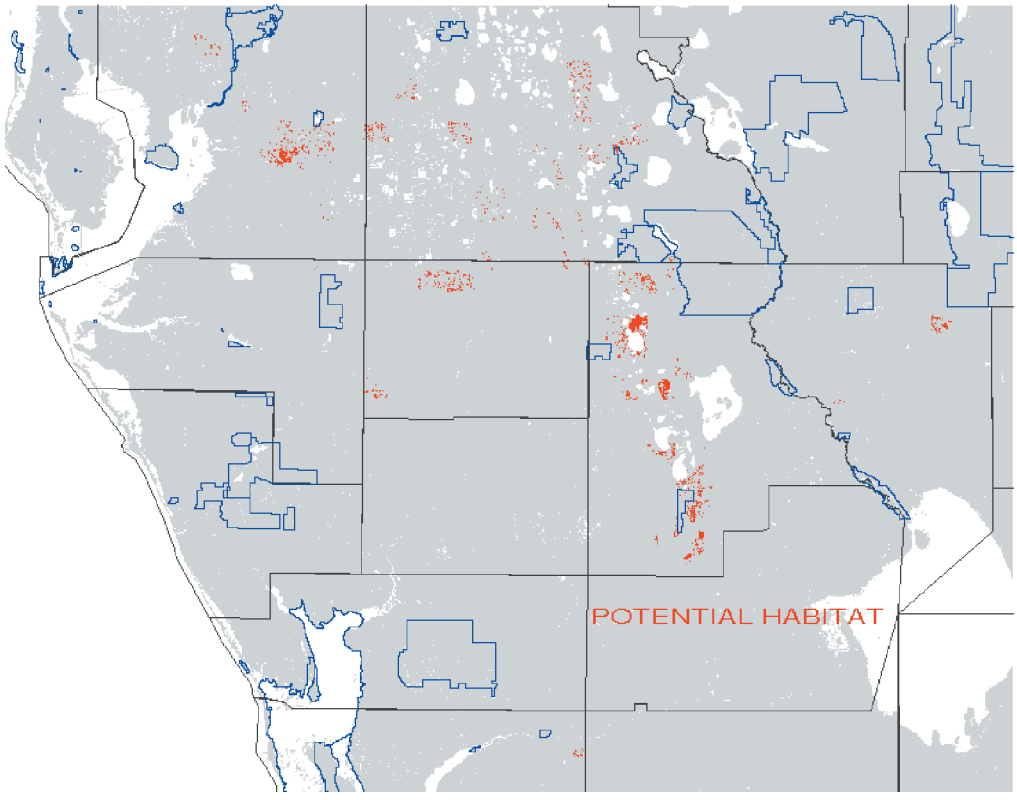


Figure 126. Distribution of kestrel habitat in south central Florida.

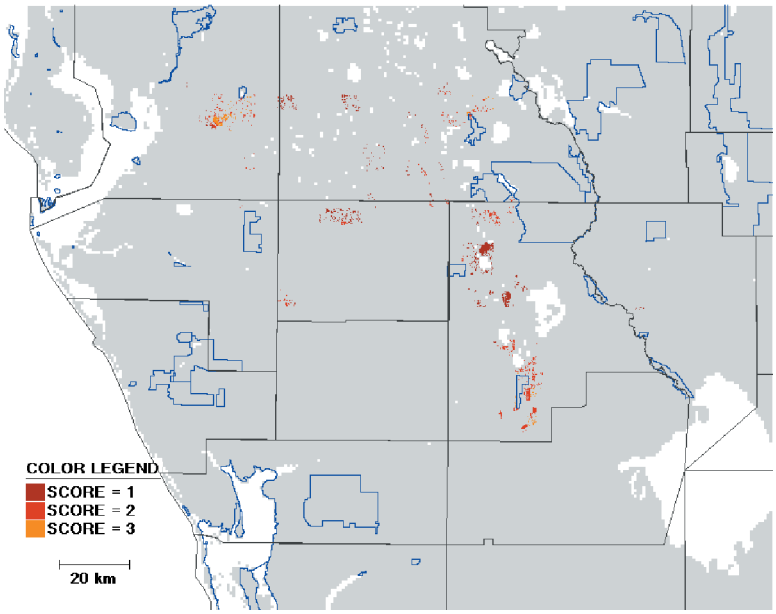


Figure 127. Qualitative scoring of kestrel habitat in south central Florida. Scores reflect the size of habitat patches and their occurrence on large landownerships.

kestrel populations in the southern portion of their range. We estimate that a total habitat base of roughly 140 km^2 (34,580 acres) exists in this area, but only 2 km^2 (500 acres) occur in current conservation areas. Habitat conservation measures would also potentially protect several other rare species (e.g., scrub associates) that occur in this region.

A scoring process identical to the one described above resulted in a map with qualitative rankings of potential kestrel habitat in this region. The largest blocks of high-scoring areas occurred around Archbold Biological Station, southwest of Avon Park Air Force Range/Arbuckle State Forest, around Tiger Creek Preserve, and in southwestern Hillsborough County (Figure 127). In contrast to the situation in north Florida, there are very few options remaining in this region, and conservation of the remaining high-scoring areas needs to proceed quickly. Only approximately 35 km^2 of the potential habitat in this region has a qualitative score > 3, and all of this habitat is important to the conservation of this regional population. Suitable habitat within the high scoring areas shown in Figure 128 were categorized as Strategic Habitat Conservation Areas for the southeastern American kestrel.

Conservation of kestrel habitat within the recommended management zones may include several types of land use, and some of the conservation

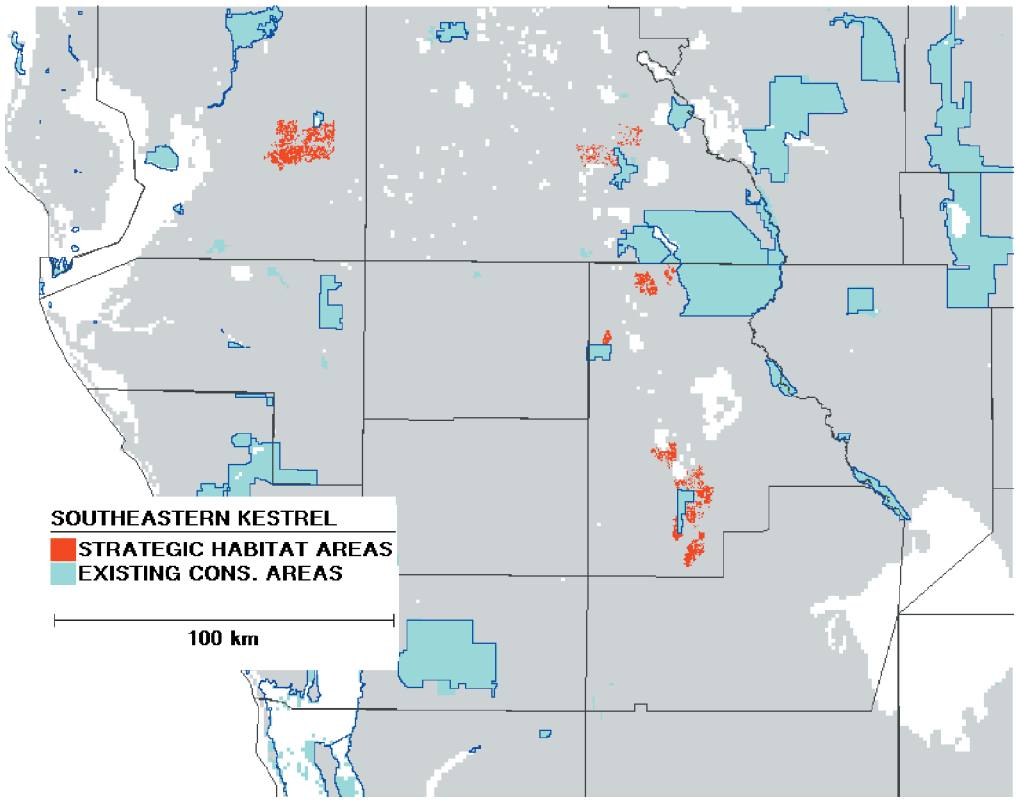


Figure 128. Strategic Habitat Conservation Areas for the southeastern American kestrel in south central Florida.

areas highlighted may contain high percentages of "unnatural" land cover such as rangeland and shrub and brush, but portions should also retain the open pine, sandhill, prairie, and scrub land cover that occurred naturally in Florida. Ground cover in these natural areas should be kept low using frequently prescribed fires or mechanical treatment. Attention to nesting structures must also be given (Stys 1993).

Section 6.2.30. Southern Bald Eagle

The habitat distribution map developed for the southern bald eagle was based on recent aerial surveys (1991-1992) of nest locations stored in the Florida Game and Fresh Water Fish Commission Wildlife Observation database and the land-cover map. We created a 3-km zone around nesting locations and isolated the freshwater marsh and open water that constitute foraging habitat. We also created a 1-km zone around nesting locations to isolate potential nesting habitat. The forested uplands and wetlands within this zone were highlighted as potential nesting areas. The distribution map of nesting records is shown in Figure 129.

Population sizes in current public lands were estimated directly from the number of nests mapped (including some nests that may have been inactive at the time they were mapped). A total of 165 nests was mapped on existing conservation lands out of a statewide total of > 800 nests. The largest number of nests for a contiguous group of conservation areas occurs around the Ocala National Forest (56 nests in current conservation lands). Three Lakes Wildlife Management Area has the second largest number with 20 nests mapped.

We believe it is inappropriate to evaluate the security of Florida's bald eagle population in terms of the "10 populations of 200" used for other species. The statewide population probably consists of a single, panmictic population. However, we also believe that the number of nests (< 170) in current conservation areas is far below the minimum number needed for long-term security. This conclusion was also reached by Wood et al. (1989).

To identify areas of importance to southern bald eagles, we constructed a Voronoi diagram using the nest location data. We then eliminated the polygons defined by points that were larger than 200 km^2 (49,400 acres) to identify nest concentrations. The use of 200 km^2 was somewhat arbitrary, but it provides a figure that can be repeated in future analyses. The greatest concentrations (Figure 130) are centered on large lake and river systems and coastal areas in six more or less distinct areas. One of the largest concentrations occurs within the area defined roughly by Lake Kissimmee, Lake Tohopekaliga, East Lake Tohopekaliga, Cypress Lake, and Lake Marian in Osceola and Polk counties. There are more than 100 bald eagle nests within this area, easily the greatest concentration of bald eagle nests south of Alaska. This area represents a core population area, and, although eagle nests are protected by

Figure 129. Habitat distribution map and occurrence records for the southern bald eagle.

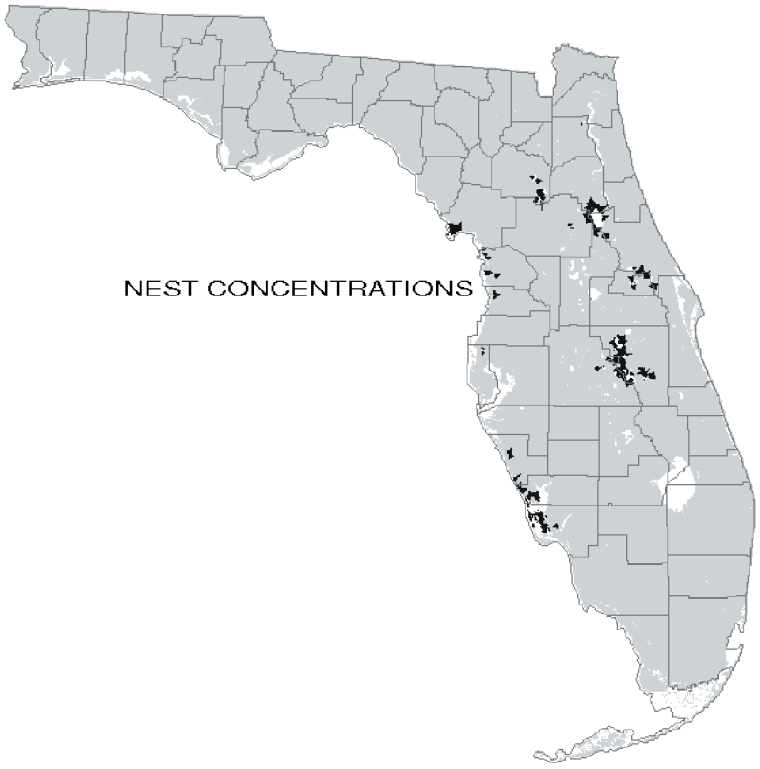


Figure 130. Voronoi diagram of eagle nests reclassified by size categories.

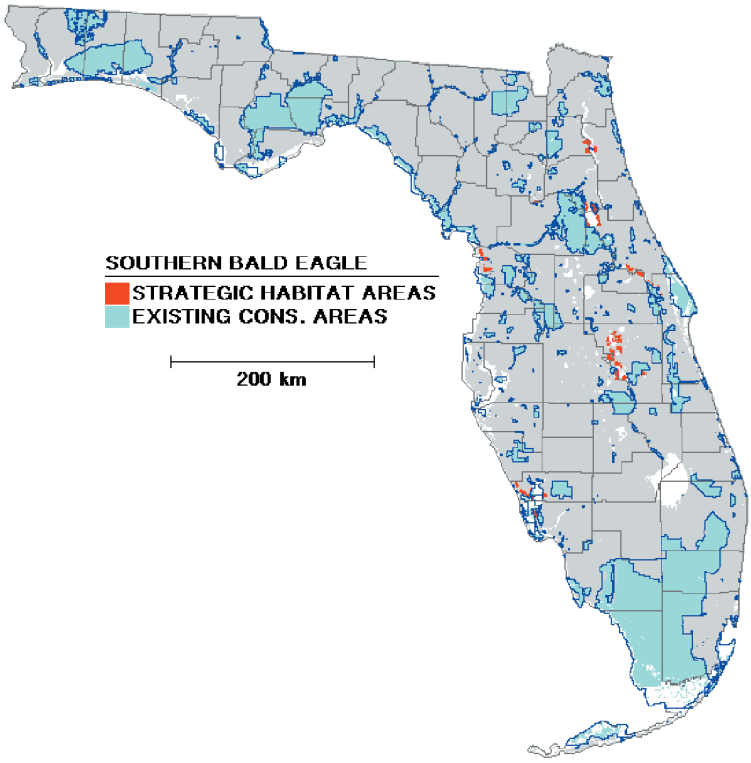


Figure 131. Proposed Strategic Habitat Conservation Areas for the southern bald eagle.

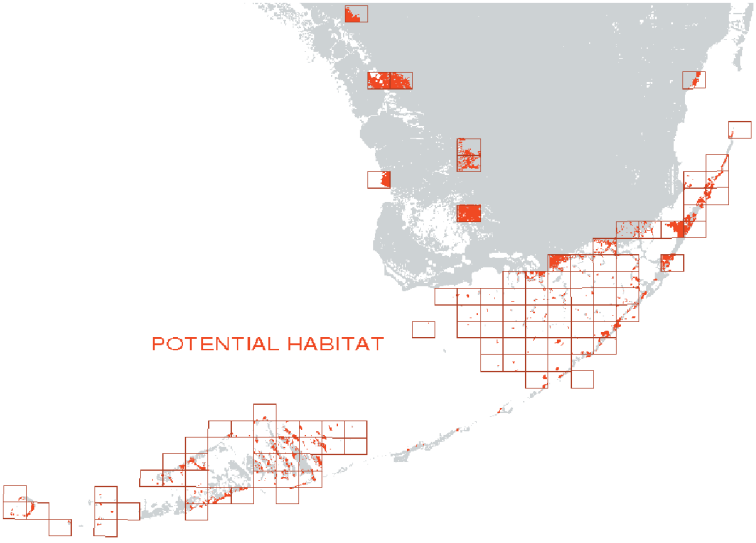


Figure 132. Habitat distribution map and occurrence records for the white-crowned pigeon in south Florida.

law, most of the eagle habitat found in this area is not part of a defined conservation area.

Other significant concentrations of eagle nests occur around (1) Lake George in Putnam, Volusia, and Lake counties (approximately 60 nests), (2) Charlotte Harbor and areas to the north (approximately 50 nests), (3) lakes Jessup, Monroe, and Harney in Seminole and Volusia counties (approximately 30 nests), (4) lakes in southern Alachua and northern Marion counties (approximately 30 nests), (5) the mouths of Crystal, Waccasassa, Withlacoochee, and Homosassa rivers in Citrus, Hernando, and Levy counties (approximately 30 nests), and (6) northern Pinellas and southern Pasco counties (approximately 20 nests).

Only the foraging and nesting habitat around Lake George receives any noteworthy level of protection, but even here less than 50% of the nests occur on existing conservation areas. The percentage of nests on conservation lands in the other areas is usually less than 25%. Additional protection of eagle nests within these core areas is important to maintaining bald eagle populations in Florida. Nesting sites on private lands along the Gulf Coast are perhaps most threatened because many nests occur on development corporation properties (Wood et al. 1989). A large percentage of the nests around Lake George, in southern Alachua County, and on the northern Gulf Coast occurs on commercial timber company lands (Wood et al. 1989), while nests in central Florida are associated with private ranch lands.

We categorized the habitat areas within the eight nesting concentrations as Strategic Habitat Conservation Areas (Figure 131) for the southern bald eagle. Because of differences in the type of threats posed in each zone (e.g., timber harvest, ranching operations, development), more specific conservation strategies and acceptable land uses may vary among these conservation zones. Wood et al. (1989) outline additional management recommendations that will help to protect eagle nests in the face of commercial timber operations and residential and commercial development.

Section 6.2.31. White-crowned Pigeon

The initial habitat distribution map developed for the white-crowned pigeon was based on the land-cover map, breeding bird atlas records (Kale et al. 1992), data presented by Bancroft (1989), and Florida Natural Areas Inventory records for white-crowned pigeons. We isolated mangrove swamp in areas of known nesting concentrations (Bancroft 1989), and we isolated the tropical hardwood hammocks in areas defined by atlas records. The species is limited primarily to the Florida Keys and Florida Bay (Figure 132).

White-crowned pigeons nest on mangrove islands throughout Florida Bay and a few other areas in the Ten Thousand Islands of the Everglades National Park. Pigeons forage primarily in tropical hardwood hammocks along the

Florida Keys, the important foraging plants in hammocks being poisonwood, blolly, and species of fig.

Although appropriate nesting habitat is protected to some degree by wetland regulations, critical foraging habitat is not well protected (Bancroft 1989). Continued residential and urban development threatens to eliminate many of the remaining patches of tropical hardwood hammock on private lands. Furthermore, although fairly extensive tracts of tropical hammocks are protected in the Upper Keys, frequently used hammocks also occur in Middle and Lower Keys and fall outside the boundaries of existing conservation areas (Bancroft 1989).

We analyzed hammocks in the Florida Keys to assess their potential importance as foraging habitat areas. The evaluation was based on information presented in Bancroft (1989). First, we isolated the mangrove islands in the Lower Keys where white-crowned pigeons had been recorded nesting as part of breeding bird atlas work. We used the areas of high nesting densities (Bancroft 1989) to delineate similar areas in the Upper Keys. Next, we created a zone around mangrove islands and arbitrarily classified hammocks based on their distance, and thus ease of access, from potential nesting areas. Hammocks within 5 km were given a score of 3, hammocks within 10 km were given a score of 2, and hammocks > 10 km were given a score of 1.

We also ranked the remaining patches of hammocks based on their size. Bancroft (1989) described limited use of small hammocks by white-crowned pigeons, and we rated individual patches of hammocks as follows: hammocks < 2 ha (5 acres) were assigned a value of 1, hammocks > 2 ha but < 4 ha (10 acres) were assigned a value of 2, and hammocks > 4 ha (10 acres) were assigned a value of 3. This map and the previous map (based on distance to mangrove islands) were then added together.

T. Bancroft (in Anon. 1992) proposed a series of preservation areas along the mainline keys to provide blocks of suitable foraging habitat for white-crowned pigeons and to enable young birds, which are not strong fliers, to reach the more extensive tracts of protected tropical hammocks located on Key Largo, Rhodes Key, and Elliott Key. The important nesting and foraging areas as indicated by our index scores are shown in Figure 133. The map resulting from our analysis did not differ substantially from the map of important foraging habitat proposed by T. Bancroft (in Anon. 1992). Only two patches of hammocks that ranked highly by our analyses were not included in the map prepared by T. Bancroft (in Anon. 1992). These patches are located around Point Charles and Newport. We include the high-ranking patches around Point Charles and Newport plus the areas proposed by T. Bancroft (in Anon. 1992) as Strategic Habitat Conservation Areas for white-crowned pigeons in the Upper Keys. Other rare species that might be protected by this system of managed areas are presented in Table 12. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

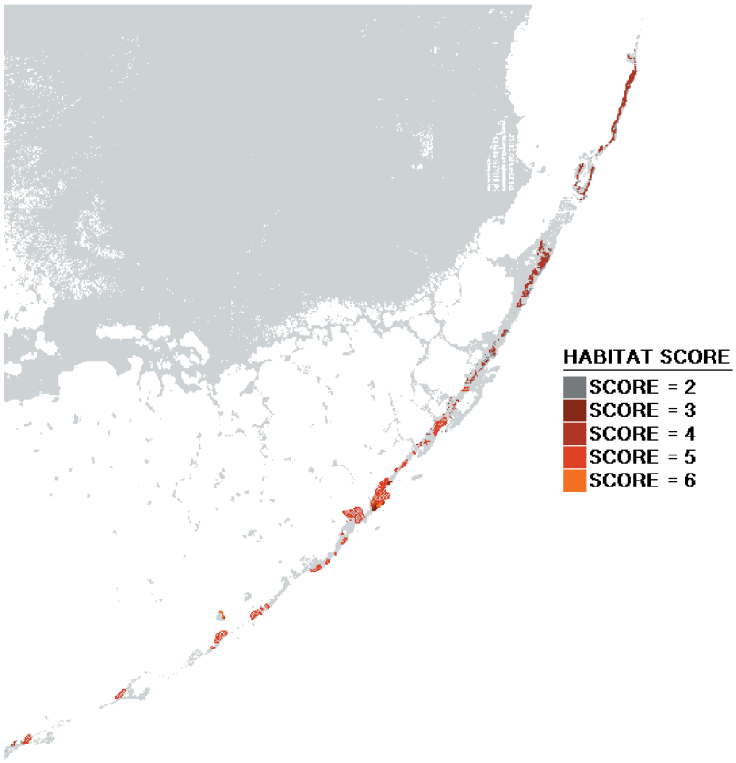


Figure 133. Qualitative scores of habitat areas for the white-crowned pigeon in the Upper Keys. Scores reflect the size of the patch of hammock and the proximity of hammocks to nesting areas.

Table 12. Species recorded within the Strategic Habitat Conservation Areas proposed for white-crowned pigeon. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

ANIMALS	PLANTS
Great white heron	Geiger tree
Great egret	Prickly-apple
Little blue heron	Key tree-cactus
Tricolored heron	Rhacoma
Reddish egret	False boxwood
Yellow-crowned night-heron	Yellowwood
White ibis	Milk bark
Roseate spoonbill	Manchineel
Black-whiskered vireo	Big Pine partridge pea
Florida prairie warbler	Wild cotton
Key Vaca raccoon	West Indies mahogany
Key mud turtle	Wild dilly
Eastern indigo snake	Bay cedar
Lower Keys ribbon snake	Joewood
Florida purplewing	Lignum-vitae
Florida tree snail	Silver palm
	Brittle thatch palm
	Florida thatch palm
	Banded wild-pine

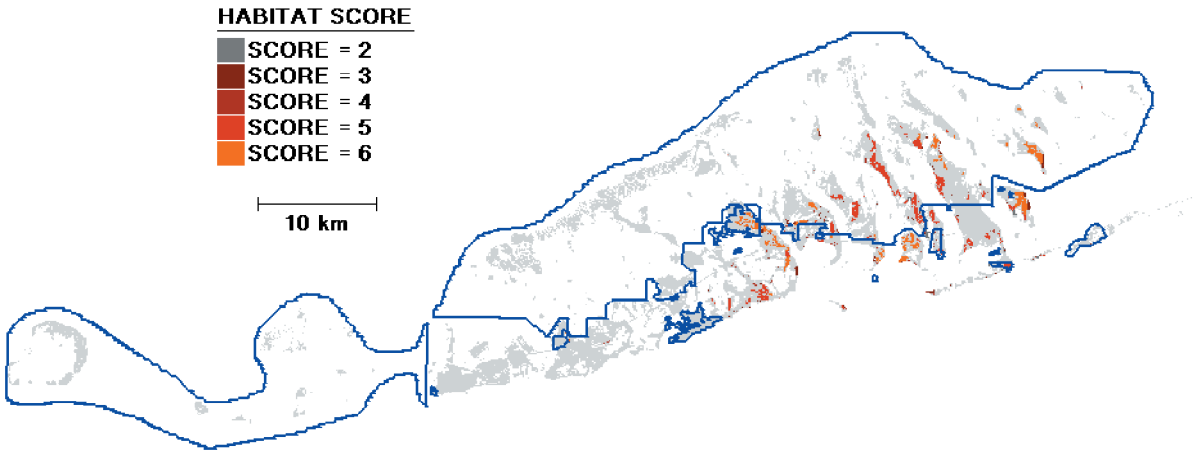


Figure 134. Qualitative scores of habitat areas for the white-crowned pigeon in the Lower Keys. Scores reflect the size of the patch of hammock and the proximity of hammocks to nesting areas.

Because of the agreement with important areas identified by T. Bancroft (in Anon. 1992), we also used the scoring system devised above to identify potentially important areas in the Lower Keys (Figure 134). According to these analyses, some of the most important patches of hammock are found on northern Big Pine Key, Little Pine Key, No Name Key, and Sugarloaf Key. Some of the hammocks shown fall within the boundaries of the Key Deer National Wildlife Refuge, but several important tracts on private lands are threatened by development. We recommend conserving the patches of tropical hardwood hammock with a score > 5 and propose these hammocks (Figure 135) as Strategic Habitat Conservation Areas for white-crowned pigeons in the Lower Keys. Other rare species that might be protected by this system of managed areas are presented in Table 12.

In addition to conservation of these important tracts of hammocks, there are additional management and land-use recommendations that should be mentioned. Poisonwood, an important food plant for pigeons, is often removed from residential and urban areas due to the rash this species produces upon contact with the skin. In lieu of poisonwood, Bancroft (1989) recommends the planting of several native fruit-bearing species (e.g., native figs and blolly) that provide forage for white-crowned pigeons. This should be a component of an urban wildlife program for the Florida Keys. In addition, the potential control of raccoon populations on some keys where pigeons nest should be investigated since raccoons can significantly lower nesting success (Bancroft 1989). Control of American crows, which are also expanding into mangrove areas where several colonial wading bird species nest, will be

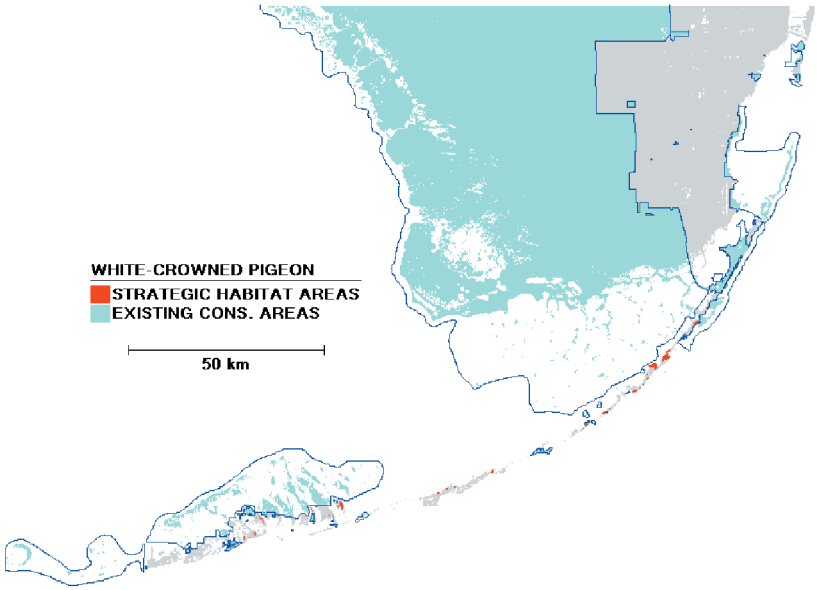


Figure 135. Proposed Strategic Habitat Conservation Areas for the white-crowned pigeon.

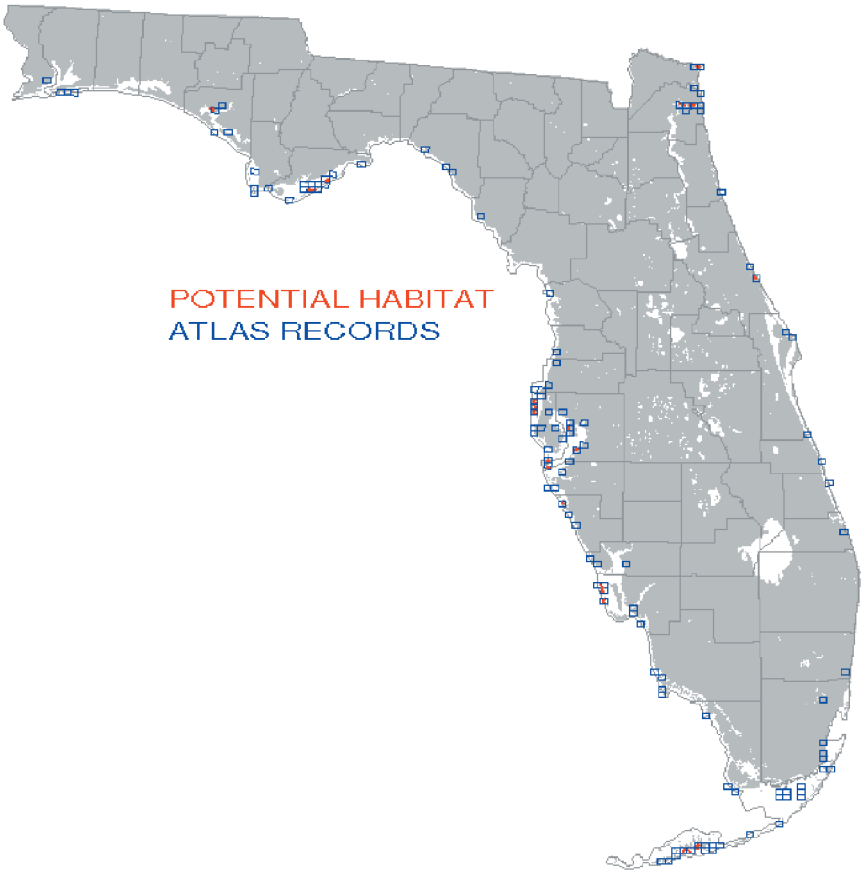


Figure 136. Habitat distribution map and occurrence records for the Wilson's plover in Florida.

much more difficult to study or initiate because of their greater vagility.

Section 6.2.32. Wild Turkey

The habitat distribution map developed for this species focussed on large blocks of contiguous forested land cover as well as the shrub and brush cover type. The only "natural" upland land-cover types not included as potential habitat were coastal strand and tropical hardwood hammock. The "natural" wetland land-cover types included in the model were cypress swamp, hardwood swamp, bay swamp, and bottomland hardwood forest. The model consisted of isolating contiguous patches of these acceptable cover types and then eliminating patches that were smaller than 250 acres in size. This habitat model does not reflect important qualitative differences that might influence the density of wild turkeys in different areas, but it does reflect tolerance of a wide range of habitat conditions (Williams 1981, Exum et al. 1987).

Based on a density of 5/km^2, we estimate that there are at least 10 populations > 200 individuals in current conservation areas in Florida. We conclude that wild turkeys have the minimum level of representation in current conservation areas.

Section 6.2.33. Wilson's Plover

The habitat distribution map for Wilson's plover was developed from point data in the Florida Game and Fresh Water Fish Commission's Wildlife Observation database and records from the Atlas of Florida Breeding Birds (Kale et al. 1992). We generated a small-circle (250 m) zone around the point locations and used all atlas records with "confirmed" or "probable" breeding codes (Kale et al. 1992). Within these areas, we isolated the open water, coastal strand, coastal salt marsh, and mangrove swamp land cover.

Wilson's plovers forage along the exposed salt flats and sandy open areas in close proximity to open water, coastal strand, salt marsh, and mangrove land cover (Stevenson and Anderson 1992). To define such areas using the land cover data, we first identified the edge between the open water land cover and the other 3 land-cover types isolated around known nesting locations. We generated a 60 m zone (2 pixels) around this edge and incorporated the barren land, salt marsh, mangrove swamp, and coastal strand found within this area. It is the appropriate land cover within this narrow band that was categorized as suitable habitat for this species.

Habitat for Wilson's plover is found throughout coastal areas of the state (Figure 136). A lack of published density

estimates makes it difficult to determine the level of protection offered by current conservation areas. However, some general recommendations can be proposed based on the quantity of habitat found on and outside of conservation areas in each region.

The Apalachee, Tampa Bay, South Florida, and Southwest Florida regions are estimated to have the greatest quantity of habitat among regions, but there is great variation in the degree to which habitat within these regions is conserved. Only 17.6% and 12% of the habitat found in the Apalachee and Tampa Bay regions, respectively, is in current conservation lands, whereas about 50% of the habitat in the South Florida and Southwest Florida regions is in current conservation areas. Such discrepancies argue for enhancing the conservation of habitat areas in the Tampa Bay and Apalachee regions.

The Treasure Coast, West Florida, and Withlacoochee regions also have a significantly smaller proportion of the habitat available in public ownership (< 25%) than other regions. Increases in the quantity of habitat conserved in these regions could have a proportionately greater effect on the security of the regions' Wilson's plover populations.

No specific habitat conservation recommendations were developed for this species. However, the habitat distribution map developed for this species is used as part of the analysis of important coastal habitats (Section 6.3.3).

SECTION 6.3. HABITAT CONSERVATION AREAS FOR OTHER ELEMENTS OF BIODIVERSITY

Although the focal species analyzed in the previous section may umbrella the habitat requirements of a number of other common and rare species, the focal species are not likely to be perfect indicators of the habitat areas required by some species (Ryti 1992). Florida supports several unique forms of plant and animal species, as well as distinct plant communities, that are not found elsewhere in the United States (Muller et al. 1988). The distributions of many of these species and communities are closely linked to a complex suite of edaphic, climatic, and vegetative characteristics that are restricted to specific areas of the state. The development of conservation areas for these additional components of biological diversity must be a fundamental aspect of Florida's habitat conservation efforts.

In this section we focus on some of these other components of Florida's biological diversity. The section may seem to present a mix of species-level and community-level analyses lacking order, but the common theme among subsections is that they deal with important biological features that we could assess using the land-cover map and other information on hand, but they are also biological features that could not be assessed in the manner used for focal species in Section 6.2. For example, Muller et al. (1989) listed 13 plant communities as being endemic or nearly endemic to Florida. Of these, three community types (scrub, dry prairie, and pine rockland) can be analyzed to some degree using the land-cover map, information on species habitat distributions, and other available data. The tropical hardwood hammocks of south Florida also contain several rare species of importance to the natural diversity of the U.S., so we performed an analysis of this community type.

Our general approach for these rare communities was to combine information on the distribution of high quality examples of a particular community with new analyses of the land-cover map and ancillary information. Since these analyses relied upon occurrence records for different species and communities, they describe many important areas but may not include all the important habitat areas that remain. New surveys and inventories will undoubtedly uncover additional high quality communities of great importance to maintaining the diversity of life in Florida.

Another component of natural diversity that warrants attention is several rare plants that are not well protected by existing conservation areas in Florida. The Florida Natural Areas Inventory analyzed occurrence records of rare plants by existing conservation areas. From this list, we selected species listed as globally rare and not found on at least 10 existing conservation areas. To the degree possible, we incorporated habitat conservation recommendations for these species.

There are also species of wildlife whose habitat conservation needs cannot be conveniently encapsulated in terms of minimum recommended numbers and distributions (i.e., at least 10 populations of 200). Among these are species that gather at specific sites at specific times and may require complex social interactions to maintain normal demographic functions. Examples of such species include colonially breeding wading birds and colonially breeding bats, and, to a lesser degree, shorebirds and nesting sea turtles. This section of the report contains analyses of these and other multi-species assemblages.

A final analysis we performed was an assessment of the distribution of "species rich" areas in Florida based on the technique known as "gap analysis" (Scott et al. 1993). This technique is being applied in many areas of the United States (Scott et al. 1993). We prepared coarse habitat and distribution maps for 120 rare species and combined these maps to determine areas where potential habitat conditions for many rare species might co-occur. Results from this analysis helped to highlight areas of potential importance to the conservation of natural resources in Florida, but we also found limitations in our application of the technique.

Section 6.3.1. Areas Supporting Globally Rare Plant Species

The Florida Natural Areas Inventory provided us with the known locations of plants having both of the following characteristics: (1) taxa listed as "imperiled globally because of extreme rarity" or "imperiled globally because of rarity" (Florida Natural Areas Inventory 1992), and (2) species occurring on fewer than 10 existing conservation areas in Florida. Records with no observations since January 1970, and records with only general occurrence locations, were not included. This data set included 947 occurrence records of which only 23% fall within existing conservation areas. Approximately 25% of the globally rare species represented by these records are not known to occur on any existing conservation area. For all of these globally rare species, conservation of appropriate habitat is essential to their survival.

We examined the Strategic Habitat Conservation Areas recommended above to identify those globally rare plants that were located on these proposed conservation areas and therefore might benefit from their protection. We also included

Table 13. Proposed or listed CARL projects included as Strategic Habitat Conservation Areas for plants, along with project location and approximate acreage not yet purchased.

PROJECT NAME	PROJECT LOCATION	APPROXIMATE ACREAGE
Catfish Creek *	Polk County	5,286
Horse Creek Scrub *	Polk County	2,365
Saddle Blanket Lakes Scrub *	Polk County	800
Coupon Bight/Key Deer Refuge *	Monroe County	1,343
Jupiter Ridge *	Palm Beach County	287
Longleaf Pine Ecosystems *	Hernando/Marion/Volusia counties	18,188
Ross Prairie *	Marion County	7,893
Warea Archipelago *	Lake/Osceola counties	1,020
Julington/Durbin Creek *	Duval County	4,580
Maritime Hammock Initiative *	Brevard County	616
Jetty Park South *	Brevard County	45
Miami Rockridge Pinelands *	Dade County	185
Fakahatchee Strand *	Collier County	13,795
Etoniah Creek *	Putnam/Clay counties	55,237
Charlotte Harbor Flatwoods *	Charlotte/Lee counties	18,608
Lake Wales Ridge Ecosystems *	Polk County	31,171
St. Joe Bay Buffer *	Gulf County	6,941
Sand Mountain	Washington/Bay counties	39,680
Sweetwater Creek	Liberty County	10,240
Juno Hills	Palm Beach County	358

* Projects presently included on the CARL list.

certain areas (Table 13) currently proposed or listed as projects by the Conservation and Recreation Lands program (Anon. 1992, 1993) that contain populations of these rare species. Of the projects included, those that appear on the current Conservation and Recreation Lands project list have been ranked highly for providing habitat critical to the survival of rare, threatened, and endangered plant species. We incorporated the areas listed in Table 13 as Strategic Habitat Conservation Areas for these rare plants. In Table 14 we indicate those rare plants that could benefit from conservation of these areas and the Strategic Habitat Conservation Areas recommended above. Figure 137 illustrates the location of the proposed Strategic Habitat Conservation Areas for globally rare plants.

Below we discuss a few examples of the projects being considered by the Conservation and Recreation Lands program (Anon. 1992, 1993) that could protect additional populations of these rare species. The panhandle of Florida, and in particular areas in Franklin, Gulf, Liberty, and Bay counties, harbors numerous endemic species of plants with very restricted distributions. The coastal area south of Port St. Joe (Gulf County) provides habitat for a number of globally rare plants that are endemic to the lowlands of the region. Three of these species (telephus spurge, tropical waxweed, and pine-woods aster) are not known from any existing conservation area. The St. Joe Bay Buffer acquisition project (Anon. 1993) would protect habitat occupied by all three of these species. Several rare species associated with sandhill lakes occupy unprotected habitat in southeastern Washington and adjacent northern Bay

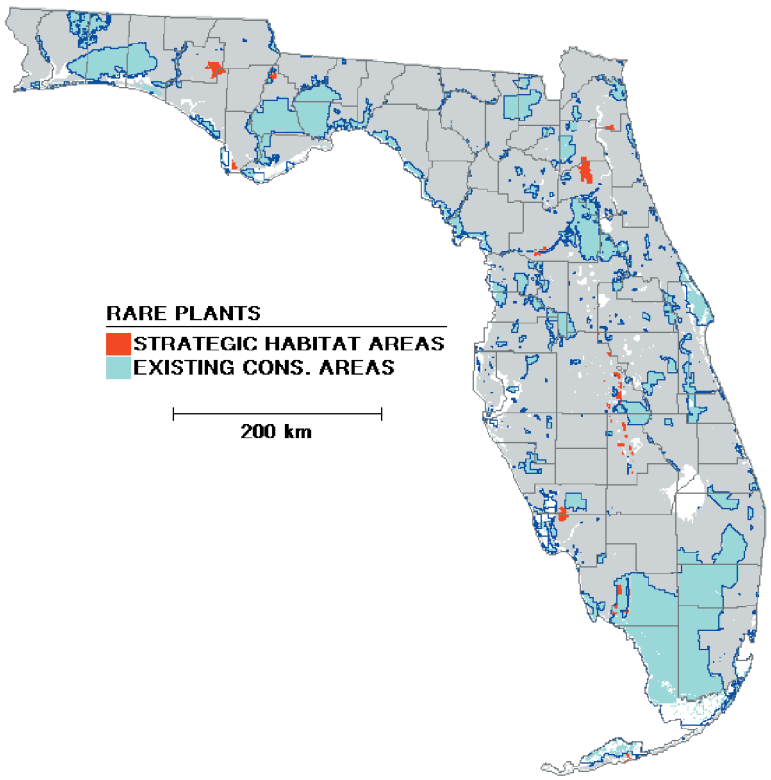


Figure 137. Areas important to several globally threatened species of plants.

Table 14. List of globally rare plant species found on < 10 conservation areas, their total number of known occurrences, total number of occurrences on existing conservation lands (ECL), total number of occurrences within proposed Strategic Plant Conservation Areas (SPCA), and total number protected by all Strategic Habitat Conservation Areas (SHCA). An asterisk indicates that all reported occurrences of the species are on existing conservation lands. Data current as of January 1993.

COMMON NAME	TOTAL NUMBER OF OCCURRENCES	NUMBER OF OCCURRENCES ON ECL	NUMBER OF OCCURRENCES WITHIN RECOMMENDED SPCA	OCCURRENCES WITHIN ALL RECOMMENDED SHCA
Pinkroot	3	1	0	1
Alabama anglepod	5	2	2	2
Apalachicola rosemary	7	1	3	3
Avon Park rabbit-bells	3	1	1	1
Bahama sachsia	11	3	4	5
Baldwyn's spiny-pod	2	2	*	
Bartram's ixia	54	2	4	4
Beach jacquemontia	11	7		
Beautiful pawpaw	18	1	6	8
Big Pine partridge pea	15	5	7	9
Blodgett's wild-mercury	15	7	1	1
Brooksville bellflower	3	1		
Carter's large-flowered flax	3	1		
Carter's small-flowered flax	3			
Chaffseed	1			
Chapman's rhododendron	22			
Chapman's sedge	3	2		
Chapman's yellow-eyed grass	1	1		*
Clasping warea	12	1	3	4
Cooley's meadowrue	1			
Cooley's water-willow	7	2		
Coville's rush	3	1	1	1
Crenulate lead-plant	3	1		
Curtiss' loosestrife	3			1
Cutthroat grass	21	9	4	
Deltoid spurge	20	4	4	5
Eaton's spikemoss	2			
Edison's ascyrum	13	2	1	5
Elliott's croton	6			
Etonia rosemary	1		1	1
Fall-flowering ixia	8	2		1
Florida gama grass	14	7	3	3
Florida golden aster	14			2
Florida semaphore cactus	1	1	*	
Florida skullcap	18	7	2	2
Florida spiny-pod	1			
Florida thoroughwort brickell-bush	3	2		
Florida threeawn	7	1		1
Florida toothache grass	5	2		
Florida willow	7	4		
Flyr's brickell-bush	1			1
Four-petal pawpaw	20	3	2	3
Fragrant prickly-apple	5	3		
Fringed campion	6	1	1	
Garber's spurge	9	4	1	3
Garrett's scrub balm	6		3	3
Gentian pinkroot	3	1		
Godfrey's blazing star	16	6		
Godfrey's sandwort	1			
Green ladies'-tresses	1	1		*
Hairy-peduncled beak-rush	5	1		
Hanging clubmoss	1	1		*
Harper's beauty	8	6		
Highlands scrub hypericum	73	8	15	35
Inkwood	12	5	1	4
Johnson's seagrass	9	7		
Lake-side sunflower	3			

Table 14. List of globally rare plant species found on < 10 conservation areas, (continued).

COMMON NAME	TOTAL NUMBER OF OCCURRENCES	NUMBER OF OCCURRENCES ON ECL	NUMBER OF OCCURRENCES WITHIN RECOMMENDED SPCA	OCCURRENCES WITHIN ALL RECOMMENDED SHCA
Lakela's mint	4	1		
Large-flowered grass-of-parnassus	5	5		*
Lewton's polygala	23	5	5	5
Longspurred mint	12	5	4	4
Miccosukee gooseberry	2			
Nodding catopsis	1	1		*
Nuttall's rayless goldenrod	1	1		*
Ocala vetch	1	1		*
Okeechobee gourd	1			1
Panhandle spiderlily	16	8	1	2
Pine pinweed	7	2	2	3
Pine-woods aster	39			
Pinelands spurge	2	1		
Porter's broad-leaved spurge	3	2		
Porter's broom spurge	11	4	4	5
Porter's hairy-podded spurge	2	2		*
Purple balduina	3	1		
Quillwort yellow-eyed grass	4	1		
Rain lily	1	1		*
Rock Key devil's-claws	1			
Rocklands morning-glory	4	3		
Rough strongbark	1			
Rugel's pawpaw	6			
Sand flax	12	2	6	9
Sand-dune spurge	10	5		
Sanibel lovegrass	11			1
Scrub bluestem	33	1	11	17
Scrub lupine	37	2	1	4
Scrub mint	9	1	2	2
Scrub ziziphus	1	1		*
Small-flowered lily-thorn	1	1		*
Smooth-barked St. John's-wort	29		2	2
Southern marshallia	1	1		*
Star anise	11	7	1	3
Tampa vervain	14	4		1
Telephus spurge	24		4	4
Tennessee leafcup	1	1		*
Three-spined prickly-pear	4	2	1	1
Tiny polygala	6	2		
Tropical waxweed	18	1	1	
Variable-leaf crownbeard	5	2	1	1
Variable-leaved Indian-plantain	3	1		
Wagner's spleenwort	1	1		*
Wedge spurge	4	1	3	3
Wedge-leaved button-snakeroot	19	1	6	13
West's flax	10	3		
Wild potato morning-glory	3	2		
Wright's anemia	1			
Total	947	214	124	199

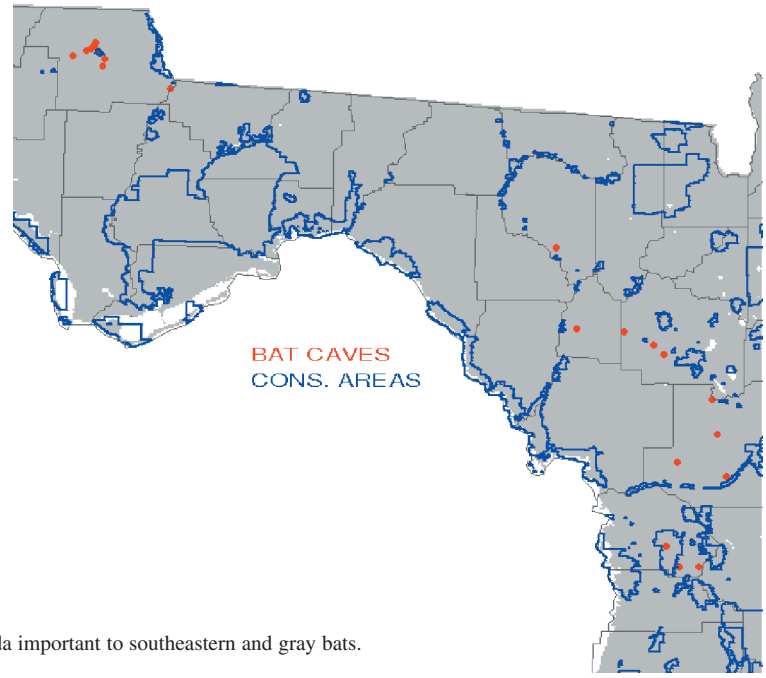


Figure 138. Cave sites in Florida important to southeastern and gray bats.

counties. Three species found there (meadowbeauty, smooth-barked St. John's-wort, and karst pond xyris) are endemic to Florida. The St. John's-wort currently has only one protected population. The other two species have < 10 protected populations. The Sand Mountain acquisition proposal (Anon. 1993) in Washington and Bay counties encompasses populations of all three species.

The Warea Archipelago acquisition project (Anon. 1993) in Lake and Osceola counties targets protection of the few remaining sites inhabited by the clasping warea, an endemic species. There is currently only one protected population of this species. The project also would provide additional protection for the Lewton's milkwort, a globally rare endemic whose distribution is predominantly restricted to the Lake Wales Ridge. In Duval County, the Julington/Durbin Peninsula acquisition project would provide additional protection for Bartram's ixia and variable-leaf crownbeard. Both plants are found in the mesic pinelands of only a few counties in northeast Florida. Each species currently has only two protected populations. The Miami Rockridge Pineland acquisition project in Dade County would provide significant protection for a number of poorly protected pine rockland species including Florida thoroughwort, Brickell-bush, Bahama sachsia, deltoid spurge, Blodgett's wild mercury, and Florida gama grass. These pine rockland sites are highly vulnerable to development, and in fact several of the sites originally proposed in 1986 have been destroyed. One other extremely significant CARL project in south Florida, the Coupon Bight/Key Deer project in Monroe County, offers the prospect for the protection of several globally rare plants whose distribution in the United States is restricted to south Florida or more narrowly, the Florida Keys. These species include Blodgett's wild mercury, Garber's spurge, sand flax, Bahama sachsia, wedge spurge, Big Pine partridge pea, and inkwood. The area encompassed by this project presently is subject to tremendous growth pressure.

Of the 947 occurrence records used in this analysis, approximately 16% occur within 300 feet of state and federal highways. This suggests that proper management of these roadsides may enhance the security of many of these rare species. Management of these areas will require cooperation among various concerned agencies, but a first important step is simply to describe the locations of each population more precisely. This type of action is especially critical for certain species such as Godfrey's sandwort whose only known population occurs along a highway right-of-way. Panhandle highways having a large number of species potentially occupying the roadside area include State Road 65 in Franklin and Liberty counties; State Road 30 in Franklin and Gulf counties; State Road 71 in Gulf and Calhoun counties; and State Road 20 in Liberty and Bay counties.

A large number of occurrences also was found in close proximity to several highways in peninsular Florida. These include U.S. Highway 27 in Polk, Highlands, and Glades counties; State Road 21 in Clay County; and U.S. Highway A-1-A in Brevard, St. Lucie, Martin, and Palm Beach counties. Although occurrences along county roads were not quantified, many of the remaining records may also occur in proximity to these roadways.

Section 6.3.2. Bat Maternity and Winter Roosting Caves

A few species of bats gather at specific locations in Florida to breed and roost. The concentration of these species at specific sites makes these species especially vulnerable to human disturbance, habitat loss, pesticide contamination, environmental calamities, and other threats.

The southeastern bat is found throughout the southeastern United States, but it appears to be most abundant in Florida (Humphrey and Gore 1992). Young of this species are born almost exclusively in caves, and survival of the species is dependent on availability of suitable cave sites. Locations of maternity caves used by southeastern bats were obtained from the Florida Natural Areas Inventory and supplemented by data provided in Hovis and Gore (1993). The general locations of important caves are shown in Figure 138.

The gray bat is another rare species that roosts at specific caves in Florida (Gore 1992). Gray bats generally forage over streams and rivers bordered by forests and may forage at distances up to 25 km (15 miles) from maternity caves (LaVal et al. 1977). They also use forested corridors to move between caves and foraging areas (LaVal et al. 1977).

For maternity caves in north central Florida containing southeastern bats, we developed Strategic Habitat Conservation Areas based on recommendations (Hovis and Gore 1993) designed to protect the entrance to the cave. Table 15 shows other rare species that might benefit from conservation of habitat within these areas. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments. For caves in Jackson County that support both southeastern and gray bats, we defined Strategic Habitat Conservation Areas as the stream side habitats occurring within 3 km (1.8 miles) of occupied caves. We also mapped all forested lands within 100 m of active caves to help prevent direct disturbance to the cave entrance. The Strategic Habitat Conservation Areas in Jackson County are shown in Figure 139.

Section 6.3.3. Coastal Communities

Several focal species associated with coastal habitats (e.g., American oystercatcher, piping plover, Wilson's plover) could not be evaluated in terms of the size and number of populations protected by current conservation areas. This fact, coupled with the dwindling nature of coastal habitats and their importance to many additional rare species not analyzed here (Millsap et al. 1990), led us to prepare a special map to highlight some of the important coastal habitats for shorebirds, nesting sea turtles, and other components of biological diversity.

A map showing the overlap of habitat areas for different taxa of beach mice and salt marsh snakes, American oystercatcher, mangrove cuckoo, Cuban snowy plover, piping plover, white-crowned pigeon, and Wilson's plover was created by adding together the individual habitat distribution maps created for each of these species. A number of additional features was then added to this map. A map of coastal habitats of potential importance to migratory birds (Moore 1992) was generated by isolating coastal hammocks, scrub, and mixed hardwood-pine forests within 1.6 km (1 mi) of the coast. Shorebird aggregation areas recorded as part of the International Shorebird Survey (Manomet Bird Observatory, P.O. Box 936, Manomet, Massachusetts, 02345) were digitized from

Table 15. Species recorded within the Strategic Habitat Conservation Areas proposed for maternity and winter roosting caves of southeastern and gray bats. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

Amphibians and Reptiles	*Plants*
Flatwoods salamander	Canada honewort
One-toed amphiuma	Fringed campion
Apalachicola dusky salamander	Burningbush
Georgia blind salamander	West's flax
Alligator snapping turtle	Pyramid magnolia
Gopher tortoise	Liverleaf
	False rue-anemone
Fish	Schisandra
	Buckthorn
Spotted bullhead	Narrow-leaved trillium
	Florida merrybells
Invertebrates	Croomia
Hobbs cave isopod	
Dougherty plain cave crayfish	
Light-fleeing cave crayfish	
McLane's cave crayfish	

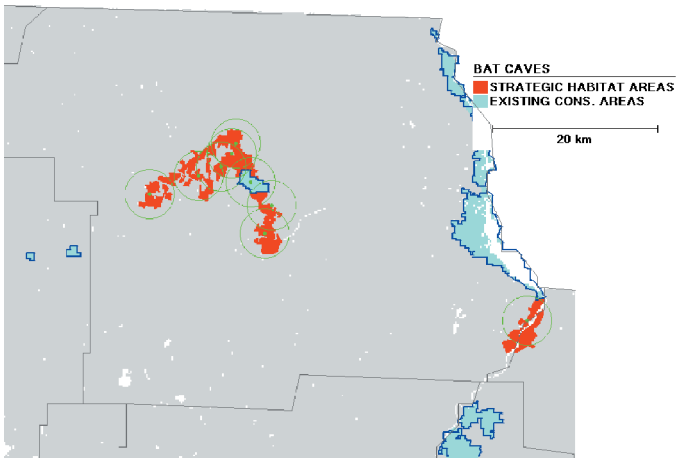


Figure 139. Proposed Strategic Habitat Conservation Area for southeastern and gray bats in Jackson County.

1:126,720 scale county road maps. Sea turtle nesting areas along the southern Atlantic and Gulf coasts were mapped based on information processed by the Florida Natural Areas Inventory. Finally, we analyzed all of the occurrence records stored by the Florida Natural Areas Inventory falling within 5 km of the Florida coast. We created a Voronoi diagram of these coastal point records and highlighted patches that were smaller than 2,025 ha (5,000 acres). This was an arbitrary figure designed to allow future analyses to be repeatable.

Adding these maps together produced a composite overlay of areas with concentrations of various important coastal elements (Figure 140). Among the more important areas are the mangrove swamps of the Ten Thousand Islands-Everglades National Park area of southwest Florida; coastal salt marshes and barrier islands of northern Florida; coastal marshes, mangrove swamps, and beach areas in and around Charlotte Harbor; areas in and around the Indian River system of Brevard County; coastal marshes associated with Ponce de Leon Inlet and the Halifax River of Volusia County; and the salt marshes and barrier islands in northeast Florida extending from the mouth of the St. Johns River to Amelia Island. Smaller areas with concentrations of important coastal species are found around Tampa Bay and nearby coastal areas; Santa Rosa Island and St. Joseph Peninsula in the western panhandle; and Tomoka Basin, Smith Creek, and Matanzas and Tolomato rivers in northeast Florida.

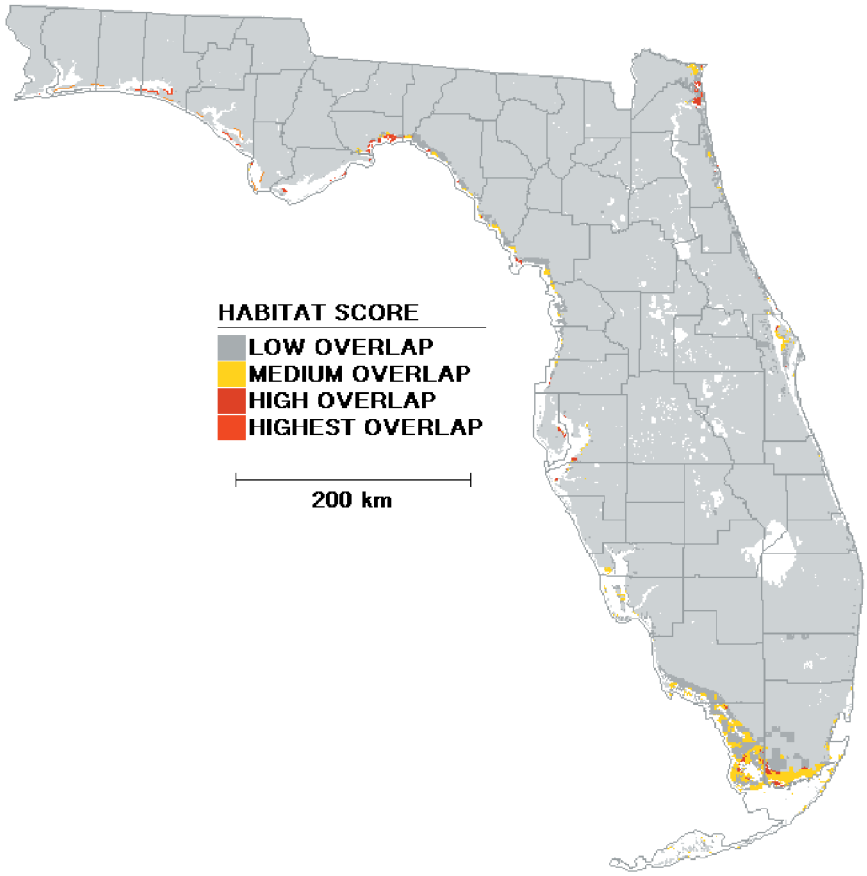


Figure 140. Important coastal habitat areas. Scores for different areas are based on records of rare species processed by the Florida Natural Areas Inventory and Florida Game and Fresh Water Fish Commission, and the presence of other important resources.

Protecting the dwindling coastal habitats important to many different species presents a great challenge. Any conservation plans developed for this broad group should contain elements of land acquisition, land-use regulation, managing human access and recreation, and landowner education. The different techniques and tools that can be used in coastal habitat conservation vary tremendously across Florida. Due to the broad scope of these analyses and the individual problems facing each site, we postpone a discussion of the important coastal habitat areas highlighted by these analyses until Section 8, where we detail important natural resources on a regional basis.

Section 6.3.4. Gap Analysis

In addition to the detailed distribution and habitat maps developed for 44 focal species described in Section 6.2, a separate set of coarse habitat distribution maps was prepared for 120 species of vertebrates (Table 16) for use in a "gap analysis" (Scott et al. 1993). Gap analysis is a theoretical approach to identifying important conservation lands by overlaying potential habitat maps for individual species. These overlays display species-rich "hot spots" where many species might co-occur. The overlay of public land boundaries can then help to show hot spots that are not protected (i.e., are "gaps") in the existing system of public lands.

Our gap analysis consisted of creating habitat distribution maps for individual species by isolating the land-cover types used by each species within the known range of the species. The species selected for this analysis included those (except fish and whales) listed by the Florida Game and Fresh Water Fish Commission as endangered, threatened, or species of special concern (Wood 1992), plus an additional 43 species of vertebrates not listed but perhaps in some jeopardy (Millsap et al. 1990). The 43 unlisted species received a biological vulnerability score > 24 in Millsap et al. (1990) but did not include wintering shorebirds whose habitat preferences could not be efficiently mapped using the land-cover map. The total number of species analyzed (Table 16) represents 24% of Florida's 542 terrestrial vertebrates and 49% of the vertebrate species found to be declining by Millsap et al. (1990).

Distribution maps were created for each species using the best available information. Sources included field guides (e.g., Burt and Grossenheider 1976, Conant 1975), breeding bird atlas data (Kale et al. 1992), and distribution maps published by the Florida Committee on Rare and Endangered Plants and Animals (Kale 1978, Layne 1978b, Humphrey 1992c, Moler 1992a). Species-by-land-cover associations were established using information provided by the Florida

Table 16. Species used in an abbreviated gap analysis.

Reptiles and Amphibians

Pine Barrens treefrog
Gopher frog
Florida bog frog
Seal salamander
Georgia blind salamander
Striped newt
American alligator
American crocodile
Atlantic loggerhead turtle
Green sea turtle
Atlantic hawksbill turtle
Kemp's ridley
Alligator snapping turtle
Leatherback
Barbour's map turtle
Carolina diamondback terrapin
Ornate diamondback terrapin
Mississippi diamondback terrapin
Mangrove terrapin
Florida east coast terrapin
Suwannee cooter
Striped mud turtle
Gopher tortoise
Florida scrub lizard
Florida Keys mole skink
Cedar Key mole skink
Blue-tailed mole skink
Peninsula mole skink
Sand skink
Key ring-necked snake
Eastern indigo snake
Red rat snake
South Florida rainbow snake
Mangrove salt marsh snake
Atlantic salt marsh snake
Florida pine snake
Short-tailed snake
Florida brown snake
Rim rock crowned snake
Central Florida crowned snake
Coastal dunes crowned snake
Peninsular crowned snake
Florida ribbon snake
Eastern diamondback rattlesnake

Birds

Eastern brown pelican
Snowy egret
Little blue heron
Tricolored heron
Reddish egret
Roseate spoonbill
Wood stork
Osprey
American swallow-tailed kite
Snail kite
Short-tailed hawk
Southern bald eagle
Swainson's hawk
Audubon's crested caracara
Southeastern kestrel
Peregrine falcon
Yellow rail
Black rail
Limpkin
Florida sandhill crane
Black-bellied plover
Cuban snowy plover
Piping plover
American oystercatcher
Royal tern
Roseate tern
Least tern
Black skimmer
White-crowned pigeon
Florida burrowing owl
Red-cockaded woodpecker
Florida scrub jay
Marian's marsh wren
Worthington's marsh wren
Bachman's warbler
Stoddard's yellow-throated warbler
Kirtland's warbler
Florida prairie warbler
Florida grasshopper sparrow
Cape Sable seaside sparrow
Louisiana seaside sparrow
Scott's seaside sparrow
Smyrna seaside sparrow
Wakulla seaside sparrow

Mammals

Homosassa shrew
Sherman's short-tailed shrew
Gray bat
Indiana bat
Wagner's mastiff-bat
Lower Keys marsh rabbit
Eastern chipmunk
Big Cypress fox squirrel
Sherman's fox squirrel
Goff's pocket gopher
Key Largo woodrat
Sanibel Island marsh rice rat
Silver rice rat
Florida mouse
Anastasia Island beach mouse
Choctawhatchee beach mouse
Pallid beach mouse
Perdido Key beach mouse
St. Andrews beach mouse
Santa Rosa beach mouse
Southeast beach mouse
Anastasia Island cotton mouse
Chadwick Beach cotton mouse
Key Largo cotton mouse
Duke's saltmarsh vole
Florida black bear
Everglades mink
Florida mink
River otter
Florida panther
Manatee
Florida key deer

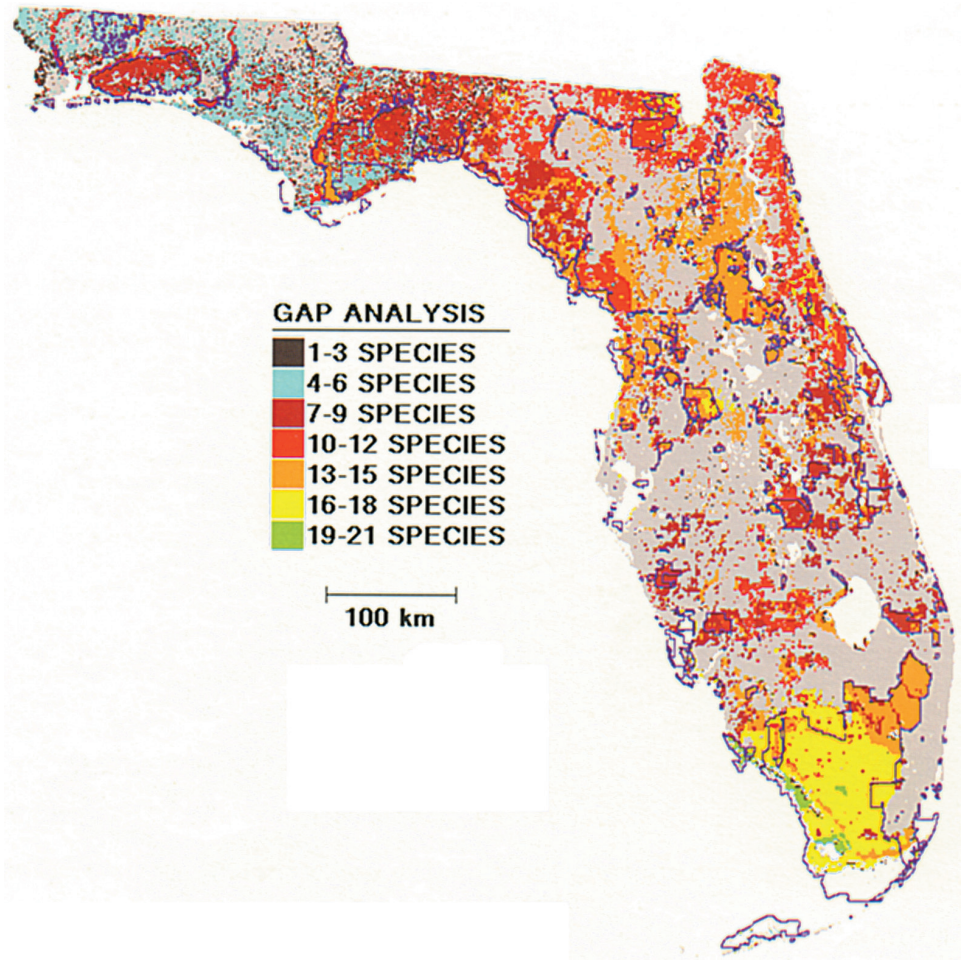


Figure 141. Overlay of coarse habitat distribution maps for 120 rare species.

Natural Areas Inventory (Anon. 1991) and Hamel (1992). These theoretical models of habitat associations and distributions are not firmly based on site-specific information, nor was any effort made to refine the maps by deleting habitat patches that were potentially too small, contained inappropriate habitat composition, or were too isolated from known population centers.

An overlay of the potential habitat maps for these 120 species (Figure 141) shows several areas of potential importance to conservation efforts for many rare species. In general, this map highlights various marshes, swamps, and hardwood forests of southern Florida; patches of scrub throughout central and north Florida; patches of coastal strand and salt marsh statewide; sandhill and xeric pineland communities in the peninsula (and to a lesser degree in the panhandle); floodplain forests in the panhandle; and tropical hardwood hammocks in south Florida. Patches of tropical hardwood hammock and scrub may be difficult to see because of their small size.

Several potentially important habitat areas are highlighted within existing conservation areas. The group of conservation areas in extreme south Florida represents one of the most important reservoirs of rare species richness in all of Florida, and proper management of these areas is of critical importance to the maintenance of Florida's rich diversity. Given the potential importance of this area to so many rare species, special attention should be given to the types of activities allowed in and around some of these conservation areas. The resolution of water management issues affecting these areas will also have great implications for some of Florida's rarest species.

The Ocala National Forest and the archipelago of conservation lands comprising the Withlacoochee State Forest in central Florida appear to contain some of the most important upland forests in the state as measured by this technique. These tracts include important associations of sandhill and scrub communities that support rich vertebrate communities (Kautz 1984, Humphrey et al. 1985).

Outside of existing conservation lands, areas immediately north of Big Cypress National Preserve and Fakahatchee State Preserve and extending as far north as Corkscrew Swamp Sanctuary stand out as potentially important regions of rich diversity that are not formally protected. Some areas in this region are being considered for acquisition, but agricultural activities are also expanding rapidly into this area. Water-use permits covering more than a million acres were recently reviewed as part of a plan to convert areas to citrus production (see Florida panther, Section 6.2.14). The region to either side of Fisheating Creek also represents a large area of "natural" land cover that is potentially important to many

rare species.

Upland sandhill and xeric pine forests north of the Ocala National Forest and along the sand ridge extending through parts of Levy, Citrus, Hernando, and Pasco counties represent large patches of unprotected lands with potentially great species richness. Some of these areas are being considered for purchase by the state, but most of these species-rich habitats face a very uncertain future as a result of expanding residential development. The proposed extension of the Florida turnpike (T. Gilbert pers. comm.) could also affect many of the species-rich habitat areas remaining in Levy County. Another large and significant species-rich area in private ownership occurs along the southeastern edge of the Green Swamp (east of the Richloam Tract of the Withlacoochee State Forest and nearby Southwest Florida Water Management District lands) in northern Polk and southern Lake counties. There are also potentially important lands scattered throughout the Big Bend area that consist primarily of forested wetlands and upland hardwood forests.

These results might change slightly if additional species were included, but this map appears to portray Florida's more important centers of biodiversity fairly accurately (see Ward 1979, Millsap et al. 1990). However, although gap analysis may help to point to areas of Florida that warrant further attention, it is inappropriate to propose conservation strategies based simply on areas showing a high coincidence of rare species. The conservation of species-rich areas does not guarantee that individual species will be adequately protected. For example, conservation of species-rich areas surrounding Big Cypress National Preserve and Everglades National Park may not adequately protect a viable population of Florida panthers. Much better autecological information concerning habitat use and population sizes is needed to determine the areas most important to panther conservation.

Another concern is that the philosophy behind gap analysis may parallel the philosophy behind the "edge" concept that was used for years to guide wildlife management practices (Harris 1988). Management of edge habitat was often stressed because edges tended to have higher species richness than other surrounding habitat areas (Harris 1988). However, more recent studies have shown that edges can have a decidedly negative impact on many of the species that occur along edges yet prefer forested habitats (Andren and Angelstam 1988, Harris 1988). The fact that edges are species rich areas says nothing of the value of edge habitat in maintaining species richness or individual species.

Section 6.3.5. Pine Rocklands

Pine rockland communities are restricted to outcrops of Miami limestone in Dade County and the Florida Keys (Snyder et al. 1990). The largest remaining patches of pine rockland forest are on Long Pine Key in Everglades National Park and on Big Pine and Cudjoe keys in the Florida Keys (Figure 142). The total area of pine rockland shown is 5,168 ha (12,765 acres).

A proposal (Anon. 1992, 1993) submitted to the Florida Conservation and Recreation Lands program identified important remnant tracts of pine rocklands in Dade County. This proposal was based on an extensive survey of all of the remaining tracts of pine rocklands in south Florida (Anon. 1992, 1993). Several species unique to the Miami Ridge might be protected through the conservation of these areas (Table 17). These tracts (Figure 143) are confronted by a wide range of problems, and urban and residential develop-

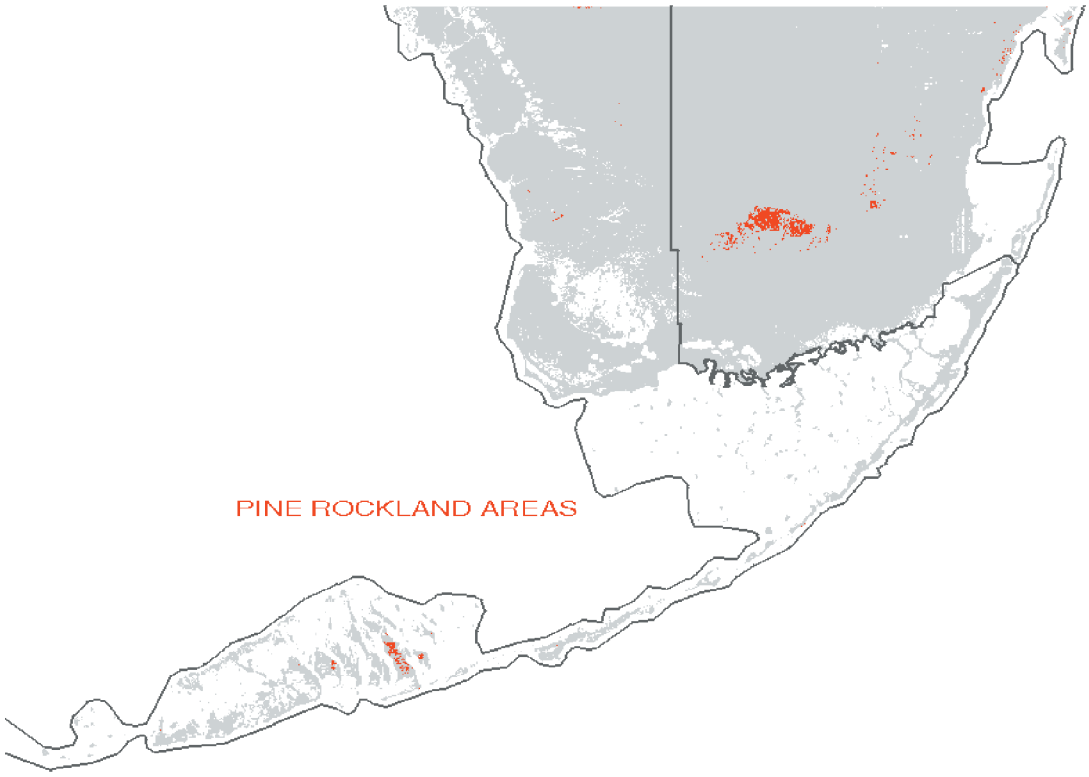


Figure 142. Distribution of pine rockland communities in southern Florida.

Table 17. Species found in Strategic Habitat Conservation Areas proposed for pine rockland communities. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

Animals	Deltoid spurge	Florida lantana
	Wedge spurge	Silver palm
Short-tailed hawk	Garber's spurge	Royal palm
Key silverside	Porter's broad-leaved spurge	Thatch palm
Lower Keys marsh rabbit	Porter's broom spurge	Powdery catopsis
Key deer	Manchineel	Fuch's bromeliad
Key mud turtle	Florida five-petaled pawpaw	Banded wild-pine
Florida Keys mole skink	A queen's delight	White-top sedge
Key ringneck snake	Pineland noseburn	Broad-leaved spiderlily
Red rat snake	Big Pine partridge pea	Cow-horned orchid
Lower Keys brown snake	Pineland milk pea	Spurred neottia
Lower Keys ribbon snake	Small's milkpea	Dollar orchid
	Brown-haired snoutbean	Night-scented orchid
Plants	Necklace pod	Worm-vine orchid
	Sand flax	Florida gama grass
Krug's holly	Tetrazygia	Golden leather fern
Florida thoroughwort brickell-bush	Twinberry	Fragrant maidenhair fern
Small-leaved melanthera	Florida pinewood privet	Maidenhair fern
Bahama sachsia	Boykin's few-leaved milkwort	Four-leaved maidenhair fern
Little strongbark	Everglades peperomia	Slender spleenwort
Christmas berry	Blunt-leaved peperomia	Halberd fern
Wild potato morning-glory	Cuban snake-bark	Bristle fern
Rocklands morning-glory	Pride-of-Big-Pine	
Pineland jacquemontia	Inkwood	
Blodgett's wild-mercury	Joewood	

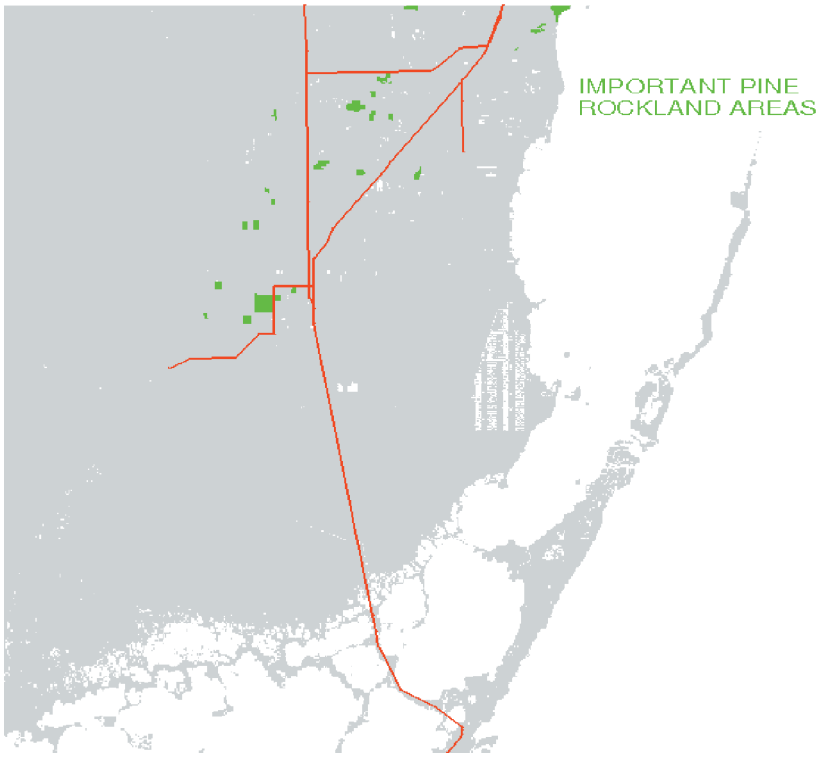


Figure 143. Important pine rockland communities in Dade County.

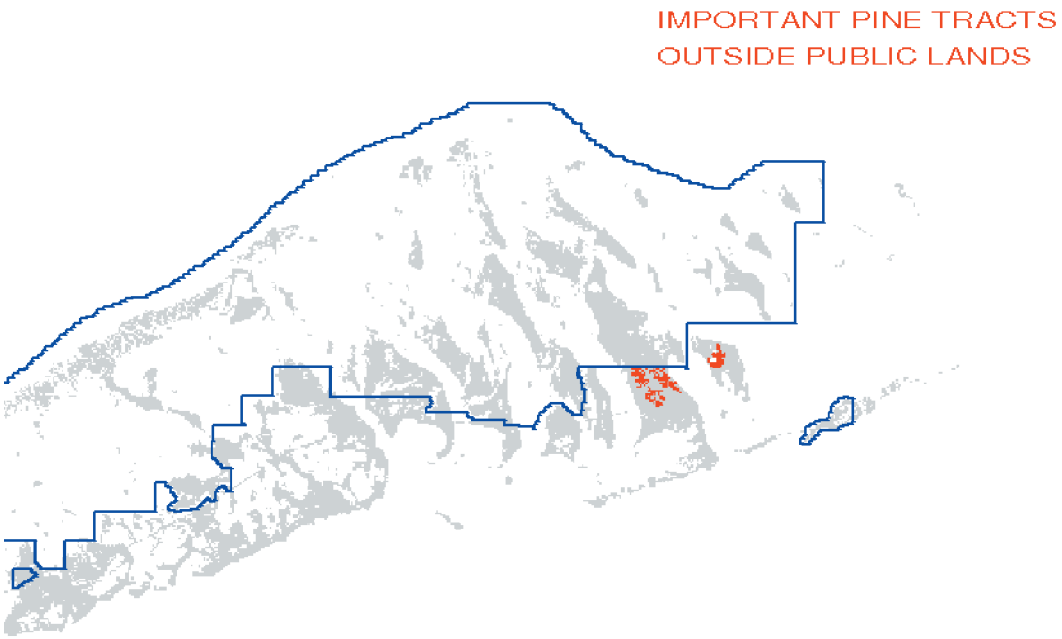


Figure 144. Important tracts of pine rocklands outside of existing conservation areas in the Florida Keys.

ment has eliminated some of these areas since the proposal was submitted to the Conservation and Recreation Lands program. Hurricane Andrew felled many canopy trees and may have enhanced the spread of exotic species. The remaining habitat within the areas shown in Figure 143 warrant some measure of conservation.

We also performed an analysis of the remaining tracts of pine rocklands found in the Florida Keys by isolating the pineland and mixed hardwood-pine land-cover mapped for the Keys. Individual contiguous tracts of these two cover types were identified, and each tract was ranked based on the number of unique occurrence records stored by the Florida Natural Areas Inventory. Sites containing < 5 occurrence records were assigned a value of 1; sites containing 6-10 occurrence records were assigned a value of 2; and sites containing > 10 occurrence records were assigned a value of 3.

Most (83%) of the remaining pine rocklands in the Florida Keys are in Key Deer National Wildlife Refuge on Big Pine Key. Only three tracts of pinelands (Figure 144) south of Key Deer National Wildlife Refuge were highlighted by these analyses, and only two of these tracts have at least 5 occurrence records in the Florida Natural Areas Inventory database. Portions of these areas have been identified as important habitat areas for the Florida Key deer. Some of the remaining habitat may have been cleared since the Landsat land-cover map was developed. However, we isolated these unprotected patches of habitat and combined them with the map of pine rocklands along the Miami Ridge to create Strategic Habitat Conservation Areas (Figure 145) for this rare and dwindling community type.

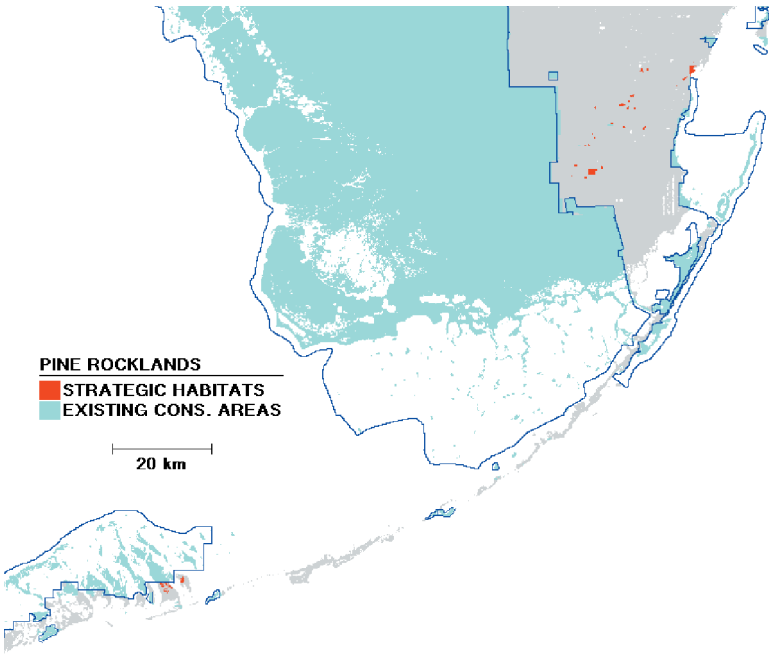


Figure 145. Strategic Habitat Conservation Areas for pine rockland communities.

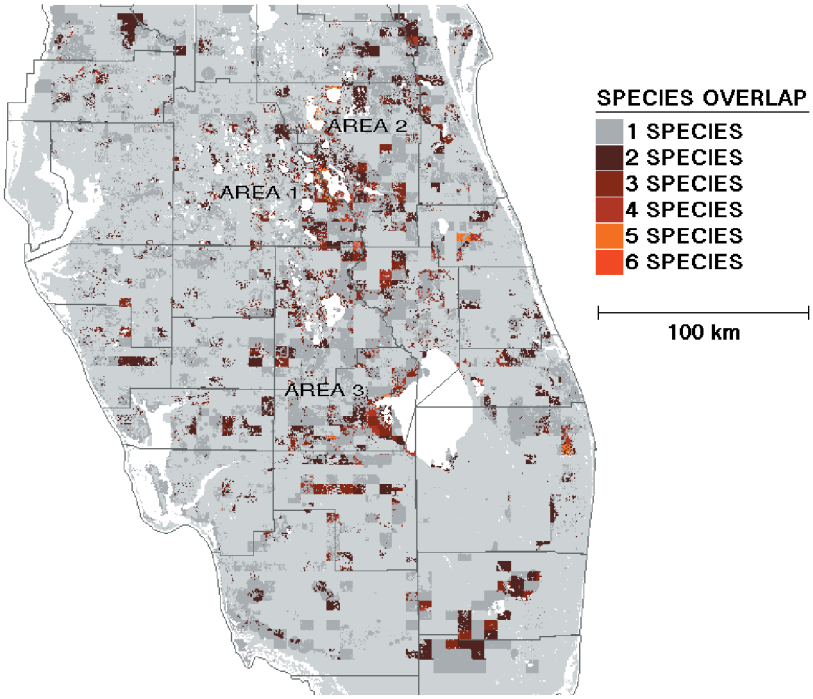


Figure 146. Overlap of habitat distribution maps for species of birds associated with prairies.

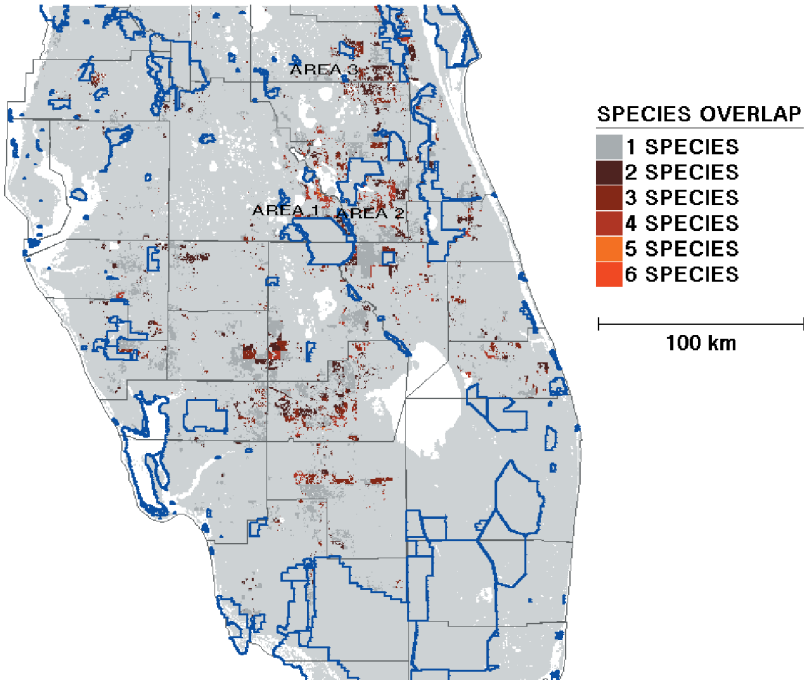


Figure 147. Important prairie lands as indicated by landownership patterns and species overlap.

Section 6.3.6. Prairie Birds

The dry prairie communities of southern Florida contain a unique assemblage of plant and animal life (Muller et al. 1989). Some of the birds associated with this community type (e.g., Florida sandhill crane, Florida burrowing owl, Florida scrub jay, Audubon's crested caracara) have distinctive, disjunct populations that are generally restricted to Florida. Existing conservation areas do not provide many of these species with the habitat base needed for long-term security (Section 6.2). Indeed, this wildlife community may be one of the least adequately represented on existing conservation lands. Although we discussed the importance of selected areas for individual species elsewhere, here we focus more generally on the prairie bird community and describe areas of potentially high species richness.

We overlaid the habitat distribution maps developed for southern bald eagle, Audubon's crested caracara, red-cockaded woodpecker, burrowing owl, Florida grasshopper sparrow, snail kite, Florida scrub jay, mottled duck, limpkin, and sandhill crane to produce Figure 146. The greatest overlap of habitat areas for prairie bird species outside of current conservation lands is found north and southeast of the Avon Park Air Force Range and nearby conservation areas (Area 1, Figure 146). Considering the potential importance of this area to these rare species, these private lands contain some of the most important wildlife habitat remaining in Florida. Other species-rich areas occur west of Lake Okeechobee (Area 2, Figure 146), and southwest of the Tosohatchee State Reserve (Area 3, Figure 146). These areas are extremely important to maintaining Florida's rare prairie avifauna and warrant some type of conservation action.

Figure 146 may include large areas of improved pasture and shrub and brush land cover (which constitute potential habitat for some of the species used to create Figure 146). To focus on some of the remaining natural areas of potential importance to prairie birds, we made two refinements. First, we restricted the areas displayed in Figure 146 to areas with dry prairie, oak scrub, and freshwater marsh land cover classes. Second, we superimposed our map of large landownerships over this map to show only those areas on large private lands where land-use agreements and conservation easements might be most easily pursued. This resulting map is shown in Figure 147, which includes boundaries of conservation areas.

There are several important areas highlighted by these analyses, though most are concentrated in Glades, Hendry, DeSoto, Highlands, Polk, Okeechobee, and Osceola counties. The area (Area 1, Figure 147) along the Kissimmee River north of Avon Park Air Force Range contains important habitat for many rare species and provides continuity between conservation areas that may become isolated with the loss of habitat on these private

lands. To the southeast, north, and west of the Three Lakes Wildlife Management Area (Area 2, Figure 147) are several large tracts of important habitat that would help to enlarge this conservation area and also maintain continuity between Three Lakes Wildlife Management Area and other conservation areas. The lands to the southwest and east of Tosohatchee State Preserve (Area 3, Figure 147) contain a large area of freshwater marsh and prairie lands that are extremely important to this rare community of birds. Other extremely important blocks of more-or-less isolated patches of species-rich areas are found in southeastern DeSoto and southwestern Highlands counties, most of central and northern Glades County, and central Hendry County.

Although we have not designated specific Strategic Habitat Conservation Areas based on these overlays, the analyses were used earlier to help refine the Strategic Habitat Conservation Areas designed for red-cockaded woodpecker, Audubon's crested caracara, limpkin, mottled duck, and Florida sandhill crane.

Section 6.3.7. Sandhill Communities

Florida's sandhill communities, which Davis (1967) showed covering nearly 20% of the state, have been reduced to < 10% of their former acreage (Figure 148). The largest remaining patches of sandhill are found in Santa Rosa, Okaloosa, and Walton counties; in the sand lakes region of Washington County; along the sand ridge extending from Levy County to Pasco County; and on sand ridges in Putnam and Clay counties.

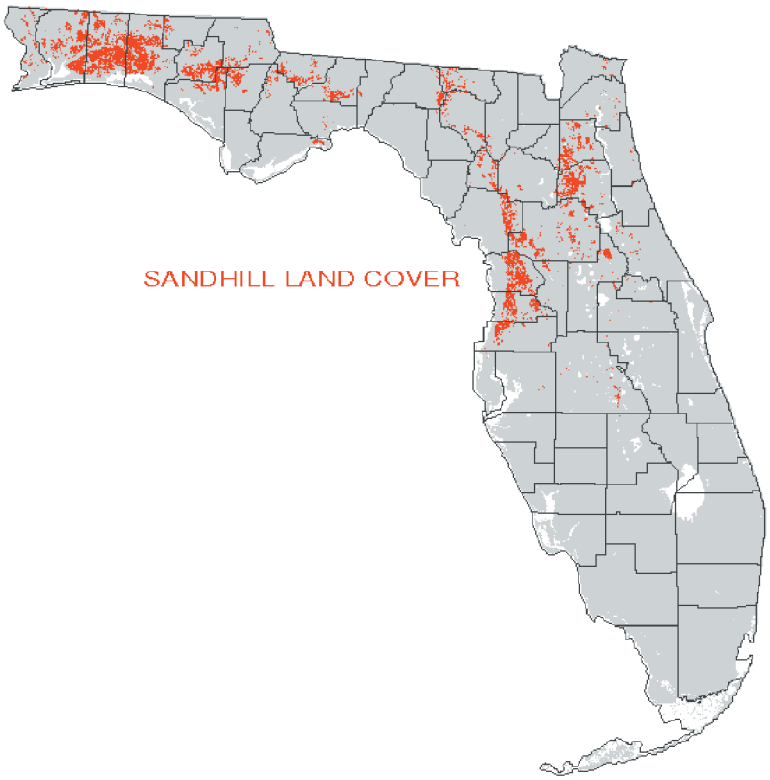


Figure 148. Distribution of remaining tracts of sandhill Florida.

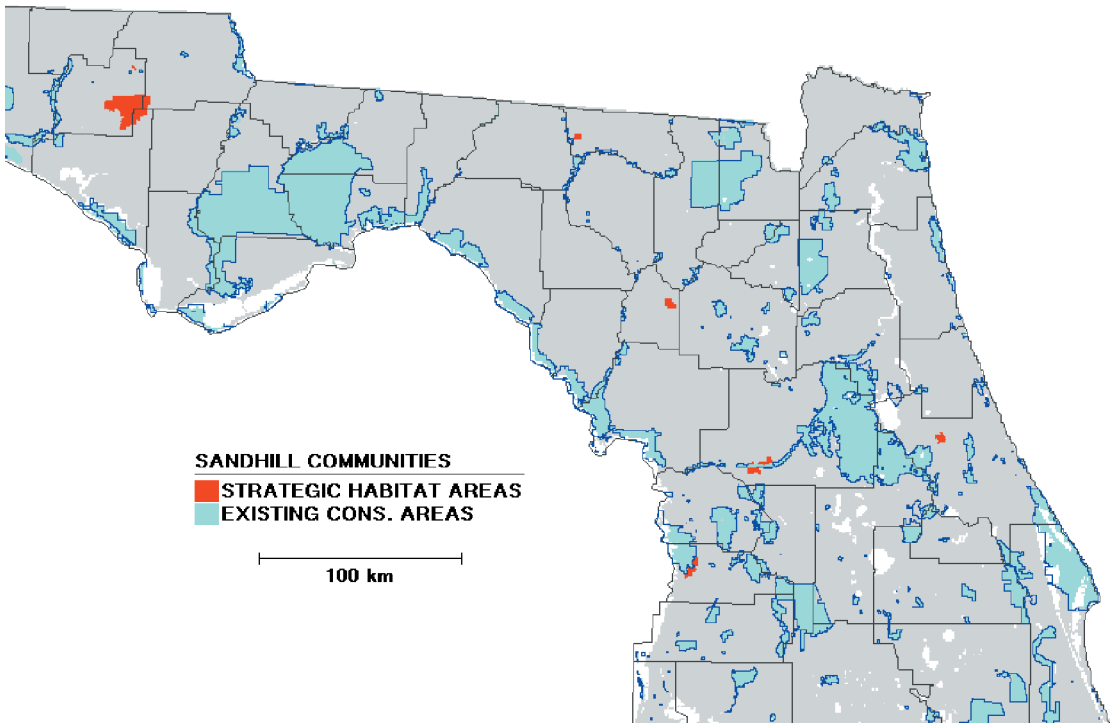


Figure 149. High quality tracts of longleaf pine and sandhill in Florida.

Table 18. Species recorded in Strategic Habitat Conservation Areas proposed for sandhill communities. Whether these species benefit from the proposed habitat conservation areas will depend on more specific habitat assessments.

Animals	*Plants*
Gopher frog	Southern milkweed
Bald eagle	Nuttall's rayless goldenrod
Short-tailed hawk	Southern marshallia
Southeastern American kestrel	Smooth-barked St. John's-wort
Red-cockaded woodpecker	Spoon-leaved sundew
Florida scrub jay	Mountain laurel
Bachman's sparrow	Orange azalea
Gopher tortoise	Gulf coast lupine
Eastern indigo snake	Piedmont water-milfoil
Short-tailed snake	Florida anise
Florida cave amphipod	Toothed savory
Hobb's cave amphipod	Longspurred mint
Leitheuser's cave crayfish	Scrub bay
McLane's cave crayfish	Ashe's magnolia
	Pyramid magnolia
	White-top pitcher-plant
	Silky camellia
	Baltzell's sedge
	Coville's rush

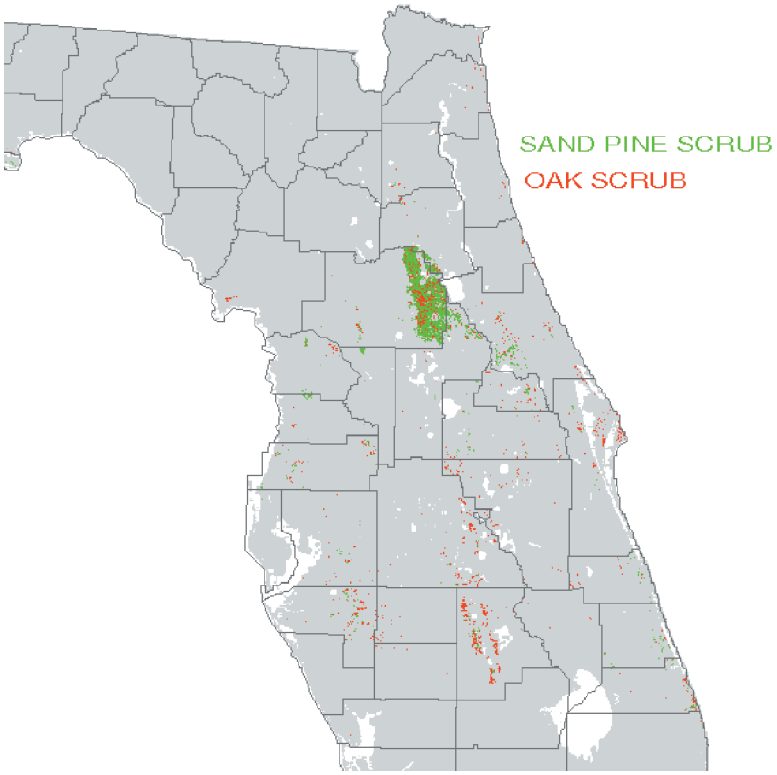


Figure 150. Tracts of sand pine and oak scrub in Florida.

The Florida Natural Areas Inventory identified several high quality sandhill tracts in a proposal submitted to Florida's Conservation and Recreation Lands program (Anon. 1992). We digitized the locations of these sites from 1:24,000 scale topographic maps. These areas (Figure 149) represent the most important tracts identified for this once extensive community type, and these areas support many rare plants and animals. These areas warrant some type of conservation action because of their high quality and the imperiled nature of this community type. We designated the patches of sandhill habitat shown in Figure 149 as Strategic Habitat Conservation Areas for this rare plant community. Some of these areas were also delimited for species that lack adequate representation on the current system of conservation areas (e.g., subspecies of fox squirrel and southeastern American kestrel). A list of species associated with these patches of habitat is provided in Table 18.

Section 6.3.8. Scrub Communities

The largest remaining tracts of oak scrub occur as numerous insularized patches at the southern end of the Lake Wales Ridge in south central Florida (Figure 150). Other patches of oak scrub are found along the eastern coastal ridge; in portions of Hardee, Manatee, and Hillsborough counties; and scattered amid tracts of sandhill and sand pine scrub elsewhere in the state. The patches of oak scrub shown in the Ocala National Forest (Figure 150) consist of oaks that dominate areas soon after clear cutting or burning of sand pine forests. The largest

remaining tract of sand pine scrub occurs in the Ocala National Forest in north central Florida (Figure 150). Sand pine scrub also occurs as scattered, isolated patches just inland from the high energy shorelines of both coasts.

A proposal to acquire 4,940 ha (12,200 acres) of scrub habitat along the Lake Wales Ridge is being reviewed by the U.S. Congress. Some of the important areas that make up this proposed acquisition are shown in Figure 151. These sites were selected by a group of biologists from Archbold Biological Station, Florida Natural Areas Inventory, Florida Game and Fresh Water Fish Commission, U.S. Fish and Wildlife Service, and elsewhere and are based on the rare plants and animals each area supports. These sites support 13 federally listed endangered and threatened plants, and 13 additional rare plants that are candidates for listing as endangered or threatened (U.S. Fish and Wildlife Service 1992). Conservation of the scrub habitat on these sites is essential to maintaining one of the nation's most endangered natural communities. The top priority sites identified and currently being considered for protection are around Carter Creek (Highlands County), Flamingo Villas (Highlands County), and Holmes Avenue (Highlands County). These three sites would protect 11 of the 13 plants listed as endangered or threatened (U.S. Fish and Wildlife Service 1992) and 8 of the 13 plants proposed for listing.

Another inventory of important scrub habitat in the Treasure Coast region was conducted by the Florida Game and Fresh Water Fish Commission (Fernald 1989). Fernald recommended 4-6 ha (10-15 acre) conservation areas for rare plants, 6-10 ha (15-20 acre) conservation areas for territories of the Florida scrub jay, and 20 ha (50 acre) conservation areas for larger scrub communities. The areas identified by Fernald (1989) are critical to maintaining examples of scrub communities along the southern Atlantic coastal ridge, and the locations of these valuable areas are shown in Figure 152. Some of the scrub habitat identified by Fernald (1989) also makes up the Strategic Habitat Conservation Areas defined for the Florida scrub jay (Section 6.2.16).

A final analysis of scrub land cover was performed to assess the potential importance of scrub patches not reviewed by Fernald (1989) or the U.S. Fish and Wildlife Service (1992). We identified 11,477 patches of sand pine and oak scrub occurring on private lands in the Tampa Bay, Withlacoochee, East Central, North Central, and Northeast Florida regions. The total area encompassed by these patches was 41,800 ha (103,240 acres); 7,116 of the patches were < 1 ha (2.5 acres) in size.

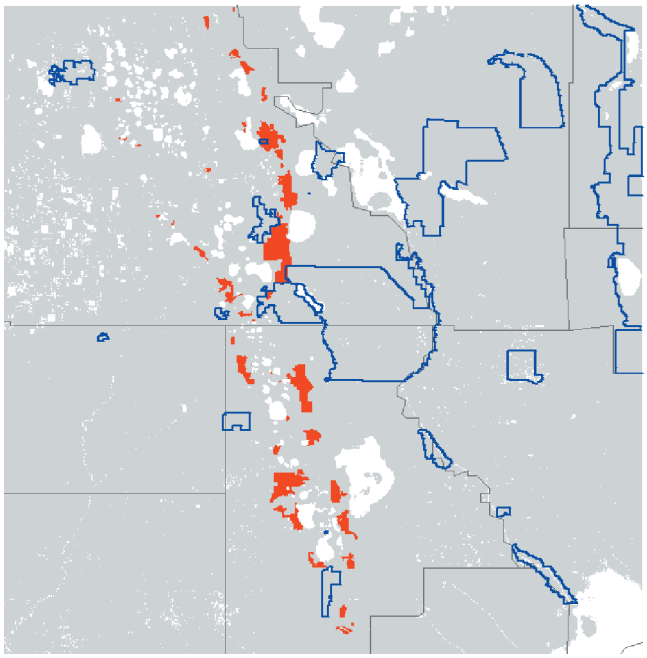


Figure 151. Tracts of oak and sand pine scrub along the Lake Wales Ridge.

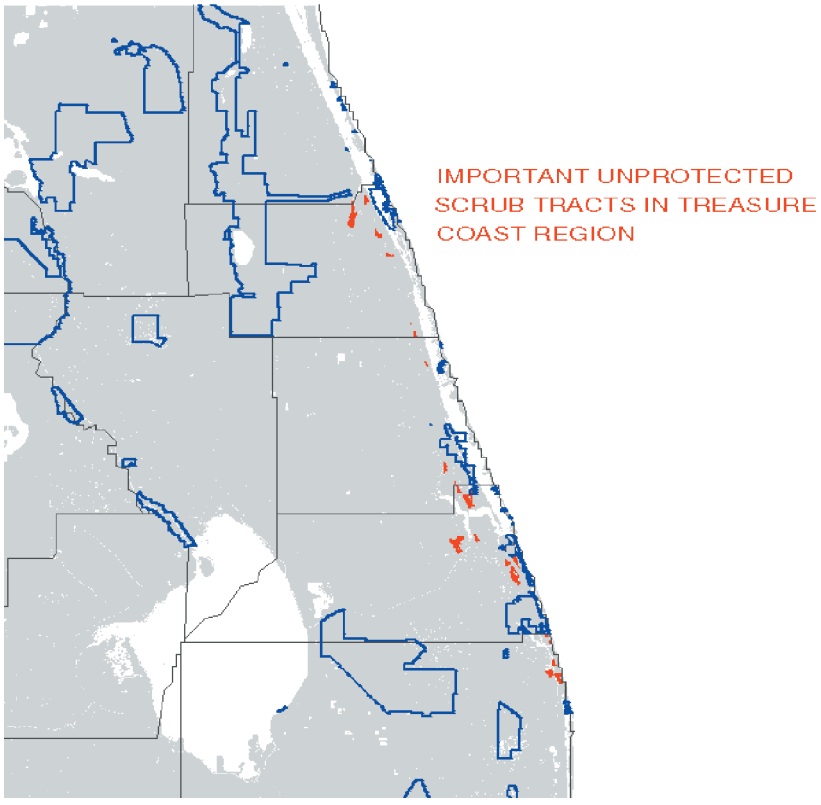


Figure 152. Tracts of oak and sand pine scrub along the southeast Atlantic coast.

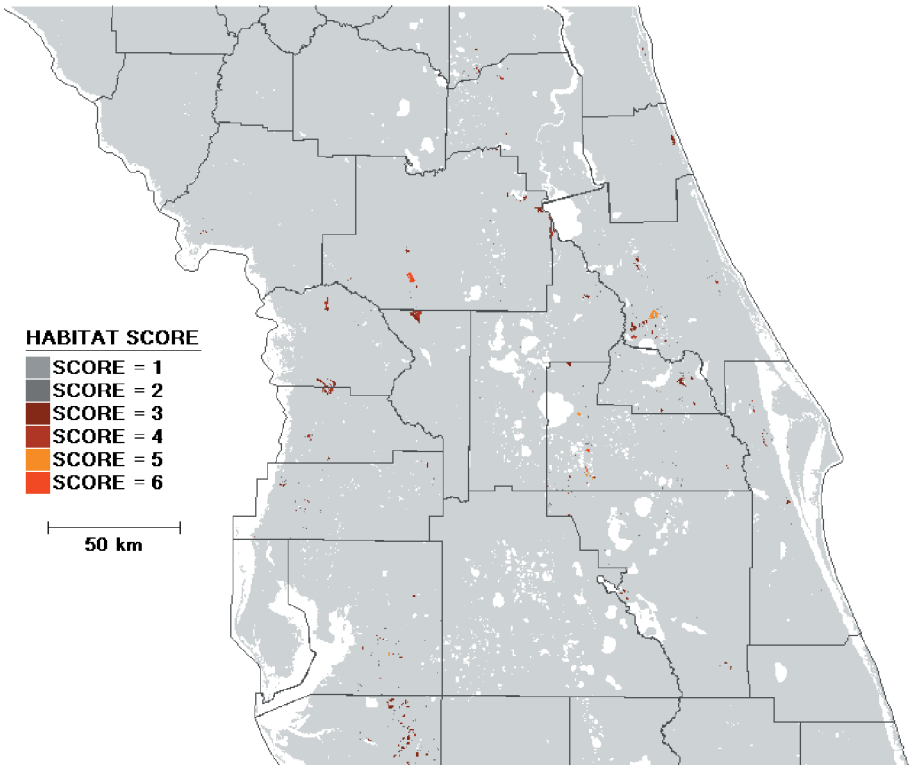


Figure 153. High quality tracts of oak and sand pine scrub in north central Florida. Quality was measured by size of the patch of habitat and the number of occurrence records processed by the Florida Natural Areas Inventory.

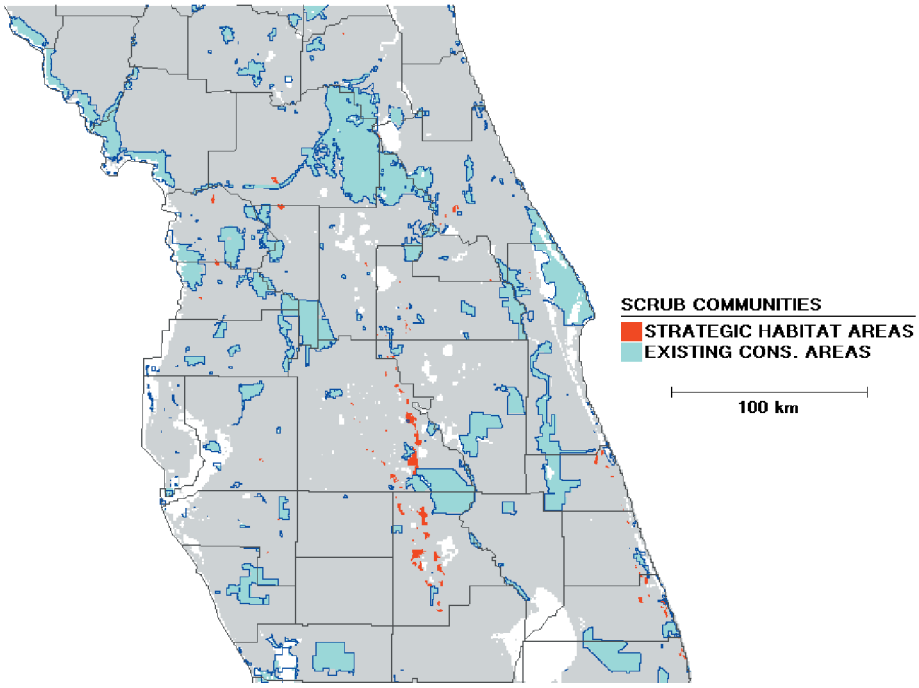


Figure 154. Strategic Habitat Conservation Areas for oak and sand pine scrub communities.

We developed a qualitative score for each patch based on its size and the number of occurrence records mapped for the patch by the Florida Natural Areas Inventory. Scrub patches < 10 ha (25 acres) were given a score of 1; patches > 10 ha but < 40 ha (100 acres) were given a score of 2; and patches > 40 ha were given a score of 3. The scoring of sites based on their size reflects a concern that patches be of a sufficient size to allow prescribed fire management procedures to be conducted safely (Doren et al. 1987). Sites with < 3 occurrence records were given a score of 1; areas with 3-5 occurrence records were given a score of 2; and areas with > 5 occurrence records were given a score of 3. A total of 154 occurrence records was found for 77 of the 11,477 unique scrub patches. One of these patches had 9 occurrence records.

The results of this scoring process are shown in Figure 153. The highest scoring scrub sites (score > 3) occurred in Brevard, Citrus, Hillsborough, Hernando, Lake, Manatee, Marion, Orange, Sumter, and Volusia counties. The total area of the 13 highest scoring sites (score > 3) was 4,260 ha (10,523 acres), while lower scoring scrub sites (score < 3) totaled to 37,540 ha (92,720 acres). Many of the higher scoring patches of scrub shown in Figure 153 were discussed as part of the habitat conservation recommendations developed for the Florida scrub jay (Section 6.2.16). Important areas not mentioned in the section concerning scrub jays include scrub patches in northeastern Manatee and southeastern Hillsborough counties, Hernando and Citrus counties, and central Clay county.

We fully recognize the problems associated with identifying scrub land cover based on satellite imagery (Kautz et al. 1993). Our analyses highlight very important scrub patches without necessarily highlighting all important patches of scrub. We treat the 13 highest scoring areas identified by our analysis of the land-cover map and other data sets, as well as sites identified by Fernald (1989) and the U.S. Fish and Wildlife Service (1992), as Strategic Habitat Conservation Areas for this rare community. These Strategic Habitat Conservation Areas are shown in Figure 154. Identification of important scrub sites represents an on-going project at Archbold

Figure 155. Tracts of tropical hardwood hammocks in south Florida.

Biological Station (J. Fitzpatrick pers. comm.). These efforts will likely expand upon the minimum conservation recommendations developed here.

Section 6.3.9. Tropical Hardwood Hammock Communities

The majority of the remaining patches of tropical hardwood hammocks are located in the Florida Keys (Figure 155). In the Upper Keys, tropical hardwood hammocks are most abundant on Key Largo and Elliott Key. Lower Keys having significant quantities of tropical hardwood hammock include Big Pine Key, No Name Key, the Torch keys, Ramrod Key, Summerland Key, Cudjoe Key, and Sugarloaf Key. The total area of tropical hardwood hammock mapped for the Florida Keys was 4,682 ha (11,564 acres), which is 76% of all tropical hardwood forests mapped during the project. Most of the remaining parcels of tropical hardwood hammock outside of the Florida Keys are found on Sanibel and Captiva islands (Lee County) and on shell middens in the Ten Thousand Islands.

To assess the importance of different patches of tropical hardwood hammock on private lands in the Florida Keys, we analyzed the size of individual patches of hammocks and the number of records of rare species that were mapped for each patch by the Florida Natural Areas Inventory. The use of patch size to assess the relative importance of each area was based on the problems of effectively managing extremely small habitat patches as well as the general importance of larger patches to several key species (Strong and Bancroft in prep.). Patches < 2 ha (5 acres) were assigned a score of 1, patches 2-4 ha (5-10 acres) were assigned a score of 2, and patches > 4 ha (10 acres) were assigned a score of 3.

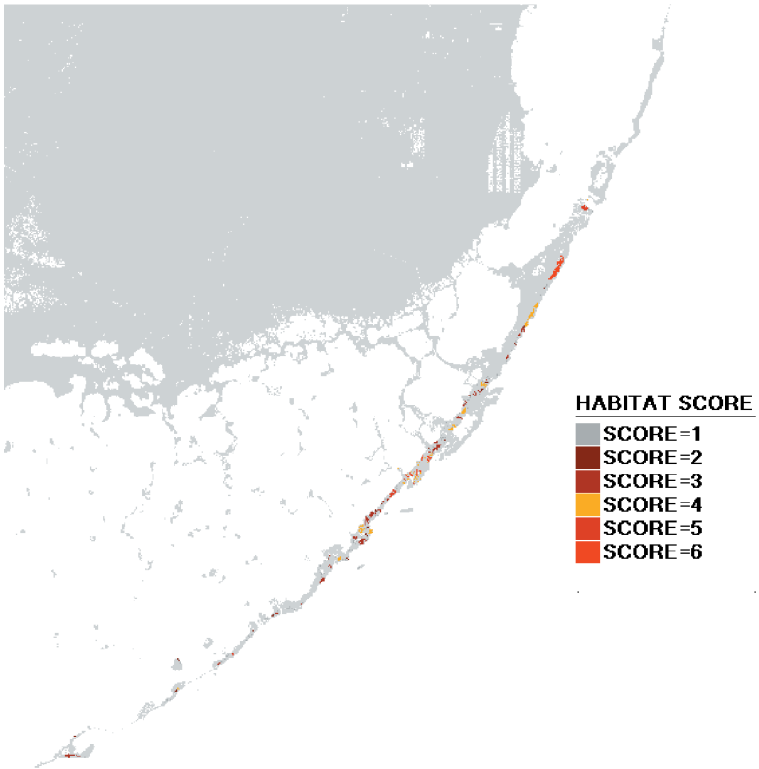


Figure 156. Qualitative scoring of tropical hardwood hammock tracts in the Upper Keys based on their size and the number of occurrence records processed by the Florida Natural Areas Inventory.

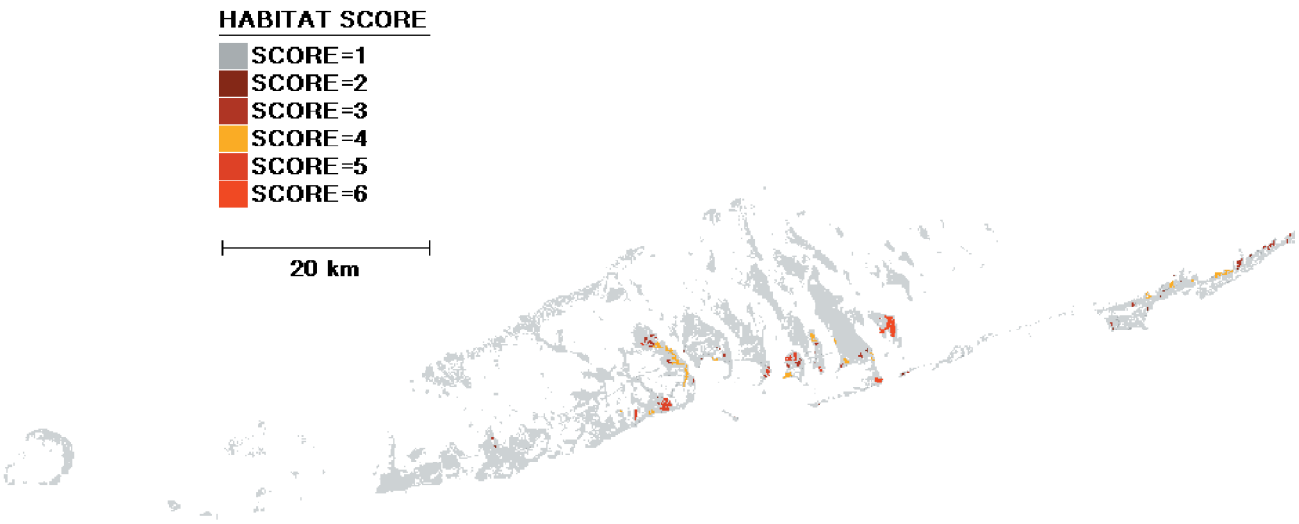


Figure 157. Qualitative scoring of tropical hardwood hammock in the Lower Keys based on their size and the number of occurrence records processed by the Florida Natural Areas Inventory.

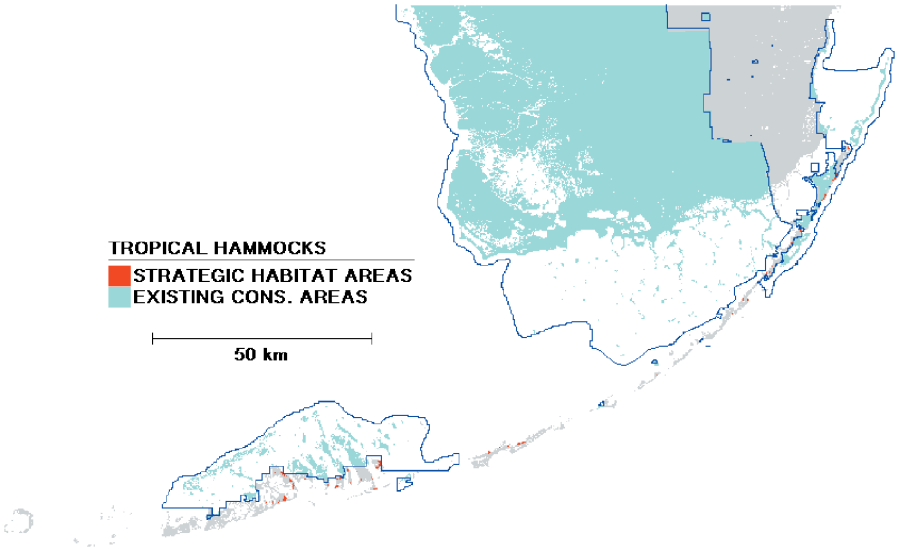


Figure 158. Strategic Habitat Conservation Areas for the tropical hardwood hammock community.

Patches of hammock were also assigned scores based on the number of occurrence records mapped for the patch by the Florida Natural Areas Inventory. Tracts containing < 7 occurrence records were assigned a score of 1; those with 8-15 occurrence records were assigned a score of 2; and hammocks with > 15 occurrence records were assigned a score of 3.

There were 453 patches of tropical hardwood hammock identified, and the average patch size was 4.7 ha (11.6 acres). Most (52.5%) patches are < 1 ha (2.5 acres). There were also 328 occurrence records for these patches of hammock. The largest number of records for a single patch was 38 records on No Name Key. This is also the largest remaining patch at 148.2 ha (367 acres).

Addition of the two maps described above shows a number of important patches of hammock on private lands throughout the Florida Keys. There are 1,199 ha (2,961 acres) of hammock in 32 separate parcels with scores > 3. The important patches of hammock shown in Figure 156 for the Upper Keys were similar to those identified in earlier analyses described for the white-crowned pigeon (Section 6.2.31). However, some of the patches of hammock shown for the Lower Keys (Figure 157) were not highlighted in the analyses performed for white-crowned pigeons (Section 6.2.31). The two highest ranking patches of hammock shown for the Lower Keys occur on No Name Key and near Long Beach (Big Pine Key). These areas represent relatively large, contiguous tracts of tropical hammock that support many rare species. Strategic Habitat Conservation Areas developed for this rare community type (Figure 158) encompassed the 12 highest scoring (≥ 5) patches. Some of these overlap with the Strategic Habitat Conservation Areas designated for the white-crowned pigeon.

Section 6.3.10. Wetlands Important to Wading Birds

Wading birds can serve as indicators of the quality of wetland systems and water resources (Bildstein et al. 1991). A very broad type of habitat delineation was performed around individual wading bird colonies that contained one of the following species: wood stork, white ibis, little blue heron, tricolored heron, snowy egret, great egret, reddish egret, or roseate spoonbill. We generated circles around known nesting colonies (Runde et al. 1991) based on approximate distances that individual species will travel to forage (Custer and Osborn 1978, Frederick and Collopy 1988, Bancroft et al. 1990). Within these circles, we isolated the wetland areas that are typically used as foraging areas. The radius of the circle generated for most species of wading birds was 15 km. However, 30 km was used to describe the core foraging areas near wood stork colonies (Browder 1984, Bryan and Coulter 1987, Frederick and Collopy 1988), and 10 km was used for reddish egrets (Kushlan 1976). The potential foraging map created for wood storks is shown in Figure 160 as an example of this technique.

We combined the maps constructed for each species to create a single map (Figure 160) that shows wetland systems of potential importance to several species of wading birds. The importance of specific wetland areas surrounding individual colonies likely changes from year to year based on rainfall and specific hydrologic conditions unique to each site (Kahl 1964, Bildstein et al. 1991). However, the potential importance of several large wetland systems such as the Water Conservation Areas south of Lake Okeechobee, Everglades National Park, Corkscrew Swamp (and nearby Okaloacoochee Slough), the Upper St. Johns River marshes, and the Green Swamp can be readily appreciated from this map. Other areas of importance to wading birds occur along or near the Peace River in DeSoto County; coastal areas in Hernando and Citrus counties; and wetlands in southern Alachua, central Pasco, northern Hillsborough, west central Osceola, western Columbia, and eastern Hamilton counties.

We designated wetlands outside of existing conservation areas where an overlap of at least 3 species occurred as Strategic Habitat Conservation Areas (Figure 161). In addition, due to the endangered status of wood storks, we also designated wetlands within 15 km of known wood stork colonies as Strategic Habitat Conservation Areas. Wood storks forage over a larger area than 15 km (Kahl 1964), but this distance encompasses most of the for-

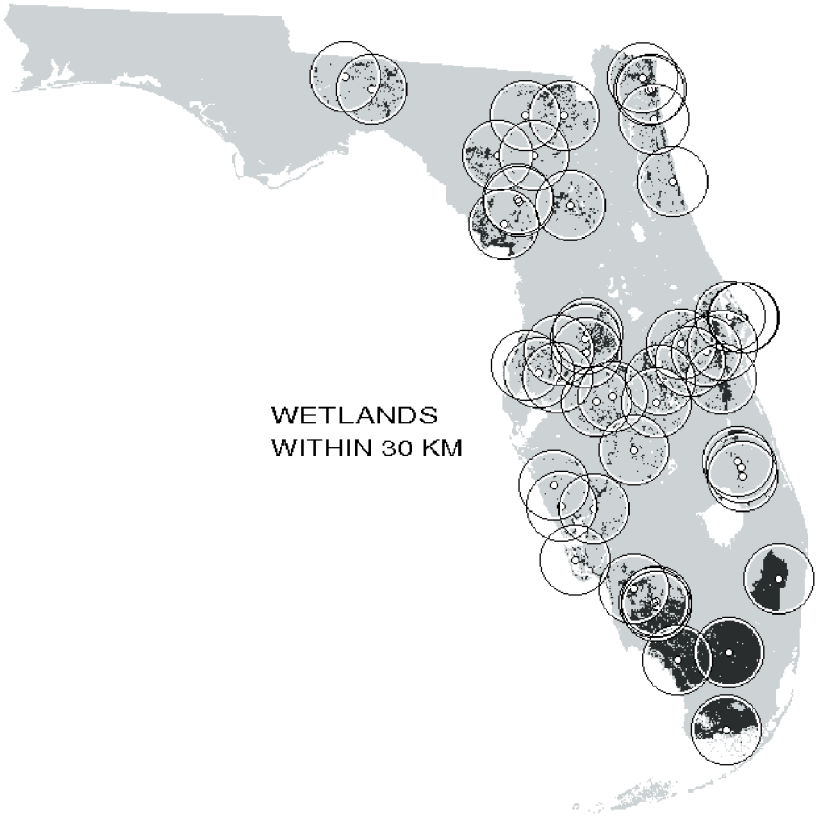


Figure 159. Foraging zones around wood stork nesting colonies.

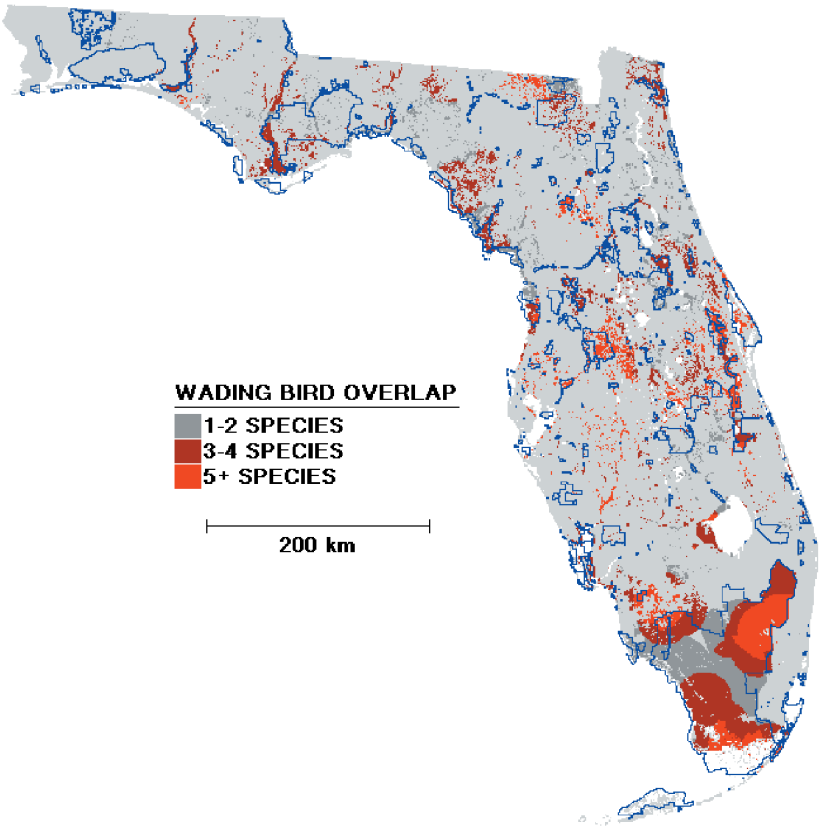


Figure 160. Overlap of potential foraging areas for 8 species of wading birds.

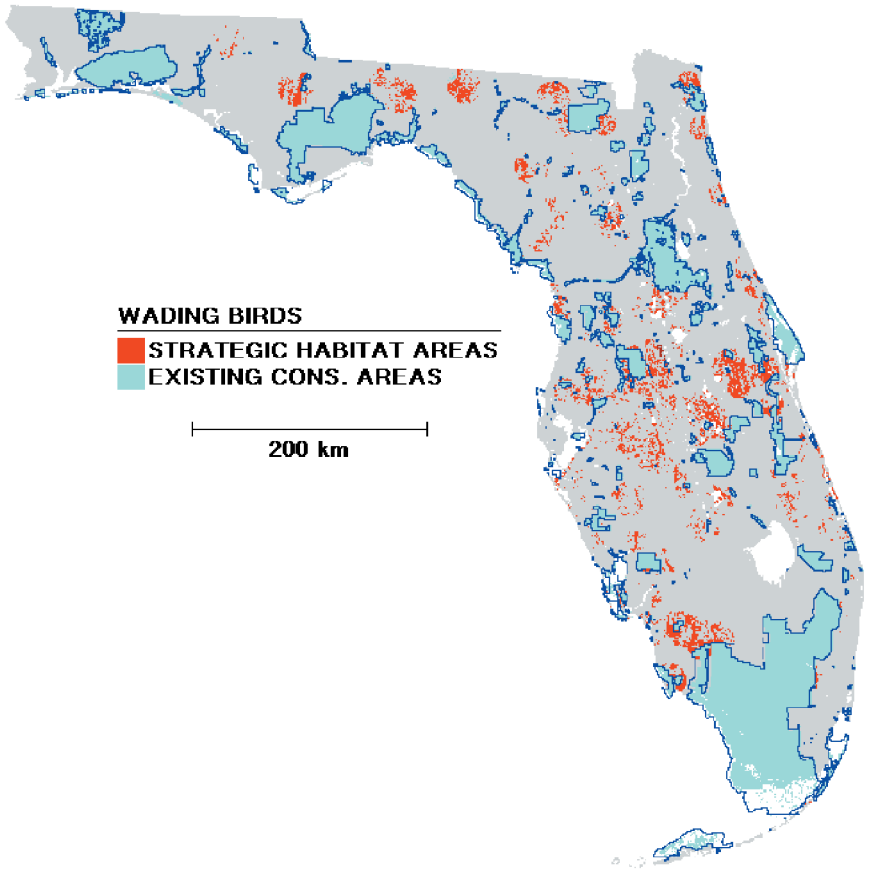


Figure 161. Proposed Strategic Habitat Conservation Areas for 8 species of wading birds.

aging distances reported from a number of studies (Kahl 1964, Browder 1984, Bryan and Coulter 1987). The wetland areas near nesting colonies also play a critical role during the nesting season soon after the young hatch (Browder 1984). Because of the regulatory status of wetland areas, the conservation of areas shown to be important to many different species can be largely achieved through the application of existing wetland laws.

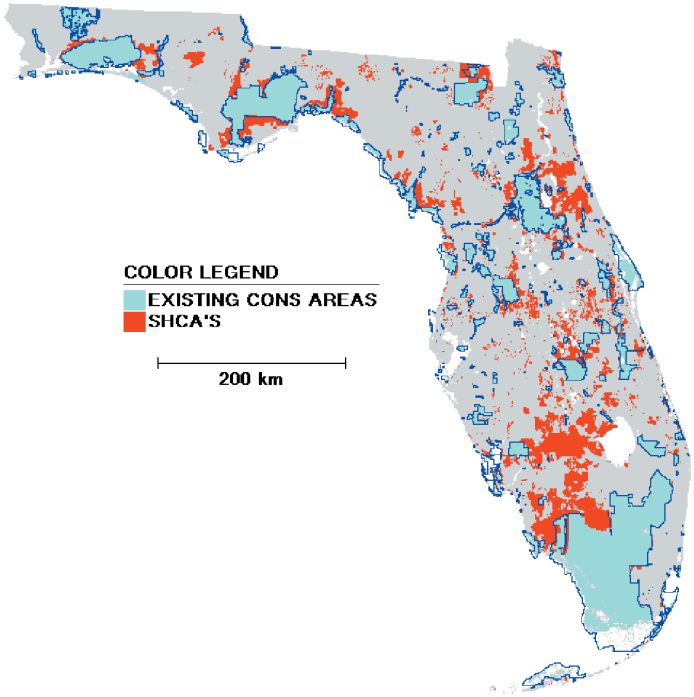


Figure 162. Combined Strategic Habitat Conservation Areas for various components of biological diversity.

SECTION 7. CLOSING THE GAPS: AN AGGREGATE MAP OF IMPORTANT HABITAT AREAS IN FLORIDA

This project was designed around the fairly simple concept of analyzing geographic data sets that could be used to describe habitat features important to different plant and wildlife species. Detailed habitat maps were developed for 44 taxa of wildlife based on known occurrences, habitat requirements, and accompanying information on land cover. We then evaluated the quantity and geographic distribution of habitat provided each taxon by current conservation areas throughout Florida. When estimating the number of distinct habitat areas provided a focal species, contiguous conservation areas (e.g., Everglades National Park and Big Cypress National Preserve) were consolidated into a single area if appropriate habitat conditions extended throughout both existing conservation area.

If current conservation areas lacked the minimum quantity of habitat needed to sustain at least 10 populations of 200, habitat areas on private lands were identified that could significantly enhance the security of each taxon. Some level of public management is required to safeguard the habitat features on these private lands, and in some cases "public management" can consist of land-use agreements that simply perpetuate current land uses such as grazing and timber operations. Table 19 describes the habitat base and degree of security provided each taxon if the Strategic Habitat Conservation Areas described in Sections 6.3.1-33 are added to the current system of conservation lands. In some cases (e.g., American crocodile), the quantity of habitat available on private lands is so limited that it does not dramatically change the current status of the species. In these situations, careful attention needs to be given to all of the remaining habitat areas, and expanded management activities should be pursued within established conservation areas.

We also analyzed other natural resources that could not be addressed by our detailed treatment of selected wildlife species. Habitat conservation areas were developed for rare plant and animal communities, as well as individual species of plants, to help maintain natural populations of these unique components of Florida's biological diversity.

SECTION 7.1. STRATEGIC HABITAT CONSERVATION AREAS IN FLORIDA

By combining the maps described briefly in the preceding paragraphs and fully detailed in Sections 6.2 and 6.3, a composite map was created showing Strategic Habitat Conservation Areas for all species, species groups, and natural communities for which recommendations were developed. The Strategic Habitat Conservation Areas merged into Figure 162 are essential to enhancing the long-term security of many plants, animals, and natural communities that constitute essential components of Florida's natural diversity. The specific Strategic Habitat Conservation Area maps of individual species and community types that were merged into Figure 162 are listed in Table 20 and were discussed in greater detail in Sections 6.2 and 6.3.

The area defined by these proposed Strategic Habitat Conservation Areas is 19,538 km^2 (4.82 million acres) or approximately 13.8% of the area of the state (excluding water). In combination with current conservation areas, which cover 28,149 km^2 (6.95 million acres), excluding water, a total of 47,687 km^2 (11.7 million acres) is recommended for conservation land uses. This is approximately 33.3% of the total land area of the State of Florida, excluding water.

Table 19. Overview of recommendations developed for focal species and their effects on population security.

American crocodile	Conserves remaining habitat areas; increases size of managed habitat by 15%.
Bog frog	Conserves remaining habitat areas; secures habitat along new stream sides.
Florida scrub lizard	No recommendations; existing conservation areas and recommendations for other components will result in sufficient habitat to sustain approximately 13 populations > 200 individuals.
Gopher tortoise	No recommendations; existing conservation areas and recommendations for other components will result in sufficient habitat to sustain many populations > 200 individuals.
Pine Barrens treefrog	No recommendations; existing conservation areas and recommendations for other components will provide sufficient habitat conservation.
Atlantic salt marsh snake	Conserves remaining habitat areas; increases size of manageable habitat by 50-70%.
Gulf salt marsh snake	Conserves habitat in three geographically distinct areas; maintains habitat across the geographic range of the species in Florida.
American oystercatcher	No recommendations.
American swallow-tailed kite	Conserves sufficient habitat to double the size of the manageable population (increasing size from roughly 200 to 400 territories); also secures habitat around important roosting sites statewide.
Audubon's crested caracara	Conserves sufficient habitat to increase the manageable population by 400% (from roughly 20 to 100 territories).
Black-whiskered vireo	Conserves large habitat blocks in geographically distinct areas of the Florida Keys, Tampa Bay, Charlotte Harbor, Indian River Lagoon, and Biscayne Bay; maintains broad geographic distribution of habitat areas.
Cuban snowy plover	Conserves remaining habitat areas; expands and enhances geographic distribution of manageable habitat areas.
Florida burrowing owl	No recommendations.
Florida grasshopper sparrow	Conserves remaining habitat areas; increases the number of manageable habitat areas from 3 to 5.
Florida sandhill crane	Triples the habitat that can be managed; provides sufficient habitat to support about 480 territories; enhances the habitat base for small populations.
Florida scrub jay	Conserves sufficient habitat to support seven new populations of at least 50-100 territories (producing a total of 10 manageable populations of about 100-200 individuals); maintains broad geographic distribution of habitat areas.
Limpkin	Increases the habitat base by approximately 45% and maintains habitat in 4 new geographically distinct areas.
Mangrove cuckoo	Conserves habitat in new geographically distinct areas (Lower Keys, Tampa Bay, Charlotte Harbor); maintains geographic distribution of habitat areas.
Mottled duck	Conserves several new habitat areas where high use and high abundances have been recorded; increases manageable habitat base by 35%.
Piping plover	No recommendations.
Red-cockaded woodpecker	Conserves habitat supporting larger populations remaining on private lands in central and south Florida; additional recommendations will enhance dispersal among smaller protected populations.
Cape Sable seaside sparrow	No recommendations.
Louisiana seaside sparrow	Conserves new habitat areas in Pensacola Bay; increases habitat base by 50% and secures habitat in 1 distinct area.

Table 19. Overview of recommendations developed for focal species and their effects on population security (continued).

Smyrna seaside sparrow	Conserves new habitat areas in northeast Florida; increases manageable habitat base by 75% and maintains habitat areas across a broad geographic region.
Scott's seaside sparrow	Conserves new habitat areas in west central Florida; increases manageable habitat base by 70% and maintains habitat areas across a broad geographic region.
Wakulla seaside sparrow	Conserves occupied habitat in two new geographically distinct areas of the panhandle; maintains the geographic distribution of habitat areas.
Short-tailed hawk	Conserves documented habitat areas; increases the manageable base of habitat by 200%.
Snail kite	Conserves documented habitat areas; maintains habitat areas in geographically distinct areas of central and southwest Florida.
Southeastern American kestrel	Conserves habitat in new geographically distinct areas; increases manageable habitat by approximately 45%.
Southern bald eagle	Conserves habitat in major nest concentration sites; in combination with recommendations developed for other species, proposed conservation areas will increase number of territories on management areas from 170 to approximately 300.
White-crowned pigeon	Conserves new foraging habitat areas in the Upper and Lower Keys. Increases the quantity of foraging habitat by approximately 35% and maintains foraging habitat across a broad geographic area.
Wild turkey	No recommendations. Recommendations developed for other components will add sufficient habitat to sustain many populations > 200 individuals.
Wilson's plover	No recommendations.
Anastasia Island beach mouse	Conserves remaining habitat areas; enhances geographic distribution of manageable habitat areas.
Choctawhatchee beach mouse	Conserves remaining habitat areas; expands habitat available to existing populations and brings the number of manageable habitat areas to three.
Perdido Key beach mouse	No recommendations.
Santa Rosa beach mouse	No recommendations.
Southeastern beach mouse	Conserves remaining habitat areas; expands habitat available to existing populations and establishes habitat for geographically distinct area.
Bobcat	No specific recommendations; recommendations developed for other species will result in many manageable populations > 200 individuals.
Florida black bear	Conserves sufficient habitat to sustain at least 5 populations > 200; increases base of habitat by approximately 65%; provides blocks of habitat and corridors that expand area available to existing populations.
Florida panther	Conserves sufficient habitat to sustain a population of 50-60 individuals.
Mangrove fox squirrel	Conserves sufficient habitat to support at least one new population in a geographically distinct area; recommendations for other species will secure sufficient habitat to sustain at least four populations > 200 individuals.
Sherman's fox squirrel	No specific recommendations; recommendations developed for other species will provide sufficient habitat to sustain > 10 populations of 200 individuals.

Table 20. Species and community analyses merged into the summary map of Strategic Habitat Conservation Areas.

FOCAL SPECIES

Amphibians and Reptiles

American crocodile
Bog frog
Salt marsh snake
- Atlantic salt marsh snake
- Gulf salt marsh snake

Birds

American swallow-tailed kite
Audubon's crested caracara
Black-whiskered vireo
Cuban snowy plover
Florida grasshopper sparrow
Florida sandhill crane
Florida scrub jay
Limpkin
Mangrove cuckoo
Mottled duck
Red-cockaded woodpecker
Seaside sparrows
- Louisiana seaside sparrow
- Smyrna seaside sparrow
- Scott's seaside sparrow
- Wakulla seaside sparrow

Short-tailed hawk
Snail kite
Southeastern American kestrel
Southern bald eagle
White-crowned pigeon

Mammals

Beach mice
- Anastasia Island beach mouse
- Choctawhatchee beach mouse
- Southeastern beach mouse

Florida black bear
Florida panther
Fox squirrel
- Mangrove fox squirrel

OTHER COMPONENTS OF BIOLOGICAL DIVERSITY

Analysis of 105 globally rare plant species
Bat maternity and winter roosting caves
- Southeastern bat
- Gray bat

Pine rocklands
Sandhill communities
Scrub communities
Tropical hardwood hammock communities
Wetlands important to wading birds
- Common egret
- Little blue heron
- Reddish egret
- Roseate spoonbill
- Snowy egret
- Tricolored heron
- White ibis
- Wood stork

A comparison of current land cover within existing conservation areas, proposed conservation areas, and private lands is provided in Table 21. Within proposed Strategic Habitat Conservation Areas, the proportional increases in such rare natural communities as coastal strand, oak scrub, sand pine scrub, sandhill, and tropical hardwood hammock are, respectively, 39.5%, 28.7%, 8.6%, 19.4%, and 30.0%. Dry prairie land cover on conservation areas would increase by 150% from 15.7% to approximately 42%, and cypress swamp land cover would increase by 100% from 33.6% to 73%.

Conservation of habitat within the Strategic Habitat Conservation Areas presented in Figure 162 will require new initiatives along several broad fronts as well as renewed efforts in more traditional types of land acquisition and land management. Florida's ambitious land acquisition programs represent a vital foundation for much of this effort, but the current level of funding may not conserve all of the important natural resources identified here. We estimate that the area needed to sustain populations of Florida panther and Florida black bear could easily consume all of the funds currently available for land acquisition, if fee-simple acquisition was the only technique used to conserve these areas. Unfortunately, even this mammoth undertaking would do little for some other rare species that also face unacceptably high chances of extinction without additional habitat conservation.

Alternatively, some of the important lands identified here may be effectively conserved using "less-than-fee" techniques, which are less expensive than outright purchase. Protective measures included under this heading are tax incentives for private landowners; purchase of conservation easements and development rights; land leasing; land-use regulations; and other techniques that secure valuable natural resources but also allow private uses of the land.

The effectiveness of these different techniques can vary greatly. Land-use regulations and tax incentives, for example, are potentially short lived since both mechanisms may be undercut quickly in a changing political climate. The frequent debates surrounding wetland regulations and endangered species laws help to demonstrate the shifting nature of these protective measures.

We recommend that acquisition of conservation easements and land-use agreements be the primary method applied to some of the Strategic Habitat Conservation Areas described in Figure 162. Procuring easements and development rights enable more comprehensive management of the natural resources of an area while also allowing compatible private land uses. Many of the wide-ranging species considered in these analyses have habitat requirements that are compatible with certain agricultural activities such as low-intensity rangeland and timber operations, and in such cases less-than-fee initiatives offer great potential. However, clear, specific, and quantitative management goals must be established

Table 21. Comparison of land cover (in ha) on private lands, existing conservation areas, and proposed Strategic Habitat Conservation Areas. Percentages are shown on the second line of each entry.

	Private	Existing Conservation	Strategic Areas	Total
Coastal Strand	1,300	2,900	1,600	5,800
	21.80	50.65	27.55	
Dry Prairie	346,900	94,800	161,400	603,200
	57.52	15.72	26.76	
Pineland	2,030,600	470,300	415,400	2,916,300
	71.41	16.13	12.46	
Sand Pine	22,400	75,000	6,900	104,200
	21.45	71.96	6.59	
Sandhill	196,400	142,600	34,100	373,200
	52.63	38.22	9.15	
Oak Scrub	30,300	32,100	11,900	74,300
	40.71	43.25	16.04	
Mixed Hardwood-Pine Forest	143,100	20,800	1,200	1,850,100
	77.27	11.26	11.47	
Upland Hardwood Forest	595,000	168,100	107,900	871,000
	68.32	19.30	12.39	
Tropical Hardwood Hammock	700	3,500	1,800	6,100
	11.92	57.78	30.30	
Salt Marsh	36,800	118,800	40,700	196,300
	18.77	60.50	20.73	
Freshwater Marsh	227,600	645,400	199,900	1,072,900
	21.21	60.16	18.63	
Cypress Swamp	165,200	210,300	249,500	625,000
	26.43	33.64	39.93	
Mixed Hardwood Swamp	346,400	165,600	215,300	727,300
	47.63	22.77	29.60	
Bay Swamp	27,200	13,500	17,000	57,700
	47.13	23.46	29.42	
Shrub Swamp	55,700	137,800	44,500	238,000
	23.39	57.91	18.70	
Mangrove Swamp	18,800	186,100	23,600	228,400
	8.23	81.45	10.32	
Bottomland Hardwood Forest	10,700	17,700	10,600	38,900
	27.44	45.43	27.13	
Grass and Agriculture	2,381,900	66,900	192,000	2,640,900
	90.20	2.53	7.27	
Shrub and Brush	1,272,700	120,100	139,500	1,532,300
	83.06	7.84	9.10	
Exotic Plants	13,200	2,200	200	15,500
	84.71	13.90	1.39	
Barren and Urban Lands	1,432,600	91,200	58,800	1,582,600
	90.52	5.76	3.72	
Totals	9,407,300	2,814,969	1,953,800	14,095,100
	66.74	19.70	13.76	

for these techniques to be effective, and methods for monitoring management agreements must also be developed. Another option that might be attractive in a limited number of cases is public acquisition of land and then leasing the land back to the original title holder for certain agricultural or recreational operations.

Funds available through the state's various land acquisition programs are not often used for some of these "less-than-fee" conservation strategies because of the high cost of easements, difficulty of monitoring and enforcing easements, and lack of public access. Nevertheless, we recommend that conservation easements be further examined in appropriate areas. Some of the areas that might be appropriate are described more specifically in sections dealing with Florida black bear (Section 6.2.11), Florida panther (Section 6.2.14), Florida sandhill crane (Section 6.2.15), and Audubon's crested caracara (Section 6.2.5). Although there will likely be instances where the protection provided by conservation easements proves to be less than complete, the sheer area of habitat that needs to be conserved, coupled with the limited funds available, require that we explore these possibilities more completely.

Additional funds for habitat management and restoration will also be needed since a system of conservation areas can not be left idle if it is to provide adequate protection for the rare plant and animal species it is designed to support. Ongoing habitat management is critically needed once land is protected, and the annual cost of managing state lands in Florida could exceed $180 million assuming that federal lands make up about 40% of the total conservation land base, conservation easements on private lands make up about 30% of the land base, and land-management costs on the remaining state-owned lands are about $20 per acre per year (Anon. 1992, Anon. 1993). While this may seem like a substantial yearly payment, the importance of management cannot be ignored. In fact, the fate of all rare species will ultimately be determined by the quality of ongoing habitat management.

Most areas in public ownership are managed for multiple uses (e.g., recreation, conservation, timber production), but multiple use often translates into multiple conflicts as diverse interests vie for the natural resources provided by publicly managed lands. Given the critical importance of many state forests, wildlife management areas, and state recreation areas to the maintenance of secure populations of rare species in Florida, more explicit guidelines for handling these conflicts may be necessary.

Another aspect of wildlife conservation and management that requires greater attention is the protection of conservation areas from usurpation for other public and private uses. Public lands originally conserved for their important natural resources often serve as magnets for powerline corridors, road rights-of-way, and other public and private ventures because of the reduced costs of purchasing land and easements. Among the many examples of problems of this nature are the construction of a four-lane road through rare scrub habitat in a state park in the Florida panhandle, the proposed construction of a power transmission line through a wildlife management area in southwest Florida, the proposed construction of a turnpike through several conservation areas in north central Florida, and the proposed construction of a turnpike through valuable habitat on public lands in Levy County. Although it seems somewhat incongruous that "protected" natural areas are appropriated in such a manner, the legal power to prevent such acts is often weak. We recommend that increased attention be given to this problem and that a more formal process be established to dedicate public lands and selected wetland systems to a statewide system of habitat conservation areas. Public lands and wetlands that are dedicated to a statewide system of conservation areas should be appropriated for other land uses only under very narrowly defined conditions.

The establishment of proposed wildlife conservation areas has economic implications for some local governments. The average increase in the percentage of conservation areas in each county is 10.9%, but the percentage of conservation lands in several counties would increase by more than 20% (Table 22). These counties are Baker, Charlotte, Collier, Flagler, Glades, Hendry, Highland, Lee, Osceola, Polk, Putnam and Volusia counties. If the percentages for all forms of conservation areas shown in Figure 162 are combined (e.g., current conservation areas and proposed conservation areas), then 12 counties would have > 40% of their total land area (exclusive of water) available for less restrictive land uses. These are Baker, Charlotte, Collier, Dade, Flagler, Franklin, Glades, Liberty, Monroe, Okaloosa, Wakulla, and Walton counties. Concerns over the loss of ad valorem taxes might need to be addressed in some counties where a significant proportion of the total land base is included as one of the Strategic Habitat Conservation Areas shown in Figure 162. However, conservation of habitat in the identified areas does not imply a complete economic drain. Outdoor recreation opportunities, compatible timber and agricultural activities, and other revenue generating activities allowed in most proposed conservation areas constitute a significant source of income. Local businesses in some areas have even begun to promote the "wilderness" aspect of their area (Tallahassee Democrat, May 19, 1991). Moreover, designated conservation areas do not require the infrastructure that often places a great burden on local governments. Proposed conservation areas will not require new schools, new roads, new sewage treatment plants, new water supply systems, new electric facilities, and extensive police and fire protection.

SECTION 7.2. COMPARISON OF AGGREGATE MAP OF STRATEGIC HABITAT CONSERVATION AREAS WITH OTHER MAPS OF NATURAL RESOURCES

The Nature Conservancy, Florida Department of Natural Resources, and Florida Audubon Society convened 40 biologists in January, 1991, for the purpose of outlining important ecological resources in Florida. The map developed at this meeting was transferred to a 1:500,000 scale map of Florida and digitized by the Florida Natural Areas Inventory (Figure 163). The total recommended area for protection encompassed by this map (also known as the "charette" map) is roughly 29,350 km^2 (7.25 million acres), with 10,930 km^2 (2.7 million acres) falling into the highest priority category.

Although the coarse scale at which the charette map was digitized (1:500,000) makes it difficult to make precise comparisons to Figure 162, the degree of overlap between the charette map and Figure 162 is less than might be expected. Only 37% of the Strategic Habitat Conservation Areas we have defined for rare plants and animals are included in the charette map, and only 4,210 km^2 (1.04 million acres) coincide with the highest priority category in the charette map.

Table 22. Acreages of existing conservation lands and proposed Strategic Habitat Conservation Areas (SHCA) for individual Florida counties. The percentage of total area of each county is provided in parentheses.

County	Existing Conservation Lands	Proposed SHCAs	County	Existing Conservation Lands	Proposed SHCAs
Alachua	32,604 (5.48)	33,839 (5.69)	Lake	115,102 (17.56)	115,843 (17.67)
Baker	105,222 (28.15)	117,819 (31.47)	Lee	21,489 (4.28)	120,783 (23.97)
Bay	35,321 (7.19)	14,573 (2.99)	Leon	131,404 (29.67)	34,580 (7.79)
Bradford	16,055 (8.39)	741 (0.42)	Levy	74,841 (10.44)	129,181 (18.01)
Brevard	181,051 (27.16)	99,788 (14.95)	Liberty	319,865 (59.27)	79,781 (14.79)
Broward	483,626 (63.52)	5,681 (0.74)	Madison	6,916 (1.55)	38,532(8.54)
Calhoun	247 (0.00)	37,297 (10.16)	Manatee	22,477 (4.83)	14,326 (3.07)
Citrus	74,841 (19.22)	41,743 (10.71)	Marion	316,160 (30.80)	90,896 (8.85)
Charlotte	69,407 (15.61)	143,754 (32.37)	Martin	20,007 (5.65)	31,369 (8.85)
Clay	70,889 (18.56)	17,043 (4.45)	Monroe	579,215 (91.46)	18,772 (2.98)
Collier	594,035 (46.21)	488,072 (37.96)	Nassau	6,422 (1.52)	39,767 (9.54)
Columbia	82,992 (16.50)	56,316 (11.19)	Okaloosa	320,853 (53.44)	16,055 (2.66)
Dade	698,269 (56.33)	23,959 (1.93)	Okeechobee	16,549 (3.36)	89,908 (18.22)
Desoto	0 (0.00)	78,052 (18.79)	Orange	68,419 (11.78)	46,930 (8.08)
Dixie	41,743 (9.35)	48,412 (10.82)	Osceola	86,450 (9.68)	224,770 (25.18)
Duval	65,208 (13.06)	36,309 (7.24)	Palm Beach	333,697 (26.72)	26,182 (2.09)
Escambia	15,560 (3.69)	247 (0.07)	Pasco	50,388 (10.72)	58,539 (12.42)
Flagler	2,223 (0.74)	183,027 (59.12)	Pinellas	3,211 (1.76)	6,916 (3.97)
Franklin	75,335 (21.55)	108,927 (31.18)	Polk	102,999 (8.68)	244,530 (20.63)
Gadsden	13,338 (4.03)	3,952 (1.19)	Putnam	50,635 (10.60)	135,109 (28.21)
Gilchrist	1,482 (0.63)	18,525 (8.21)	St. Johns	13,585 (3.42)	45,448 (11.32)
Glades	494 (0.10)	393,965 (69.61)	St. Lucie	5,187 (0.01)	27,417 (7.60)
Gulf	34,086 (9.56)	49,400 (13.88)	Santa Rosa	208,715 (31.89)	26,923 (4.13)
Hamilton	6,916 (2.08)	16,549 (5.07)	Sarasota	43,719 (12.23)	21,983 (6.14)
Hardee	247 (0.00)	33,839 (8.40)	Seminole	7,410 (3.73)	11,609 (5.96)
Hendry	1,482 (0.18)	263,549 (35.39)	Sumter	82,004 (22.53)	22,230 (6.10)
Hernando	61,750 (20.11)	10,374 (3.40)	Suwannee	5,928 (1.36)	9,386 (2.10)
Highland	62,491 (9.57)	157,339 (24.09)	Taylor	62,491 (9.48)	80,275 (12.17)
Hillsborough	25,688 (3.93)	44,213 (6.79)	Union	8,892 (5.58)	1,729 (1.16)
Holmes	2,223 (0.01)	741 (0.20)	Volusia	69,160 (9.56)	181,051 (25.04)
Indian River	60.762 (19.04)	19,266 (6.02)	Wakulla	271,206 (69.24)	21,489 (5.50)
Jackson	13,338 (2.20)	20,254 (3.38)	Walton	184,756 (27.15)	99,788 (14.67)
Jefferson	30,628 (8.05)	74,594 (19.62)	Washington	17,537 (4.56)	46,189 (11.94)
Lafayette	988 (0.26)	21,736 (6.19)			

The Strategic Habitat Conservation Areas proposed in Figure 162 will conserve habitat for many other natural resources. Many of the species that benefit from these conservation areas are listed in Sections 6.2.1-6.3.11. However, an evaluation of the different taxa tracked by the Florida Natural Areas Inventory provides a better indication of the extent to which the proposed Strategic Habitat Conservation Areas protect the full diversity of life in Florida. The Florida Natural Areas Inventory maintains records for 715 plant and animal taxa and other natural features such as natural communities. We selected the plant and animal taxa that are followed by the Florida Natural Areas Inventory and determined their presence on existing conservation areas and the proposed Strategic Habitat Conservation Areas. The Strategic Habitat Conservation Areas proposed here will establish a habitat base for 76 taxa that currently have no records from existing conservation areas, and when proposed Strategic Habitat Conservation Areas are combined with existing conservation areas, only 111 taxa followed by the Florida Natural Areas Inventory lack at least one occurrence record from an existing or proposed conservation area (Table 23). If fish are taken out of this tally due to the fact that water areas were excluded from the mapping of Strategic Habitat Conservation Areas, proposed and existing conservation areas miss only 96 of the taxa followed by the Florida Natural Areas Inventory. When considering the fact that several of the vertebrate species (e.g., salt marsh vole) listed in Table 23 are believed to occur on some existing conservation areas in Florida yet are not recorded for these areas in the Florida Natural Areas Inventory database, the proposed habitat conservation areas appear to support most of the rare higher vertebrates monitored by the Florida Natural Areas Inventory.

The proposed Strategic Habitat Conservation Areas and existing habitat conservation areas appear to miss several invertebrates, fishes, and some plants. More specific habitat conservation strategies should be developed for these elements of Florida's biological diversity. However, we note that some of the plants shown in Table 23 are not considered globally rare or threatened by the Florida Natural Areas Inventory. In addition, the absence of records of fish often resulted from the exclusion of water areas when mapping many of the proposed Strategic Habitat Conservation Areas. The Florida Natural Areas Inventory has begun to analyze additional conservation areas for some of these rare plants, and the Florida Game and Fresh Water Fish Commission plans to analyze several of the rare fish shown in Table 23.

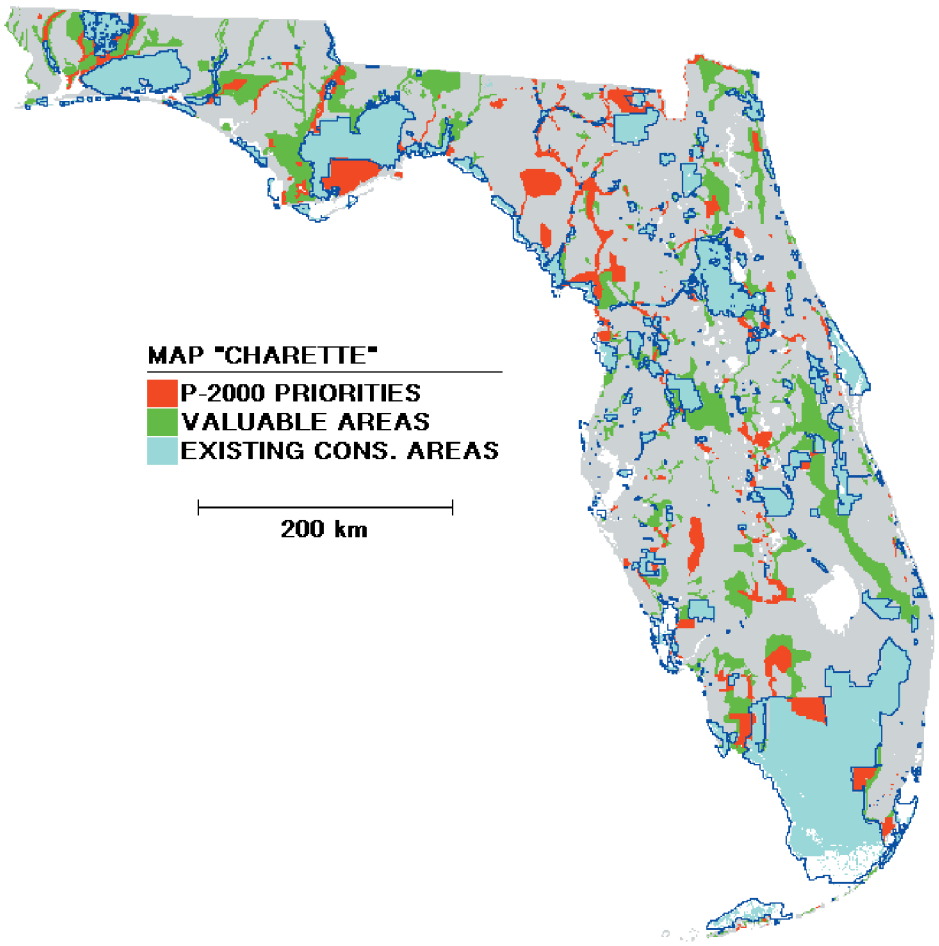


Figure 163. Map of important natural resources based on the "charette" map.

Table 23. Records in the Florida Natural Areas Inventory database that do not have occurrence records within existing conservation areas or proposed Strategic Habitat Conservation Areas.

Amphibians and Reptiles

Seal salamander
Hawksbill sea turtle
Atlantic ridley sea turtle
Leatherback sea turtle
Gulf coast smooth softshell turtle

Birds

Mangrove clapper rail
Roseate tern
American redstart
Worm-eating warbler

Fish

Sea lamprey
Shortnose sturgeon
Alligator gar
Bluehead chub
Rough shiner
Bluestripe shiner
Striped shiner
River redhorse
Lake Eustis pupfish
Saltmarsh topminnow
Shoal bass
Crystal darter
Saddleback darter
Striped croaker
Key blenny

Mammals

Big brown bat
Hoary bat
Saltmarsh vole

Invertebrates

Caecidotea parva (a cave isopod)
Crangonyx sp. (undescribed cave amphipod)
Palm Springs cave crayfish
Red-eyed cave crayfish
Orange Lake cave crayfish
Miller's cave crayfish
Troglocambarus sp. (undescribed cave crayfish)
Squirrel Chimney cave shrimp
Florida atala butterfly
Sandhilll clubtail
Tawny sand clubtail
Maidencane cruiser
Triangle floater
Fat threeridge
Flat floater
Apalachicola floater
Rayed creekshell
Narrow pigtoe
Round pearlshell
Southern pocketbook
Gulf moccasinshell
Bankclimber
Oval pigtoe
Southern creekmussel
Florida tree snail
Stock Island tree snail
Blue Spring aphaostracon
Fenney Spring aphaostracon
Helicoid Spring snail
Enterprise Spring snail
Ponderosa Spring snail
Wekiwa Spring snail

Plants

Apalachicola river aster
Balsam torchwood
Broad-leaved nodding-caps
Buckthorn
Carter's small-flowered flax
Carex microdonta
Chaffseed
Chapman's skeletongrass
Cooley's meadowrue
Craighead's nodding-caps
Creeping-leaf stalkgrass
Crenulate lead-plant
Cuban snake-bark
Cucumber magnolia
Devil's shoestring
Dwarf spleenwort
Eastern purple coneflower
Eaton's spikemoss
Florida crabgrass
Florida pondweed
Giant water-dropwort
Godfrey's sandwort
Hairy beach sunflower
Hay scented fern
Heart-leaved willow
Key tree-cactus
Lakela's pinweed
Large whorled pogonia
Little-people
Miami palmetto
Mexican tear-thumb
Miccosukee gooseberry
Pine-woods aster
Pine-woods bluestem
Pinesap
Rock Key devil's-claws
Rugel's pawpaw
Rough strongbark
Shade betony
Shootingstar
Sleeping beauty water-lily
Tallahassee hedge-nettle
Turk's cap lily
Wedglet fern
West Florida cowlily
White baneberry
Winter grape-fern
Wright's anemia
Yellow-root

SECTION 8. IDENTIFYING REGIONAL HOT SPOTS

SECTION 8.1. MAPS OF REGIONAL HOT SPOTS

Although Figure 162 shows areas in Florida that are essential to sustaining many rare plants, animals, and natural communities, this map does not include other natural areas that might warrant conservation based on their importance to local populations of rare species (e.g., the last scrub jay population in a county) or other natural resources. Figure 162 defines the minimum habitat conservation areas deemed necessary to maintain key components of biological diversity, not all of the high quality habitat or natural communities remaining in Florida. The conservation of additional habitat areas would certainly enhance the security of the species and communities analyzed here as well as other natural resources. In this section we discuss some of the important natural resources found throughout Florida to provide guidance to local governments interested in expanding upon the minimum conservation goals outlined here.

The importance of conserving locally valuable resources cannot be overstated. Not only do natural areas significantly enhance the quality of life and ameliorate the urban environment, but they can also play a key role in enhancing the overall security of rare plants and animals by helping to maintain a broad geographic distribution of populations (Howe et al. 1991). Small regional parks and recreation areas can serve as important conservation sites for species with small area requirements (Faeth and Kane 1978, Adams and Dove 1989). Conservation of small, local populations can also provide invaluable educational and recreational opportunities since most Floridians have a greater interest in the small population of some rare species found next door rather than the larger population found many miles away.

The information compiled for this report created one of the most comprehensive data sets available on the distribution of biological resources throughout Florida. Although it is difficult to display all of the information in an easy manner, we attempt here to display as much information as possible in hopes of making some of the information available to a broader audience. We constructed "hot spot" maps of biological resources for each region by overlaying the habitat maps developed for the 44 focal taxa, wading birds, and important natural communities (Section 6) and subdividing the composite map into 3 broader categories of Class 1, Class 2, and Class 3 areas based on the number of focal species that would likely find appropriate habitat conditions in the area.

Class 1 lands depict areas where habitat conditions for 3-4 focal species likely occur; Class 2 lands show areas where habitat conditions for 5-6 focal species likely occur; and Class 3 lands show areas where habitat conditions for 7+ focal species likely occur. Class 1 lands are often large forested tracts that have varying degrees of natural quality. These tracts stand out because of their size and forested nature, and because habitat generalists such as wild turkey, bobcat, and black bear were included in our analyses. Although the number of listed species protected by Class 1 lands may be relatively low, these forest areas often serve vital functions when viewed from a regional perspective. They help to buffer more pristine natural areas from encroaching urban and residential development. They may also serve as dispersal areas between nature preserves or help to maintain air and water quality, provide recreational opportunities and forest resources, and other functions. In some cases, Class 1 areas may also be crucial to a species' existence.

Class 2 and Class 3 areas generally provide habitat for wide-ranging habitat generalists as well as species with more specific habitat requirements. The Class 2 and Class 3 lands identified in each region warrant more thorough consideration for some type of conservation initiative, and many are absolutely critical to maintaining viable populations of several rare species. Maps of regional hot spots also include occurrence records from the Florida Natural Areas Inventory database to help show where concentrations of rare species occur.

Separate regional maps of the Strategic Habitat Conservation Areas were also prepared to provide greater detail. An extended narrative also accompanies each set of figures to describe some of the important features of each region. These narratives are based on the analyses performed here as well as information presented in the Florida Natural Areas Inventory and Florida Game and Fresh Water Fish Commission Wildlife Observation databases. **Because the narratives are based only on documented occurrence records, the lists of species presented are by no means comprehensive**.

The regional overviews also include separate sections that describe the important coastal resources within each region. Several species analyzed here (e.g., American oystercatcher and Wilson's plover) did not lend themselves to the analyses performed for other focal species (see Section 6.3.10). The coastal subsections provide greater information on these important habitat areas. We also note that the Florida Natural Areas Inventory has completed a mapping of most of the remaining natural coastal communities throughout Florida (Johnson and Muller 1993). These reports significantly expand upon the information presented here.

A final piece of information included in the introductions to each region is the percentage of each region or county that is covered by established conservation areas (e.g., state park, national wildlife refuge). The average proportion of conservation lands within individual regions is 19.6%, but 3 regions (Tampa Bay, Central Florida, and North Central Florida) have much less than 10% of their total acreage in some type of conservation status. Other regions falling below the statewide average include Northeast, East Central, and Treasure Coast. In contrast, the South Florida region has 67.6% of its total acreage in some type of conservation area.

The combination of these various data sets provides a fairly complete picture of important natural resources in each region as they are currently known. The maps can aid in the initial planning stages for the placement of potential habitat protection areas and mitigation parks, and they also provide a better perspective on the distribution of important biological resources throughout Florida. The maps are available in a variety of digital and hard copy formats.

Figure 164 (a-c). Distribution of important resources in the Apalachee Region.

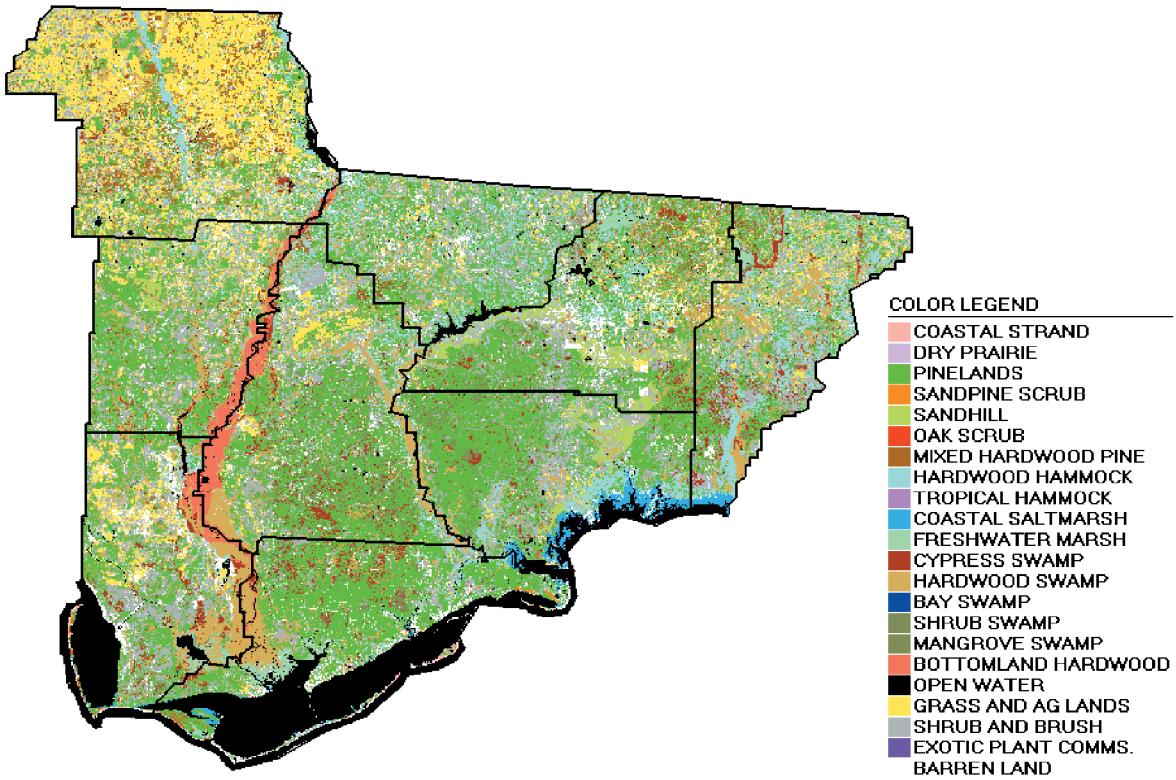


Figure 164a. Landsat land-cover map for the Apalachee Region.

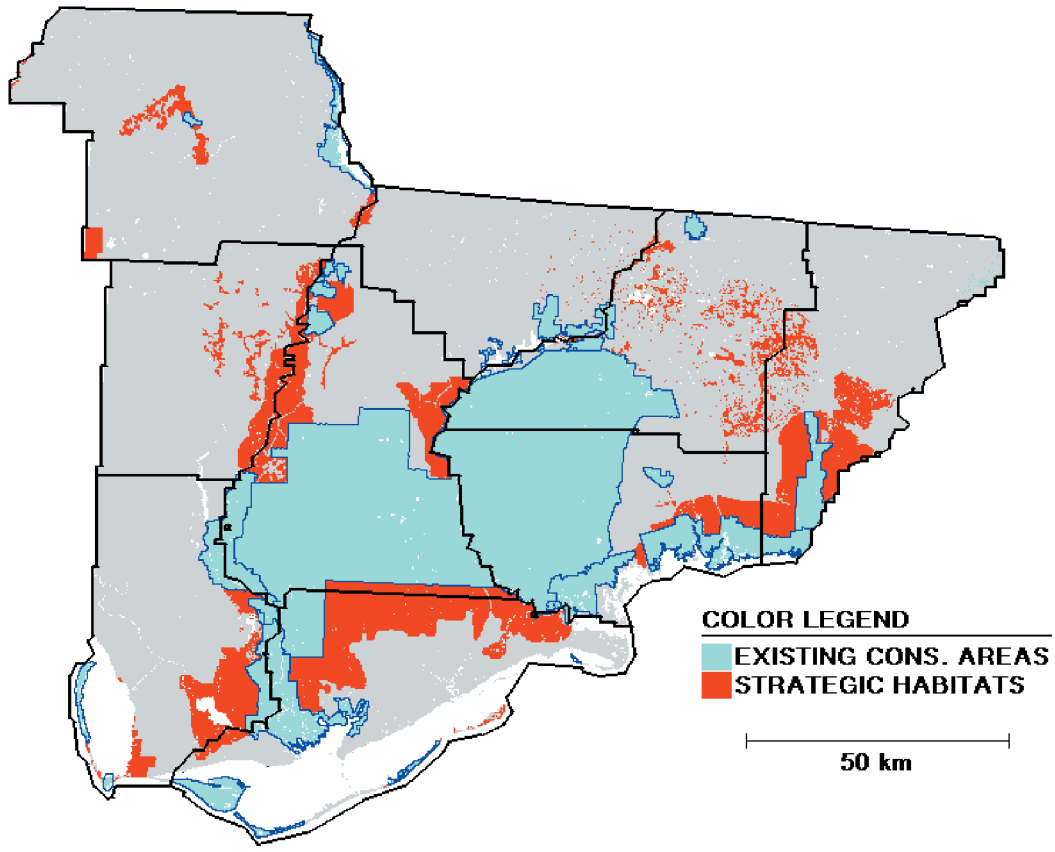


Figure 164b. Strategic Habitat Conservation Areas and existing conservation lands.

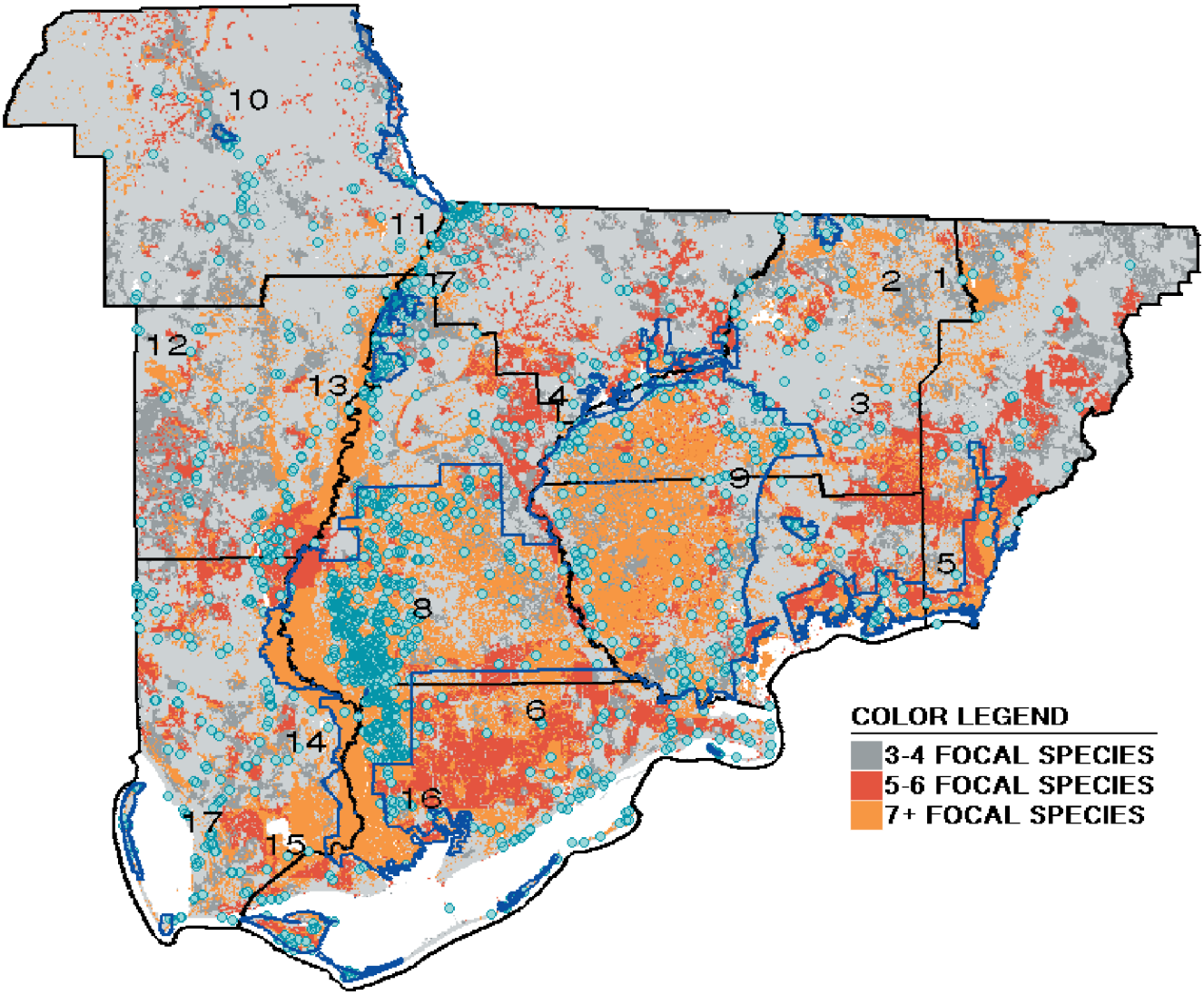


Figure 164c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.1. Apalachee Region

The Apalachee Region (Figures 164a, 164b, and 164c) contains some of the largest and most diverse tracts of forested wildlife habitat remaining in Florida. Although much of the forest cover in the region has been altered by large scale commercial timber operations, many of these areas are extremely valuable because they maintain conditions required by several rare species with large area requirements. This region also contains extensive areas with few roads, a feature important to species such as black bear whose distributions may be affected by high road densities (Wooding and Brady 1987). The remaining coastal habitats of the Apalachee Region are very important to a large number of listed and declining species. Some of the more important features of this region are referenced by number in Figure 164c and discussed in greater detail below.

Even though this region has a larger proportion of its total area in some type of conservation status (23.6% versus the statewide average of 19.6%), Gulf, Jefferson, Gadsden, Jackson, and Calhoun counties are below the statewide average of 15.3% for individual counties.

Area 1. Freshwater marsh and forested wetland systems in Jefferson and Leon counties. Portions of the area make up a Strategic Habitat Conservation Area for rare wading birds. Colonial rookeries in the area contain wood stork (Lake Lafayette, Ochlockonee River), little blue heron (Lake Iamonia, Gress Swamp, Ochlockonee River), great egret (Lake Iamonia, Ochlockonee River), and snowy egret (Lake Miccosukee, Ochlockonee River). Occurrences of additional rare species are listed by major drainages. **Lake Miccosukee:** indigo snake, American swallow-tailed kite, mud sunfish, Mexican tear-thumb, Miccosukee gooseberry, and buckthorn. **Lake Iamonia:** southern bald eagle and karst pond xyris. **Lake Jackson** (including Lake Carr): round-tailed muskrat, southern bald eagle, least tern, and striped newt. **Lake Lafayette:** least tern and tiger salamander. Ochlockonee, Aucilla, Wakulla, and St. Marks drainages are discussed elsewhere.

Area 2. Areas of mixed hardwood-pine, upland hardwood forest, and pine forest in north Jefferson and Leon counties. Selected areas support southeastern shrew, red-cockaded woodpecker (3 active sites, 15 inactive sites), southeastern American kestrel, Cooper's hawk, gopher tortoise, eastern indigo snake, Florida pine snake, Florida mountain-mint, and turk's cap lily.

Area 3. Extensive tract of sandhill land cover southeast of Tallahassee. Species associated with this area include fox squirrel, southern bald eagle, southeastern American kestrel, gopher tortoise, eastern indigo snake, Florida pine snake, gopher frog, and bent golden aster. Much of the area was recently logged. An aquatic cave to the south of the area supports the Woodville cave crayfish.

Area 4. Ochlockonee River basin and tributaries in Leon, Liberty, and south Gadsden counties. Portions of the area make up a Strategic Habitat Conservation Area for Florida black bear. Occurrences of other species are listed by major drainages. **Ochlockonee River:** round-tailed muskrat, southern bald eagle, red-cockaded woodpecker, wood stork (nesting colony), little blue heron (nesting colony), southern bald eagle (3 nest records), American swallow-tailed kite, gopher tortoise, Suwannee cooter, alligator snapping turtle, eastern indigo snake, one-toed amphiuma, Apalachicola dusky salamander, Suwannee bass, bannerfin shiner, spotted bullhead, Atlantic sturgeon, Ashe's magnolia, wiregrass gentian, scare-weed, bent golden aster, and purple bankclimber. **Bear Creek** (Gadsden County): American swallow-tailed kite, copperhead, eastern indigo snake, gopher tortoise, and Florida anise. **Oklawaha Creek** (Gadsden County): American swallow-tailed kite, Cooper's hawk, one-toed amphiuma, Apalachicola dusky salamander, Chapman's rhododendron. **Hammock Creek** (Gadsden County): bent golden aster and Chapman's rhododendron. **Telogia Creek** (Gadsden and Liberty counties): swallow-tailed kite, Florida pine snake, Apalachicola dusky salamander, and dusky shiner.

Area 5. Spring-fed rivers and forested wetlands in Wakulla and Jefferson counties. Portions of these areas constitute a Strategic Habitat Conservation Area for Florida black bear, American swallow-tailed kite, and limpkin. Additional occurrences of rare species are listed by major drainages. **Aucilla and Wacissa rivers** (including Bailey Mill Creek): limpkin, eastern indigo snake, American alligator, Suwannee cooter, alligator snapping turtle, one-toed amphiuma, dusky shiner, blackbanded sunfish, eastern mudminnow, eastern mud sunfish, Florida willow, corkwood, Flyr's brickell-bush, and Horst's cave crayfish. **St. Marks River** (including Black Creek): West Indian manatee, eastern indigo snake, tiger salamander, one-toed amphiuma, and dusky shiner. **Wakulla River** (north of confluence with St. Marks): West Indian manatee, osprey, Florida pine snake, eastern indigo snake, alligator snapping turtle, gopher tortoise, dusky shiner, and Woodville cave crayfish.

Area 6. Remote forest areas in Franklin County. Portions of the area constitute a Strategic Habitat Conservation Area for Florida black bear. Other rare species recorded for the area include little blue heron (rookery), osprey, Bachman's sparrow, Florida pine snake, indigo snake, alligator snapping turtle, flatwoods salamander, Barbour's map turtle, violet flowered butterwort, wiregrass gentian, white-topped pitcher plant, pinewoods bluestem, meadow-beauty, and Florida bear-grass.

Area 7. Bluffs and ravines along the east bank of the Apalachicola River (Liberty and Jackson counties), an important area of high endemism (Ward 1979, Muller et al. 1989). Portions of the area constitute a Strategic Habitat Conservation Area for Florida black bear. Rare animal species recorded in this region include southern bald eagle, alligator snapping turtle, Barbour's map turtle, Suwannee cooter, gopher tortoise, copperhead, eastern indigo snake, Florida pine snake, one-toed amphiuma, four-toed salamander, Apalachicola dusky salamander, and goldstripe darter. This region supports several endemic species of plants. Some of the rarest plant species in the area are croomia, Florida yew, Florida torreya, schisandra, Baltzell's sedge, pyramid magnolia, fringed campion, Ashe's magnolia, halberd-leaved yellow violet, Indian cucumber root, Alabama angelpod, Florida spiney pod, rattlesnake plantain, trailing arbutus, buckthorn, wild hydrangea, Carolina lily, American bladder-nut, false hellebore, orange azalea, toothed savory, narrow-leaved trillium, Carolina lily, Apalachicola wild indigo, Apalachicola rosemary, Marianna columbine, Florida anise, and trout lily.

Area 8. West half of Apalachicola National Forest, Liberty County. A mix of cypress swamp, hardwood forest, pinewood savannas, and longleaf pine forests grading into Apalachicola River floodplain forests. Portions of the area constitute a Strategic Habitat Conservation Area for Florida black bear. Occurrence records of additional rare species include fox squirrel, red-cockaded woodpecker, Cooper's hawk, American swallow-tailed kite, Florida pine snake, Apalachicola kingsnake, alligator snapping turtle, Barbour's map turtle, gopher tortoise, flatwoods salamander, coal skink, Piedmont water-milfoil, large-flowered grass-of-parnassus, bog-button, Carolina grass-of-parnassus, southern milkweed, mock pennyroyal, Chapman's crownbeard, birds-in-a-nest, Chapman's butterwort, meadowbeauty, Harper's beauty, violet-flowered butterwort, panhandle spiderlily, Drummond's yellow-eyed grass, Apalachicola dragon-head, thick-leaved water-willow, Florida skullcap, West's flax, Florida skullcap, and Florida bear-grass.

Area 9. East half of the Apalachicola National Forest (Wakulla District). Extensive area of sandhill land cover and karst topography containing sinkholes and terrestrial caves, grading into mesic pinelands and hardwood forests. Rare species recorded in the area include black bear, gray bat, red-cockaded woodpecker, gopher tortoise, alligator snapping turtle, gopher frog, Florida pine snake, Apalachicola king snake, eastern indigo snake, striped newt, Apalachicola dusky salamander, one-toed amphiuma, spotted bullhead, dusky shiner, slender-leaved dragon-head, Chapman's butterwort, bent golden aster, Godfrey's blazing star, Ashe's magnolia, wiregrass gentian, scare-weed, southern red lily, mock pennyroyal, southern milkweed, panhandle meadowbeauty, karst pond xyris, and Woodville cave crayfish.

Area 10. Forested areas near Marianna. Portions constitute a Strategic Habitat Conservation Area for bat maternity caves. Other rare species recorded for the area include great

egret (rookery), Cooper's hawk, alligator snapping turtle, Barbour's map turtle, one-toed amphiuma, dusky shiner, flatwoods salamander, spotted bullhead, false rue-anemone, virgin's bower, Barbara's buttons, wood spurge, Tennessee leafcup, pinnate-lobed rudbeckia, Marianna columbine, heart-leaved willow, Hobb's cave isopod, Dougherty Plain cave crayfish, and Georgia blind salamander.

Area 11. Ocheesee Pond and west floodplain of Apalachicola River, Jackson County. Portions of the area are proposed as a Strategic Habitat Conservation Area for rare wading birds and bats. Species recorded in the area include American swallow-tailed kite, southern bald eagle, little blue heron (rookery), yellow-crowned night-heron (rookery), indigo snake, copperhead, gopher frog, flatwoods salamander, one-toed amphiuma, pinewoods bluestem, West's flax, a meadowbeauty, and Florida torreya (at Ocheesee Pond). Wood storks have become increasingly common at Ocheesee Pond in recent years and many now breed in the vicinity (J. Cox pers. obs.).

Area 12. Sandhill land cover in and around Chipola Experimental Forest. Species recorded in the area include fox squirrel, southeastern American kestrel, gopher tortoise, gopher frog, and Apalachicola dusky salamander (Fourmile Creek).

Area 13. Forested areas around Apalachicola and Chipola rivers, Calhoun County. Portions of the area are proposed as a Strategic Habitat Conservation Area for Florida black bear and rare wading birds. Other rare species recorded in the area include American swallow-tailed kite, eastern indigo snake, Florida pine snake, Alligator snapping turtle, one-toed amphiuma, flatwoods salamander, spotted bullhead, Chapman's crownbeard, pine-woods aster, wiregrass gentian, Apalachicola dragon-head, gentian pinkroot, and mock pennyroyal.

Area 14. Forested areas around the Apalachicola River, Gulf County. Portions of the area are proposed as a Strategic Habitat Conservation Area for Florida black bear, rare wading birds, and American swallow-tailed kite. Other rare species recorded for the area include Cooper's hawk, southern bald eagle, flatwoods salamander, spotted bullhead, Chapman's crownbeard, violet-flowered butterwort, southern milkweed, West's flax, Apalachicola dragon-head, gentian pinkroot, mock pennyroyal, and thick-leaved water-willow.

Area 15. Forested lands surrounding Lake Wimico. Portions of the area are proposed as a Strategic Habitat Conservation Area for American swallow-tailed kite. Other rare species recorded in the area include southern bald eagle, coal skink, and panhandle spider lily.

Area 16. Forested areas along the Apalachicola River, Franklin County. Portions of the area constitute a Strategic Habitat Conservation Area for Florida black bear and American swallow-tailed kite. Other rare species recorded in the area include osprey, yellow-crowned night-heron, least bittern, Alligator snapping turtle, Barbour's map turtle, corkwood, Carolina grass-of-parnassus, southern milkweed, mock pennyroyal, and Chapman's crownbeard.

Area 17. Ward's Ridge and flatwoods near St. Joe Bay. Portions of the area make up a Strategic Habitat Conservation Area for several rare species of plants. Rare species recorded in the area include Florida black bear, red-cockaded woodpecker, little blue heron (rookery), thick-leaved water-willow, wiregrass gentian, Chapman's crownbeard, and telephus spurge.

Coastal Areas of Gulf County. Occurrences of rare species are listed by more specific geographic areas. **St. Joseph Peninsula:** St. Andrews beach mouse, Cuban snowy plover, piping plover, Wilson's plover, black skimmer, American oystercatcher, least tern, shorebird aggregation area, Gulf salt marsh snake, and loggerhead sea turtle. **Cape San Blas:** Cuban snowy plover, piping plover, Wilson's plover, American oystercatcher, shorebird aggregation area, and Gulf coast lupine. **St. Joseph Bay:** portions of area make up a Strategic Habitat Conservation Area for western populations of seaside sparrow and Gulf salt marsh snake. Other rare species recorded in the area include American oystercatcher, sandwich tern, least tern, and loggerhead sea turtle. **St. Vincent's National Wildlife Refuge:** Cuban snowy plover, piping plover, southern bald eagle, osprey, least bittern, black rail, Wakulla seaside sparrow, Gulf salt marsh snake, corkwood, and Gulf coast lupine.

Coastal Areas of Franklin County. Rare species are listed by more specific geographic areas. **Little St. George Island:** Cuban snowy plover (nesting), osprey, shorebird aggregation area. **St. George Island Causeway:** nesting American oystercatcher, least tern, Wilson's plover, black skimmer, and gull-billed tern. **St. George Island** (includes St. George Island State Park): piping plover, Cuban snowy plover (nesting), least tern (nesting), American oystercatcher, osprey, peregrine falcon (migratory), shorebird aggregation area, Gulf salt marsh snake, and Gulf coast lupine. **Dog Island:** American oystercatcher, Cuban snowy plover (nesting), piping plover, black skimmer, least tern (nesting), black-crowned night-heron, reddish egret, and Gulf coast lupine. **Lanark Reef:** black skimmer (nesting), American oystercatcher (nesting), Cuban snowy plover, piping plover, and great egret (rookery). **Apalachicola Bay mainland:** round-tailed muskrat, piping plover, least tern, American oystercatcher, eastern indigo snake, flatwoods salamander, Apalachicola king snake, Gulf salt marsh snake, large-leaved joint-weed, Gulf coast lupine, Godfrey's blazing star, and white-topped pitcher plant. **Bald and Turkey Point:** least tern (nesting), piping plover, Cuban snowy plover (nesting), American oystercatcher (nesting), black skimmer, shorebird aggregation area, Gulf salt marsh snake, Godfrey's blazing star, and Gulf coast lupine.

Coastal Areas of Wakulla and Jefferson Counties. Rare species are listed by more specific geographic areas. **Dickerson Bay, Piney Island, and Oyster Bay:** black rail, Wakulla seaside sparrow, American oystercatcher (nesting), least tern, black-crowned night-heron, Wilson's plover (nesting), southern bald eagle, osprey, wood stork (foraging areas), shorebird aggregation area. **St. Marks National Wildlife Refuge:** West Indian manatee, round-tailed muskrat, southern bald eagle, black rail, Wakulla seaside sparrow, American oystercatcher, Wilson's plover, least tern (nesting), black-crowned night-heron, spotted turtle, Gulf salt marsh snake, and shorebird aggregation area.

Figure 165 (a-c). Distribution of important resources in the Central Florida Region.

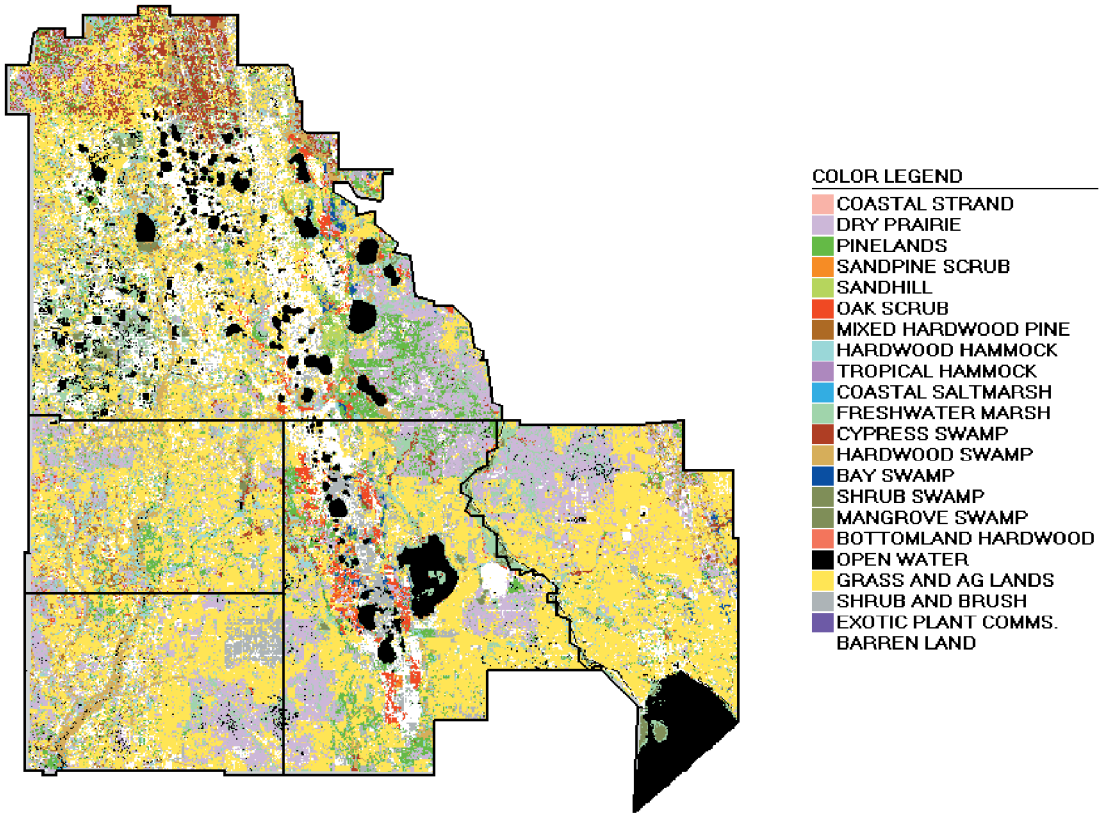


Figure 165a. Landsat land-cover map for the Central Florida Region.

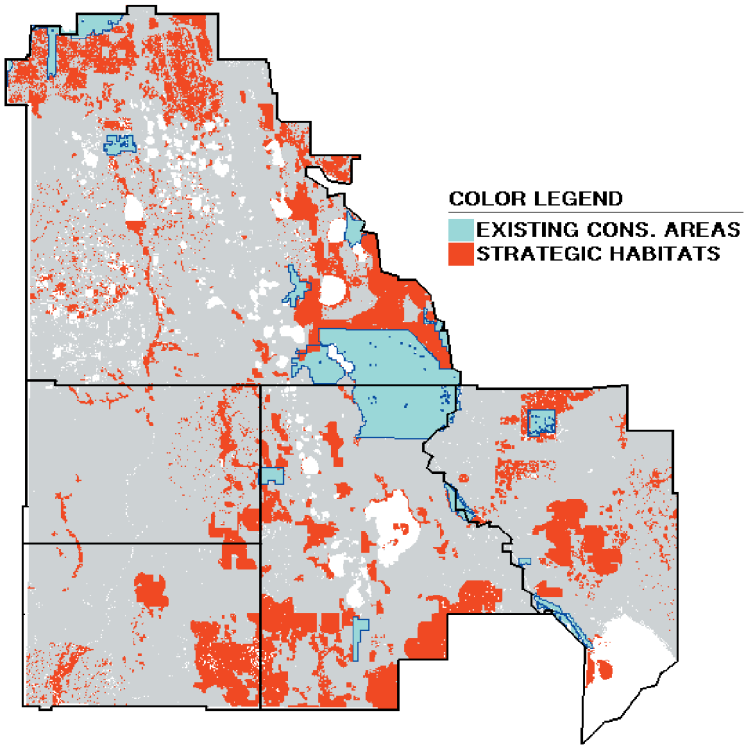


Figure 165b. Strategic Habitat Conservation Areas and existing conservation lands.

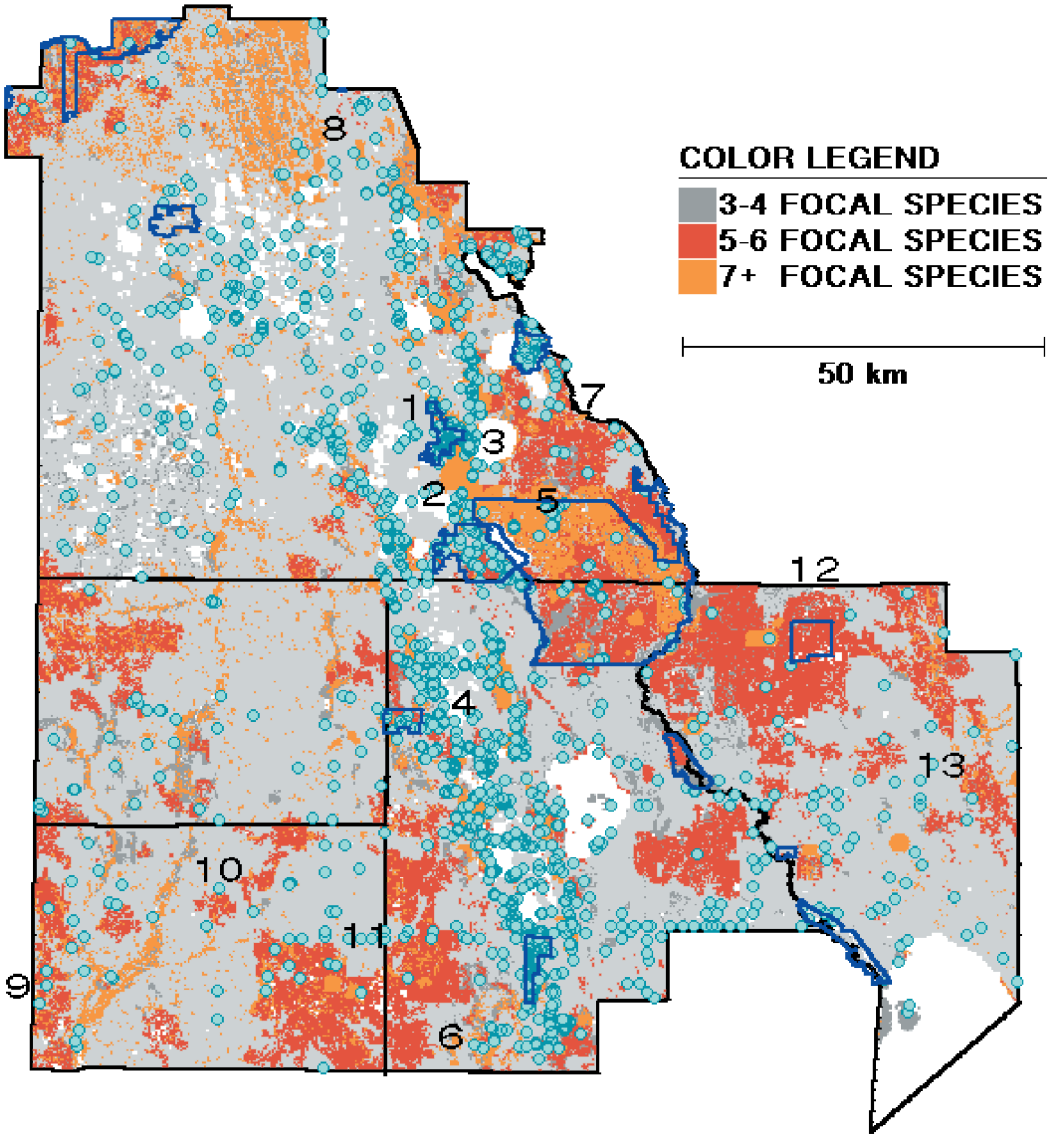


Figure 165c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.2. Central Florida Region

The Central Florida Region (Figures 165a, 165b, and 165c) has one of the smallest percentages (5.6%) of conservation lands of any region in Florida (statewide average is 19.6%). Highlands, Polk, Okeechobee, DeSoto, and Hardee counties all have a much smaller percentage of conservation lands than the statewide average for individual counties. In sharp contrast to these figures lies the fact that this region contains some of the rarest and most biologically rich lands remaining in Florida. The region contains Strategic Habitat Conservation Areas for southern bald eagle, Florida scrub jay, Florida sandhill crane, Audubon's crested caracara, Florida grasshopper sparrow, red-cockaded woodpecker, wood storks and other rare wading birds, and endemic scrub communities. Most of the important remaining natural areas are threatened by expanding citrus operations, phosphate mining, and residential development. Some of the more important features of this region are referenced by number in Figure 165c and discussed in greater detail below.

Area 1. Strategic Habitat Conservation Areas for scrub communities in Polk County. Occurrences of rare species are listed by more specific geographic areas (generally progressing north to south). **East Horse Creek Scrub:** Florida scrub jay, Lewton's polygala, and Florida willow. **Snell Creek Scrub:** gopher tortoise, Carter's warea, and Florida scrub bay. **Lake Marion Scrub:** Florida scrub jay and southern bald eagle. **Deer Lake Scrub:** southern bald eagle. **Lake Pierce/Big Gum Lake Scrub:** southern bald eagle, Florida scrub jay, gopher tortoise, scrub buckwheat, cutthroat grass, and paper-like nail-wort. **North Lake Wales Scrub:** Florida bonamia. **Lake Weohyakapka Scrub:** southern bald eagle, cutthroat grass, scrub plum, scrub bay, Curtiss' milkweed, Florida gay-feather, and Florida bonamia. **Tiger Creek Scrub** (see also Areas 2 and 3 below): short-tailed hawk, Florida scrub jay, gopher tortoise, Florida scrub lizard, scrub plum, Florida bonamia, scrub holly, and Britton's bear-grass. Sunray Deli Estates: Florida scrub jay, Florida scrub lizard, gopher tortoise, peninsular tiger beetle, Small's jointweed,

nodding pinweed, Florida bonamia, scrub buckwheat, and scrub plum. **Livingston Creek Scrub:** Florida scrub jay, southern bald eagle, and sand skink. **Lake Livingston Scrub:** Florida mouse.

Area 2. Corridor of sandhill, scrubby flatwoods, and scrub extending from Avon Park Air Force range to Tiger Creek Preserve. Strategic Habitat Conservation Area for Florida scrub jay, southern bald eagle, and Audubon's crested caracara; largest tract of sandhill land cover remaining in the region. Rare species recorded for the area include southern bald eagle (4 nest records), short-tailed hawk, southeastern kestrel, Audubon's crested caracara, Florida scrub jay, gopher tortoise, Florida scrub lizard, Florida sand skink, and scrub plum.

Area 3. Corridor of sandhill, scrubby flatwoods, hardwood swamp, and scrub extending from Tiger Creek Preserve to Lake Kissimmee State Park. Portions of the area make up a Strategic Habitat Conservation Area for Florida scrub jay, southern bald eagle, and wood stork. Other rare species recorded in the area include Florida mouse, gopher tortoise, sand skink, gopher frog, Curtiss' milkweed, Florida bonamia, cutthroat grass, scrub holly, hairy jointweed, and scrub bay.

Area 4. Strategic Habitat Conservation Areas for scrub communities in Highlands County. Rare species are listed by more specific geographic areas (generally progressing north to south). **Avon Park Airport:** Florida scrub jay, Ashe's savory, and cutthroat grass. **Lake Glenda Scrub:** Florida scrub jay, Highlands scrub hypericum, Small's jointweed, and scrub bay. **Bonnet Lake Scrub:** Florida scrub jay, Highlands scrub hypericum, Ashe's savory, and cutthroat grass. **Lake Jackson Scrub:** Florida scrub jay, Florida scrub lizard, Small's jointweed, paper-like nail-wort, Highlands scrub hypericum. **Sebring Air Terminal Scrub:** Florida scrub lizard, indigo snake, gopher tortoise, Garrett's scrub balm, cutthroat grass, and pygmy fringe-tree. **Lake Wolf Scrub:** Florida scrub jay, Florida scrub lizard. **Josephine Creek/Persimmon Lake:** gopher tortoise, Florida scrub lizard, blue-tailed mole skink, Highlands tiger beetle, and pigeon wing. **Virginia Avenue Scrub:** Florida scrub jay. **East of Lake Carrie:** Florida scrub jay, gopher tortoise, Florida sand skink, Florida scrub lizard, Highlands scrub hypericum, hairy jointweed, and Small's jointweed. **Lake Crews/Lake June in Winter:** southern bald eagle, gopher tortoise, Florida sand skink, Curtiss' milkweed, scrub holly, and hairy jointweed. **Holmes Avenue Scrub:** Florida scrub jay, Florida mouse, gopher tortoise, blue-tailed mole skink, Florida sand skink, Florida scrub lizard, and hairy jointweed. **Southwest of Lake Placid:** Florida mouse, Florida scrub jay, gopher tortoise, Florida scrub lizard, nodding pinweed, pigeon-wing, Edison's ascyrum, and scrub plum. **East of Bear Hollow:** Florida mouse, Florida scrub jay, Florida scrub lizard, blue-tailed mole skink, Edison's ascyrum, and scrub mint. **Gould Road:** gopher tortoise, Florida scrub lizard, scrub holly, paper-like nail-wort, Highlands scrub hypericum, wedge-leaved button-snakeroot, and Ashe's savory. **Northeast of Venus:** Florida scrub jay, gopher tortoise, pine pinweed, hairy jointweed, Highlands scrub hypericum, Britton's bear-grass, perforate reindeer lichen.

Area 5. Extensive area of pine flatwoods, prairie, and scrub north of Avon Park Air Force Range and west of Kicco Wildlife Management Area (bounded by State Roads 60 and 630 and the Kissimmee River). Strategic Habitat Conservation Area for red-cockaded woodpecker. Other rare species recorded in the area include Audubon's crested caracara, Florida scrub jay, Florida scrub lizard, cutthroat grass, and pigeon-wing.

Area 6. Mixture of flatwoods and scrub east of Fisheating Creek near Old Venus, southern Highlands County. Species recorded in the area include red-cockaded woodpecker, Florida scrub jay, indigo snake, and gopher tortoise.

Area 7. Western edge of Lake Kissimmee. Portions of the area proposed as a Strategic Habitat Conservation Area for snail kite, wood stork, and southern bald eagle (see also Area 10 in East Central Florida Region). Other species recorded in the area include Audubon's crested caracara, sandhill crane, limpkin, Florida scrub lizard, eastern indigo snake, and blue-tailed mole skink.

Area 8. Large complex of cypress swamp, hardwood swamp, pineland, rangeland, and dry prairie north of Lake Lowery and lying between State Road 33 and U.S. 27. Portions of the area make up a Strategic Habitat Conservation Area for Florida sandhill crane, short-tailed hawk, wood stork, and other wading birds. Other species recorded for the area include Florida black bear, American swallow-tailed kite, southern bald eagle, little blue heron (rookery), great egret (rookery), white ibis (rookery), limpkin, Bachman's sparrow, and gopher tortoise.

Area 9. Large tracts of dry prairie, scrubby flatwoods, rangeland, and sandhill land cover along the western edge of DeSoto County, north and south of State Road 72. Portions of the area proposed as a Strategic Habitat Conservation Area for Audubon's crested caracara, Florida sandhill crane, and Florida grasshopper sparrow. Other rare species recorded for the area include fox squirrel, Florida burrowing owl, Bachman's sparrow, and eastern indigo snake.

Area 10. Peace River and tributaries (Horse and Charlie creeks) extending from Arcadia south to the Charlotte County line. Portions of the area constitute a Strategic Habitat Conservation Area for nearby wading bird colonies. Rare species recorded in the area include southern bald eagle, swallow-tailed kite, great egret (rookery), tricolored heron (rookery), snowy egret (rookery), limpkin, and anhinga.

Area 11. Large tracts of dry prairie land cover and rangeland in southeast DeSoto and southwest Highlands counties (Tippen Bay, Joe Slough, Cow Slough; generally south of State Road 70). Portions of the area proposed as a Strategic Habitat Conservation Area for Audubon's crested caracara and Florida sandhill crane. Other species recorded in the area include fox squirrel, southeastern American kestrel, Florida burrowing owl, wild turkey, great egret (rookery), and eastern indigo snake.

Area 12. Large tract of dry prairie, freshwater marsh, and rangeland in north Okeechobee County (including Sevenmile Slough, Dead Pine Island Marsh, and Duck Slough; northwest of Old Eagle Island Road). Portions of the area proposed as a Strategic Habitat Conservation Area for Florida grasshopper sparrow, snail kite, Florida sandhill crane,

and Audubon's crested caracara. Other species reported in the area include fox squirrel, Florida burrowing owl, southeastern American kestrel, great egret (rookery), peregrine falcon, wild turkey, eastern indigo snake, and gopher tortoise.

Area 13. Forested wetlands, dry prairie, upland hardwood forests, and rangeland around Jim Green and Fort Drum creeks (east of U.S. 441, north and south of State Road 68). Portions of the area make up Strategic Habitat Conservation Areas for Audubon's crested caracara and Florida sandhill crane. Other rare species recorded from the area include fox squirrel, American swallow-tailed kite, southeastern kestrel, wild turkey, anhinga, eastern indigo snake, great egret (rookery), gopher tortoise, and mole kingsnake.

Figure 166 (a-c). Distribution of important resources in the East Central Florida Region.

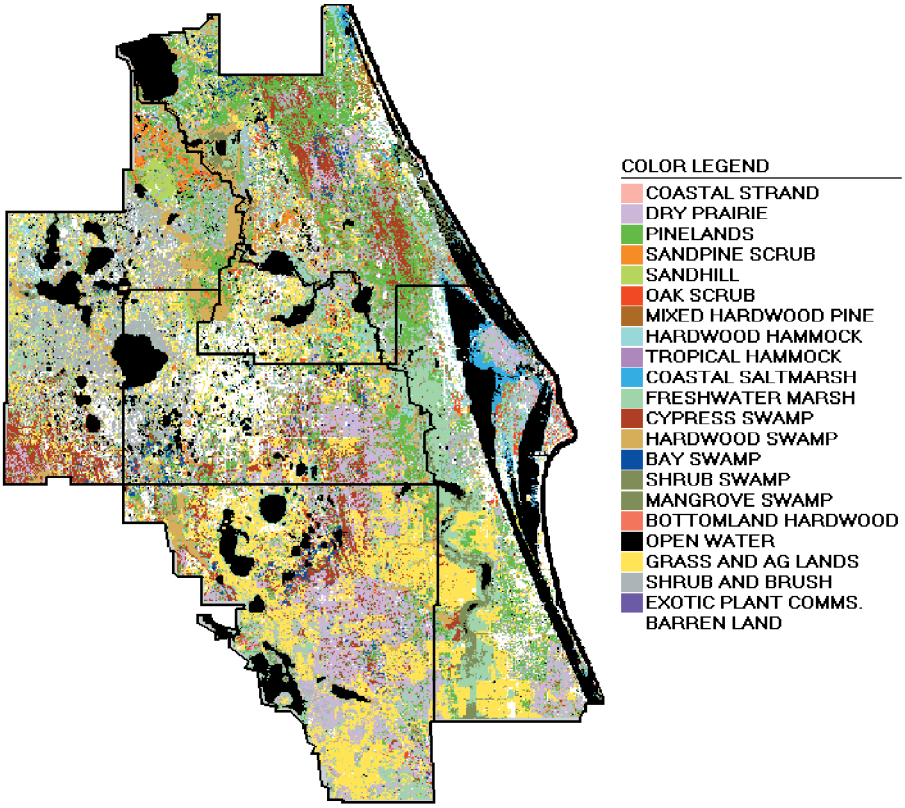


Figure 166a. Landsat land-cover map for the East Central Florida Region.

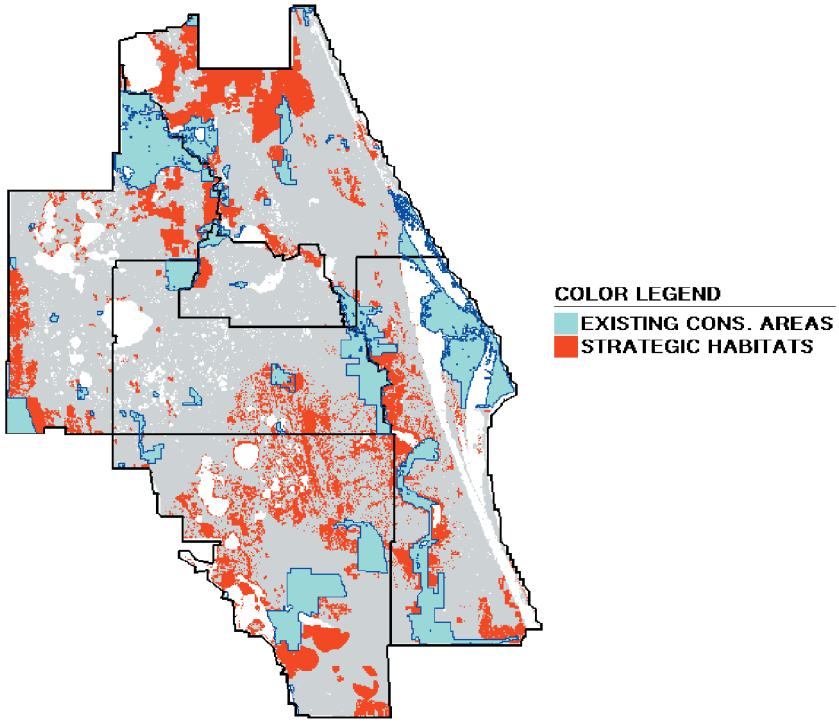


Figure 166b. Strategic Habitat Conservation Areas and existing conservation lands.

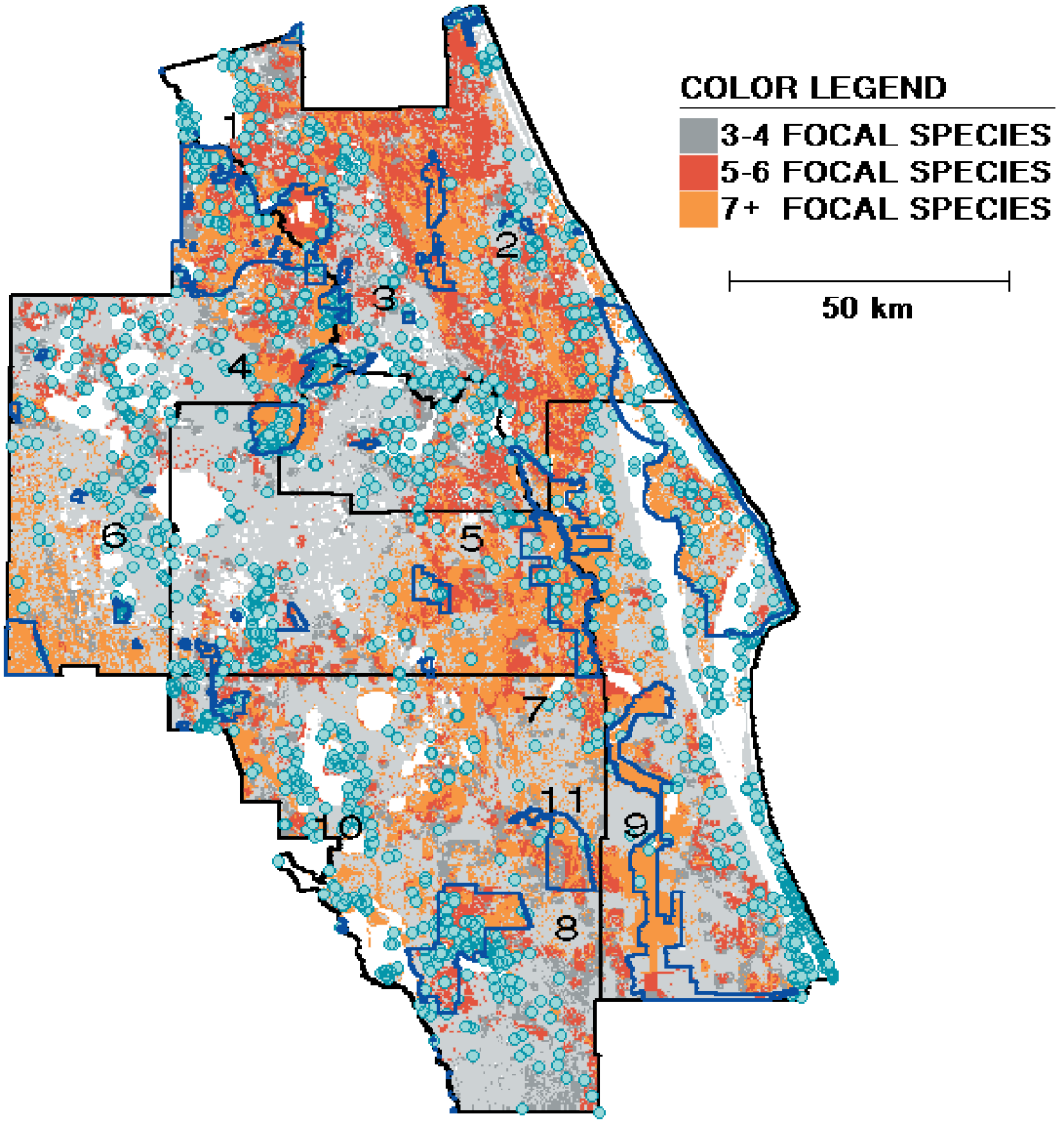


Figure 166c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.3. East Central Florida Region

The tremendous growth of this region's human population in recent years has resulted in the spread of residential and urban areas throughout the region. Prior to this period of rapid urbanization, agricultural practices had eliminated large acreages of native upland communities such as sandhill, scrub, and pine flatwoods. Despite these changes, there are many private tracts that provide important habitat for several rare species of wildlife (Figures 166a, 166b, and 166c). In fact, our analyses indicate that some of the state's most significant wildlife habitat is found in this region, particularly the freshwater marshes, forested wetlands, mesic pinelands, and dry prairies that characterize much of the eastern half of the region. Some of the more important features of this region are referenced by number in Figure 166c and discussed in greater detail below. The percentage of conservation lands in the region (14.1%) falls well below the statewide average (19.6%). Counties that fall below the statewide average for individual counties (15.6%) are Orange, Volusia, Seminole, and Osceola.

Area 1. Forest lands (including sandhill, scrub, and pine flatwoods) along the east and south edge of Lake George, extending eastward to State Road 11 (see also Area 2). Portions of the area make up a Strategic Habitat Conservation Area for southern bald eagle and Florida black bear. Especially important are forest lands east and west of U.S. Highway 17 from Pierson to Bakerstown and Barberville to DeLeon Springs. Other rare species recorded in the area include limpkin, gopher tortoise, indigo snake, and scrub holly.

Area 2. Extensive forested area north and south of Interstate 4, east of Interstate 95, and extending south to Lake Harney (see also Area 5). Portions of the area represent a Strategic Habitat Conservation Area for Florida black bear, American swallow-tailed kite, wading birds (snowy egret, great egret, wood stork, and little blue heron), and southern bald eagle. Other species recorded in the area include wild turkey, limpkin, mottled duck, gopher tortoise, scrub holly, fall-flowering ixia, Curtiss' sandgrass, nodding pinweed, large-flowered rosemary, and Rugel's pawpaw.

Area 3. Patches of sand pine scrub, sandhill, and oak scrub around Deltona, extending northeast along U.S. 400, and east to Blue Springs State Park. Portions of the area make up a Strategic Habitat Conservation Area for Florida scrub jay. Other rare species recorded in the area include Curtiss' milkweed and scrub bay.

Area 4. Forested wetlands along the St. Johns and Wekiva river systems (east from Lake Norris). Portions of the area make up a Strategic Habitat Conservation Area for Florida black bear, southern bald eagle, and American swallow-tailed kite. Other species recorded in the area include mottled duck, Florida scrub jay, limpkin, anhinga, gopher tortoise, great egret (rookery), little blue heron (rookery), eastern indigo snake, and bluenose shiner.

Area 5. Forested wetlands and marshes east of St. Johns River, Lake Poinsett north to State Road 46 (includes Tosohatchee State Reserve and St. Johns River National Wildlife Refuge). Portions of the area proposed as a Strategic Habitat Conservation Area for Audubon's crested caracara, snail kite, and wading birds. Other rare species recorded in the area include fox squirrel, great egret (rookery), mottled duck, limpkin, American swallow-tailed kite, wild turkey, southern bald eagle, black rail, gopher tortoise, and fall-flowering ixia.

Area 6. Small tracts of scrub and sandhill west of Lake Apopka and near Ferndale and Davenport. The area is important to rare plants such as warea, bonamia, and scrub bay.

Area 7. North central Osceola and south central Orange counties, east of St. Cloud (Econlockhatchee River Swamp and surroundings, including Big Bend Swamp, Lake Conlin, and Four-mile Swamp). Portions of the area make up a Strategic Habitat Conservation Area for Audubon's crested caracara, Florida sandhill crane, red-cockaded woodpecker, mottled duck, wood stork, and other colonial wading birds. Additional rare species recorded in the area include bobcat, southern bald eagle, American swallow-tailed kite, southeastern American kestrel, limpkin, little blue heron (rookery), snowy egret (rookery), white ibis (rookery), great egret (rookery), wild turkey, eastern indigo snake, gopher tortoise, and nodding pinweed.

Area 8. Rangeland, prairie, and freshwater marsh in south central Osceola County, west of Kenansville. Portions of the area make up Strategic Habitat Conservation Areas for Florida grasshopper sparrow and Audubon's crested caracara. Other rare species found in the area include fox squirrel, Florida burrowing owl, and Florida sandhill crane.

Area 9. Forested and herbaceous wetlands surrounding Water Management District conservation lands in Brevard County (includes areas southwest of Lake Poinsett and west of Lake Winder; see areas 7 and 8 above). Portions of the area proposed as a Strategic Habitat Conservation Area for wood stork, Audubon's crested caracara, American swallow-tailed kite (late-summer roosts), snail kite, and mottled duck. Other rare species are listed by major drainage basins. **Wolf Creek:** southern bald eagle. **Jane Green Creek:** see Area 8. **Cox Creek:** wood stork (rookery), snowy egret (rookery), southern bald eagle, and American swallow-tailed kite (late summer roost).

Area 10. Lakes Kissimmee, Marian, Tohopekaliga, East Lake Tohopekaliga, Reedy Creek, Cobb Marsh, Lake Russell, and nearby upland areas. Portions of the area make up a Strategic Habitat Conservation Area for wood stork, mottled duck, snail kite, and southern bald eagle. Other rare species are listed by individual lakes. **Lake Kissimmee and Lake Hatchineha:** great egret (rookery), snail kite, southern bald eagle, Audubon's crested caracara, mottled duck, and limpkin. **Cypress Lake/Reedy Creek:** Florida mouse, wood stork (rookery), southern bald eagle (10 nests), eastern indigo snake, limpkin, Audubon's crested caracara, Florida burrowing owl, gopher tortoise, gopher frog, Florida sand skink, Florida scrub lizard (portions of area recently secured as part of Reedy Creek/Lake Marion Creek Mitigation Site). **Lake Tohopekaliga:** snail kite, southern bald eagle (30 nests), and gopher tortoise. **East Lake Tohopekaliga:** snail kite, great egret, and southern bald eagle. **Lake Gentry, Big Bend Marsh, Brick Lake, and Alligator Lake** (see also Area 6 above): southern bald eagle, Audubon's crested caracara, eastern indigo snake, gopher tortoise, and scrub bay. **Lake Marian:** Florida black bear, fox squirrel, snail kite, Audubon's crested caracara, Florida sandhill crane, Florida burrowing owl, and southern bald eagle (15 nests).

Area 11. Areas surrounding Bull Creek Wildlife Management Area; east of U.S. 441, south of U.S. 192, extending east to St. Johns River along Jane Green Creek. Portions of the area make up a Strategic Habitat Conservation Area for wood stork, mottled duck, American swallow-tailed kite (late summer roost area), red-cockaded woodpecker, and Audubon's crested caracara. Other rare species recorded include bobcat, Florida burrowing owl, limpkin, wild turkey, Florida sandhill crane, eastern indigo snake, and short-leaved rosemary.

Coastal Areas of Volusia County. Rare species are listed by geographic areas. **Tomoka Basin** (east of Old Dixie Highway, including Tomoka State Park): least tern (nesting), Florida scrub jay, and gopher tortoise. **Port Orange:** brown pelican, great blue heron, and black-crowned night-heron nesting colonies. **Harbor Oaks to New Smyrna Beach:** Strategic Habitat Conservation Area for Atlantic salt marsh snake and winter concentrations of piping plover and other shorebirds (Ponce Inlet, Matanzas, Smyrna Dunes, and U.S. Coast Guard station); rare species include least tern (nesting), Wilson's plover, black skimmer, and sand-dune spurge. **New Smyrna Beach to Cedar Island:** Strategic Habitat Conservation Area for Atlantic salt marsh snake and wood stork and other wading birds; rare species include snowy egret (rookery), little blue heron (rookery), mountain mullet, and balsam torchwood. **Canaveral National Seashore:** wood stork (rookery), black-crowned night-heron (rookery), southern bald eagle, shorebird aggregation areas (several), green turtle, hand fern, and coastal vervain.

Coastal Areas of North Brevard County. Rare species are listed by more specific geographic areas. **Scottsmoor to Titusville:** patches of coastal scrub (near Mims) and hammock (Turnbull Hammock); rare species recorded in the area include Florida scrub jay, southern bald eagle, eastern indigo snake, large-flowered rosemary, Curtiss' milkweed, scrub bay, and nodding pinweed. **Merritt Island National Wildlife**

Refuge/Kennedy Space Center/Banana River Aquatic Preserve: portions of the area make up a Strategic Habitat Conservation Area for several wading birds; rare species include West Indian manatee (congregation area), southeastern beach mouse, wood stork (rookery), white ibis (rookery), glossy ibis (rookery), snowy egret (rookery), great egret (rookery), black-crowned night-heron (rookery), reddish egret (rookery), roseate spoonbill (rookery), tricolored heron (rookery), Florida scrub jay, southern bald eagle, Wilson's plover, least tern (2 nesting colonies), pine snake, mole kingsnake, gopher tortoise, green turtle, leatherback turtle, hawksbill turtle, Curtiss' sandgrass, brown-haired snoutbean, coastal vervain, nodding pinweed, sea lavender, and beach star. **Merritt Island** (north of Barge Canal Pier): mixture of scrub and scrubby flatwoods; species include Florida scrub jay, gopher tortoise, and Curtiss' sandgrass. **Artesia:** Florida scrub jay, least tern (nesting colony), black skimmer (nesting colony), and coastal vervain. **Indian River City to Bellwood**: patches of scrubby flatwoods and coastal hammocks; species include Florida scrub jays, indigo snake, hand fern, Tampa vervain, and large-flowered rosemary. **Dellespine to Cocoa:** large area of scrubby flatwoods containing Florida scrub jay, southern bald eagle, and Florida scrub lizard.

Coastal Areas of South Brevard County. Species are listed by more specific geographic areas. **Pineda:** Florida scrub lizard and Florida scrub jay. **Georgiana and Horti Point:** Florida scrub jay and Florida scrub lizard. **Satellite Beach** (includes portions of proposed Archie Carr National Wildlife Refuge): Florida scrub jay, leatherback turtle, green turtle. **Eau Gallie:** gopher tortoise and Florida scrub jay. **Cape Malabar:** Florida scrub jay, tricolored heron (rookery), great egret (rookery), and least tern (nesting colony). **Coconut Point** (areas north to Spessard Holland Park and south to Floridana Beach, includes portions of proposed Archie Carr National Wildlife Refuge): tricolored heron (rookery), least tern, black skimmer, leatherback turtle, green turtle, gopher tortoise, rivulus, coastal vervain, necklace pod, brown-haired snoutbean, Florida lantana, prickly apple. **Long Point Park/Sebastian Inlet State Recreation Area** (including Matthew's Cove): reddish egret (rookery), black skimmer (nesting), royal tern (nesting), shorebird aggregation area, eastern indigo snake, Florida lantana, prickly apple, coastal strand, terrestrial peperomia, and necklace pod.

Figure 167 (a-c). Distribution of important resources in the North Central Florida Region.

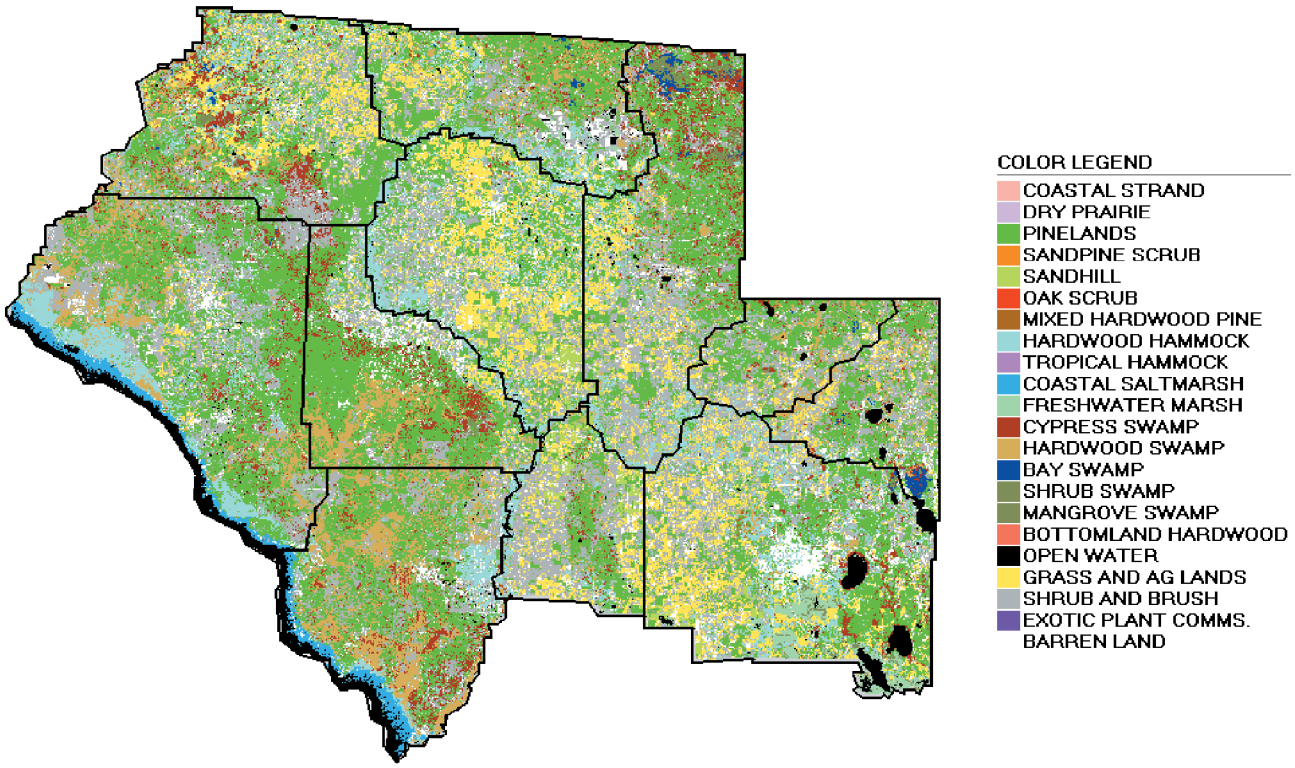


Figure 167a. Landsat land-cover map for the North Central Florida Region.

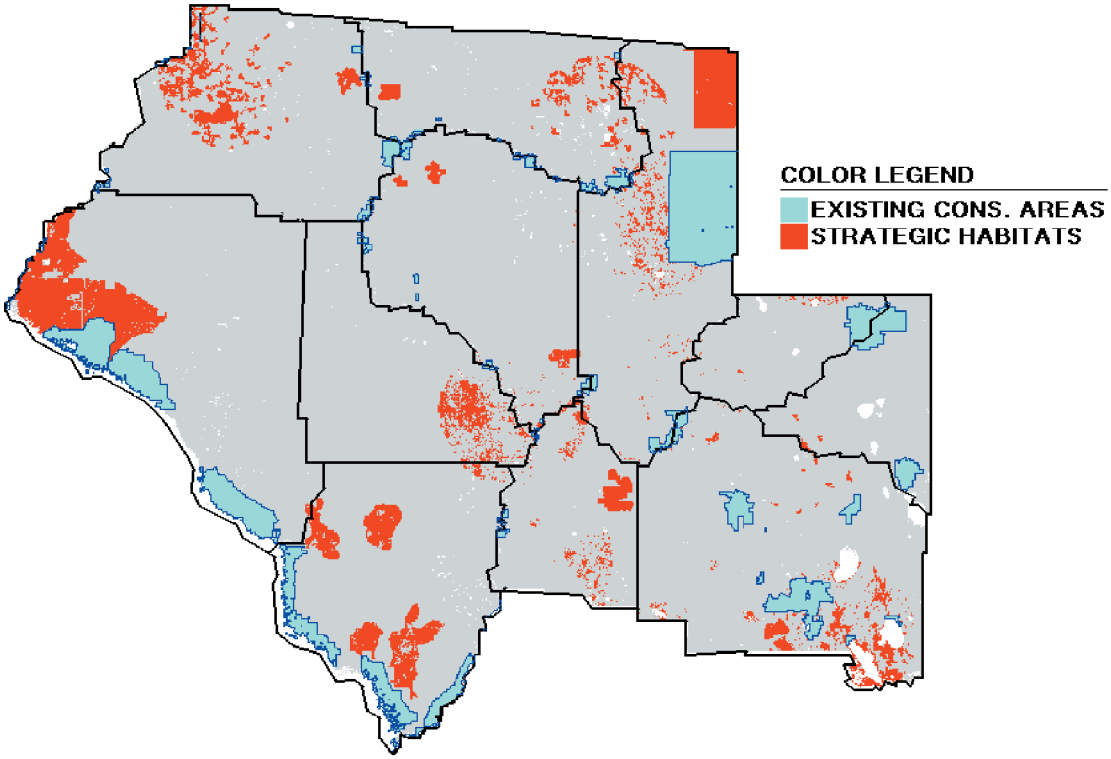


Figure 167b. Strategic Habitat Conservation Areas and existing conservation lands.

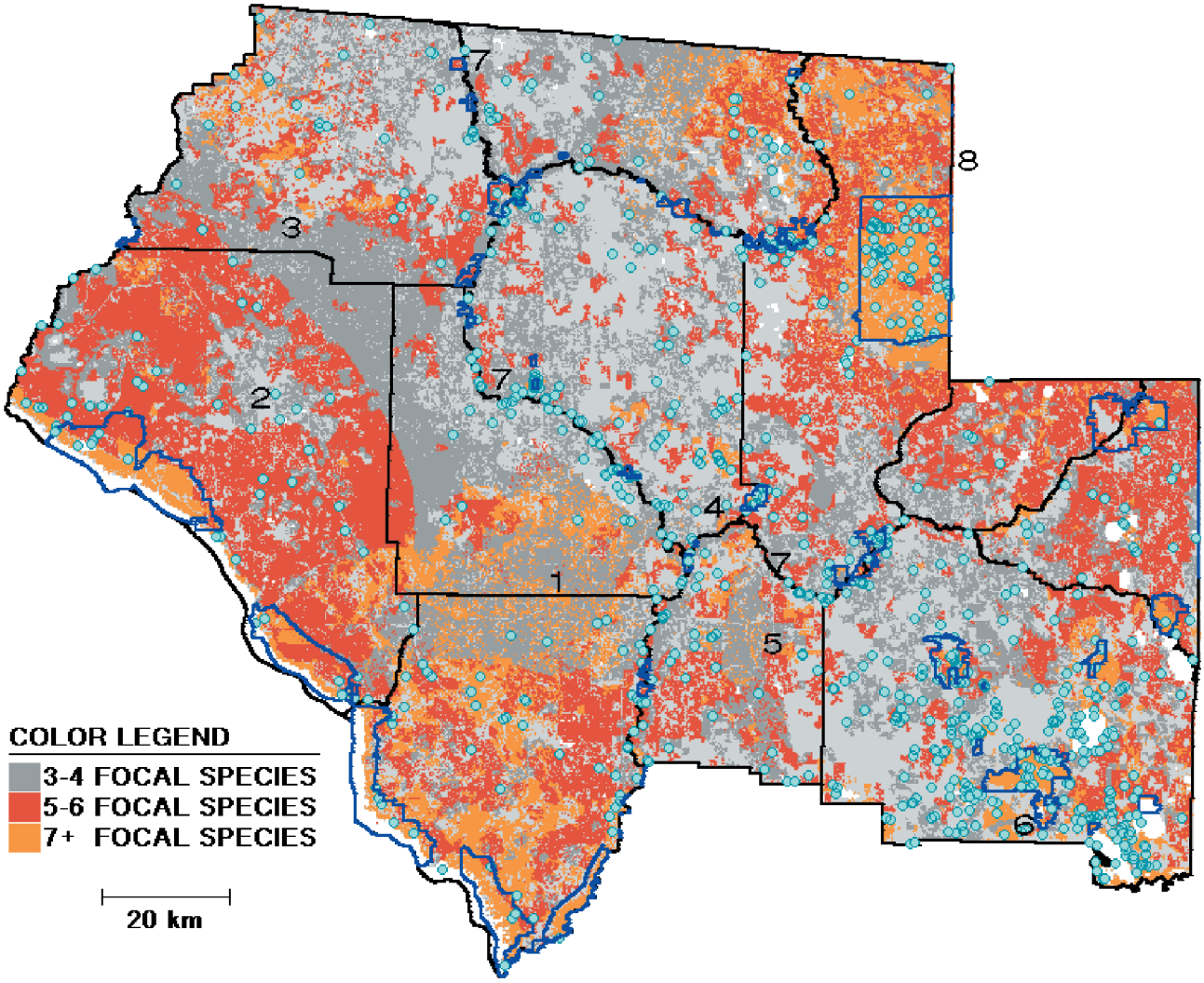


Figure 167c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.4. North Central Florida Region

The area encompassed by the North Central Florida Region includes extensive tracts of pineland, upland hardwood forest, hardwood swamp, cypress swamp, and coastal salt marsh (Figure 167a, 167b, and 167c). The natural quality of many of these areas has been affected by commercial timber operations, but these large forested areas provide important habitat for wide-ranging species such as black bear, bobcat, American swallow-tailed kite, and wild turkey. The low density of major roads throughout the eastern portion of the region is also beneficial. A few small patches of rare, xeric upland land-cover types, such as sandhill and oak scrub, remain scattered throughout the region, but most of these cover types have been converted to agricultural land uses. Some of the more important features of this region are referenced by number in Figure 167c and discussed in greater detail below.

The quantity of conservation land in this region is proportionately less than the quantity found in other regions of Florida. Only 6.4% of the total land area is in some type of conservation status, compared to a statewide average of 19.6%. Dixie, Taylor, Lafayette, Madison, Bradford, Alachua, Hamilton, Union, and Gilchrist counties all contain a smaller percentage of conservation lands than the statewide average for individual counties (15.6%).

Area 1. Forested areas in Dixie and Lafayette counties. Portions of these areas are proposed as Strategic Habitat Conservation Areas for American swallow-tailed kite, short-tailed hawk, and several species of wading birds (great egret, little blue heron, tricolored heron, white ibis, and wood stork). Occurrences of rare species are listed by more specific geographic areas. **Lower Suwannee River:** great egret (two rookeries), wood stork (rookery), yellow-crowned night-heron (several small rookeries), limpkin, American swallow-

tailed kite (breeding and a late-summer roost), gopher tortoise, eastern indigo snake, striped newt, Florida pine snake, Atlantic sturgeon, Suwannee bass, and cedar elm. **California Swamp:** American swallow-tailed kite, short-tailed hawk, yellow-crowned night-heron (small rookeries), little blue heron, and Texas anemone. **Pumpkin Swamp:** American swallow-tailed kite, little blue heron (rookery), great egret (rookery), eastern indigo snake, and Texas anemone. **Steinhatchee River:** great egret, American swallow-tailed kite, limpkin, Cooper's hawk, short-tailed hawk, eastern indigo snake, gopher tortoise, pine wood dainties. **Mallory Swamp:** American swallow-tailed kite, great egret, limpkin, and mud sunfish.

Area 2. Large forested tracts in Taylor County. Most of the "natural" land cover has been altered by commercial timber operations, but portions of these areas are proposed as a Strategic Habitat Conservation Area for American swallow-tailed kite and Florida black bear. Occurrences of rare species are listed by more specific geographic areas. **Steinhatchee River** (including Rocky and Boggy creeks): American swallow-tailed kite, eastern indigo snake, pine wood dainties, and Texas anemone. **Spring Warrior Swamp and Spring Warrior Creek:** American swallow-tailed kite, gopher tortoise, pondspice, and Godfrey's golden aster. **Thomas Mill Island/Regular Creek/Fenholloway River:** American swallow-tailed kite, great egret (rookery), Cooper's hawk, and eastern indigo snake. **Econfina River:** Florida black bear and American swallow-tailed kite. **San Pedro Bay:** American swallow-tailed kite, Florida sandhill crane, great egret, little blue heron, gopher tortoise, Florida pine snake, and mud sunfish. **Aucilla River:** Cooper's hawk, American swallow-tailed kite, Florida black bear, yellow-crowned night-heron, and gopher tortoise.

Area 3. Forested tracts in east and south Madison County. Portions of this area are proposed as a Strategic Habitat Conservation Area for rare wading birds such as wood stork, white ibis, great egret, snowy egret, and little blue heron. Wading bird rookeries are located primarily in the eastern and southern portions of the county, but birds forage throughout the area. Additional rare species are listed by specific geographic areas. **Hixtown Swamp:** Florida sandhill crane, little blue heron (rookery), great egret (rookery), gopher tortoise, and incised groove-bur. **Aucilla River** (including Little Aucilla River, Alligator and Rocky creeks, and Johanna Lake): Florida black bear, great egret (rookery), little blue heron (rookery), white ibis (rookery), American swallow-tailed kite, limpkin, and eastern mudminnow. **Econfina River:** great egret (rookery). **Dobson Pond:** little blue heron (rookery) and tricolored heron (rookery). **Grassy Pond:** great egret (rookery) and Florida pine snake. **San Pedro Bay:** great egret (rookery), little blue heron (rookery), eastern indigo snake, and gopher tortoise.

Area 4. Mixture of agricultural lands and xeric upland communities in Madison, Suwannee, Lafayette, Columbia, Gilchrist, and Alachua counties. Rare species are listed by more specific geographic areas. **Northeast Madison County** (area approximately defined by State Road 53, U.S. 90, and the county border): southeastern American kestrel, Cooper's hawk, eastern indigo snake, Florida pine snake, and gopher tortoise. **Blue Springs** (Hamilton County): southeastern American kestrel, Bachman's sparrow, red-cockaded woodpecker, and gopher tortoise. **Site 1 North of Branford** (north and south of State Road 247 and centered at the intersection of Cross County Road and Sand Hill Road): fox squirrel, southeastern American kestrel, Florida burrowing owl, gopher tortoise, Florida pine snake, and eastern indigo snake. **Site 2 North of Branford** (east of State Road 249, north of Brannen Road): southeastern American kestrel, Cooper's hawk, gopher tortoise, and Florida pine snake; also in vicinity is a cave formerly used by southeastern bats. **Site North of Bell** (primarily between County Road 340 and County Road 138): fox squirrel, Bachman's sparrow, Florida pine snake, short-tailed snake, and gopher tortoise. **East of Craggs** (patches of sandhill between County Road 232 and 340): southeastern American kestrel, Bachman's sparrow, gopher tortoise, Florida pine snake, and eastern indigo snake.

Area 5. Terrestrial caves in Gilchrist, Suwannee, and Alachua counties (including portions of Area 4 above). Areas immediately surrounding these caves proposed as a Strategic Habitat Conservation Area for southeastern bats. Additional records from these caves include light-fleeing cave crayfish and Hobbs' cave isopod.

Area 6. Wetlands and surrounding areas in south Alachua County. Portions included as Strategic Habitat Conservation Areas for Florida sandhill crane, southern bald eagle, and several rare wading birds (wood stork, little blue heron, great egret, yellow-crowned night-heron, and tricolored heron). Other species are listed by major drainage basins. **Paynes Prairie:** round-tailed muskrat, limpkin, gopher tortoise, eastern indigo snake, tiger salamander, and virgin's bower. **Levy and Kanapaha Prairies:** fox squirrel, southeastern American kestrel, limpkin, gopher tortoise, Florida pine snake, and eastern indigo snake. **Orange and Lochloosa Lakes:** Florida black bear, osprey, limpkin, gopher tortoise, eastern indigo snake, and blackbanded sunfish. **Newnan's Lake and Lochloosa Creek:** southeastern weasel, fox squirrel, osprey, limpkin, gopher tortoise, short-tailed snake, spotted turtle, flatwoods salamander, striped newt, and loose-coiled snail.

Area 7. Forested areas along Santa Fe, Withlacoochee, and Suwannee rivers and Olustee Creek. Rare species recorded within 100 m of these water bodies are grouped by county. **Alachua:** canebrake rattlesnake, Suwannee cooter, and Suwannee bass. **Bradford:** Florida pine snake. **Columbia:** American swallow-tailed kite (summer roost), canebrake rattlesnake, gopher tortoise, Suwannee cooter, Suwannee bass, Florida willow, and sand grain snail. **Gilchrist:** American swallow-tailed kite (summer roost), Florida pine snake, Suwannee cooter, spotted bullhead, Suwannee bass, cedar elm, pallid cave crayfish, Florida cave amphipod, and Hobbs' cave amphipod. **Hamilton:** great egret (rookery), eastern indigo snake, gopher tortoise, Suwannee cooter, alligator snapping turtle, mountain mullet, Suwannee bass, and pallid cave crayfish. **Lafayette:** white ibis (rookery), little blue heron (rookery), great egret (rookery), hairy woodpecker, Suwannee bass, Suwannee cooter, spotted bullhead, and pallid cave crayfish. **Madison:** Suwannee bass, cedar elm, and pallid cave crayfish. **Suwannee:** Suwannee cooter, cedar elm,

Florida willow, and pallid cave crayfish. **Union:** alligator snapping turtle.

Area 8. Area around Osceola National Forest (Hamilton and Columbia counties). Portions of the area make up a Strategic Habitat Conservation Area for Florida black bear and several wading birds (white ibis, wood stork, and little blue heron). Due to a lack of survey data, only 3 additional species are known for this area based on information stored in the Florida Natural Areas Inventory, Nongame Wildlife Program Wildlife Observation, and breeding bird atlas databases. These are gopher tortoise, red-cockaded woodpecker, and eastern mudminnow. The more important habitat areas for black bears are areas east of U.S. 41 (Sandlin Bay, Pinhook Swamp, and Impassable Bay). Other important areas lie in the Northeast Region and Georgia (see Florida black bear, Section 6.2.11).

Coastal Areas of Taylor County. Records of rare species are listed by more specific geographic areas. **County Line to Spring Warrior Creek:** southern bald eagle, osprey, Wakulla seaside sparrow, shorebird aggregation areas (Smith McCallah Creek), eastern indigo snake, gopher tortoise, and corkwood. **Spring Warrior Creek to Steinhatchee:** West Indian manatee, southern bald eagle, black rail, piping plover, shorebird aggregation areas (Adam's Beach, Dekle Beach, Keaton Beach, and Hagen's Cove), and eastern indigo snake.

Coastal Areas of Dixie County: Records of rare species are listed by more specific geographic areas. **Jena to Pepperfish Keys:** southern bald eagle, Wakulla seaside sparrow, white ibis (rookery), black rail, Gulf salt marsh snake, and corkwood. **Pepperfish Keys to Suwannee:** southern bald eagle, American oystercatcher, Scott's seaside sparrow, shorebird aggregation area, and Gulf salt marsh snake.

Figure 168 (a-c). Distribution of important resources in the Northeast Florida Region.

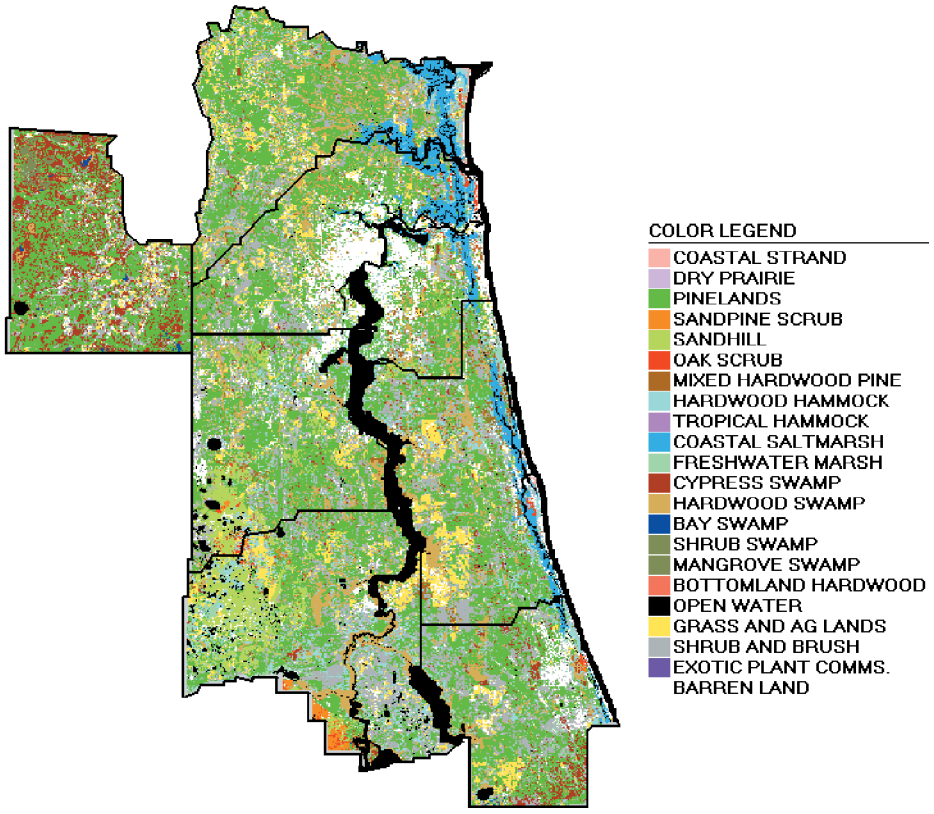


Figure 168a. Landsat land-cover map for the Northeast Florida Region.

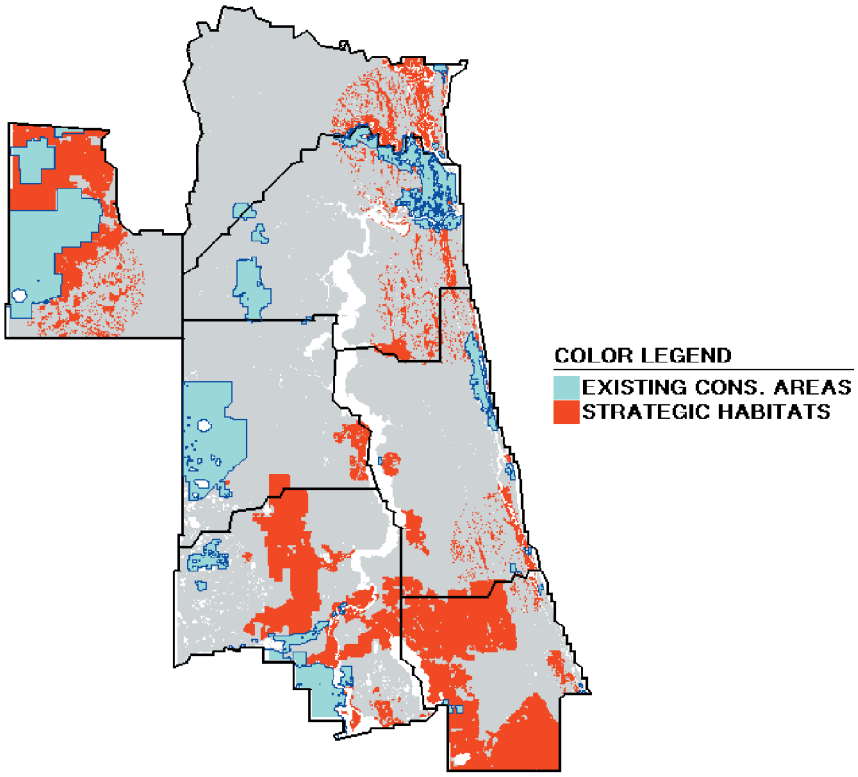


Figure 168b. Strategic Habitat Conservation Areas and existing conservation lands.

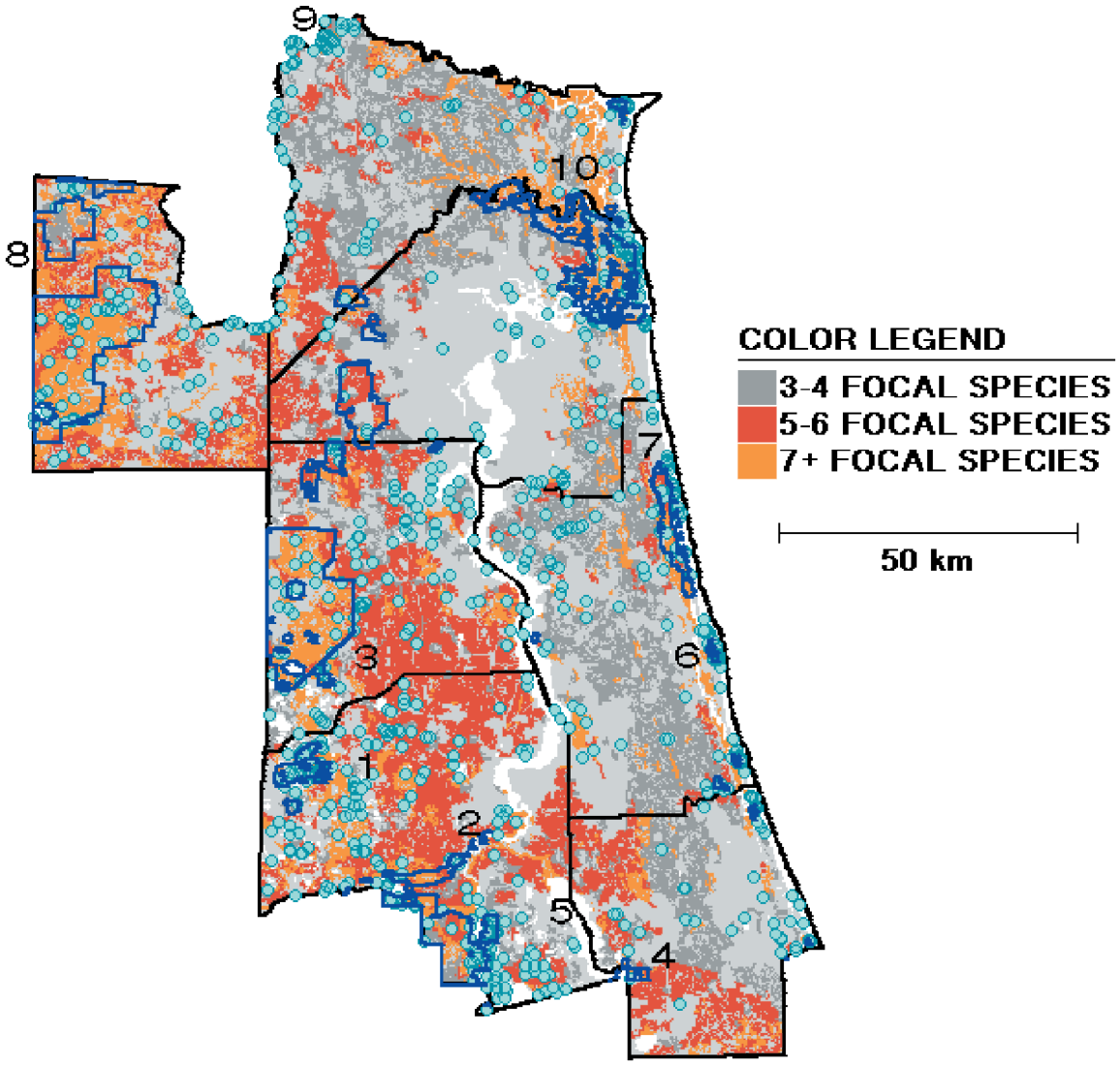


Figure 168c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.5. Northeast Florida Region

The Northeast Florida Region contains a diverse mixture of land-cover types (Figures 168a, 168b, and 168c) and several large forested areas that support rare, wide-ranging species such as Florida black bear, bobcat, wild turkey, and American swallow-tailed kite. Large tracts of xeric upland communities (sandhill and scrub) in Clay and Putnam counties are also extremely important to a large number of rare vertebrates (see Areas 1 and 3 described below). The percentage of conservation lands in this region (11.9%) is well below the statewide average of 19.6%. Individual counties lower than the statewide average (15.6%) are Putnam, Duval, Nassau, and Flagler counties. Some of the more important features of this region are referenced by number in Figure 168c and discussed in greater detail below.

Area 1. Upland areas in Putnam County. Important areas for Florida sandhill crane and southeastern American kestrel. Other species are listed by more specific geographic areas. **Northeast of McMeekin** (defined by State Roads 21, 26, 20, and 315): round-tailed muskrat, fox squirrel, Florida mouse, southern bald eagle, eastern indigo snake, Florida pine snake, gopher tortoise, striped newt, gopher frog, rosemary wolf spider, and spoon-leaved sundew. **Southeast of McMeekin** (defined by State Roads 200, 20, and 315): fox squirrel, Florida sandhill crane, short-tailed hawk, southern bald eagle, gopher tortoise, spotted turtle, Florida pine snake, eastern indigo snake, dusky shiner, rosemary wolf spider, Florida mountain-mint, and Florida willow. **Southeast of Georges Lake** (areas around Rice Creek, Etonia Creek, and Simms Creek): Florida scrub jay, southern bald eagle, Cooper's hawk, eastern indigo snake, Etonia rosemary, gopher tortoise, Bartram's ixia, and Black Creek crayfish.

Area 2. Mixed forests in south central Putnam County (Rice Creek, Cow Heaven Bay, and Sweetwater, Paley, and Deep creeks). Portions of the area make up a Strategic Habitat Conservation Area for the Florida black bear. Other rare species include Florida mouse, southeastern American kestrel, American swallow-tailed kite, Florida scrub jay,

southern bald eagle, short-tailed hawk, little blue heron (rookery), limpkin, gopher tortoise, short-tailed snake, eastern indigo snake, Florida scrub lizard, short-tailed snake, gopher frog, tesselated darter, snail bullhead, and Florida willow.

Area 3. Sandhill and xeric uplands in Clay County. Portions constitute Strategic Habitat Conservation Areas for the Florida scrub jay and Florida sandhill crane. Other rare species are listed by more precise geographic areas. **Camp Blanding Wildlife Management Area, Goldhead Branch State Park, and Surroundings** (particularly to the south): red-cockaded woodpecker, southeastern American kestrel, Florida scrub jay, little blue heron (rookery), eastern indigo snake, Florida pine snake, gopher tortoise, gopher frog, Florida spiny-pod, Curtiss' milkweed, Chapman's rhododendron, pondspice, St. John's-Susan, Bartram's ixia, hartwrightia, incised groove-bur, and Florida mountain mint. **South of Penney Farms** (either side of Saunders Road): Florida black bear, Cooper's hawk, Bartram's ixia, and hartwrightia. **North of Penney Farms** (south of State Road 21): southern bald eagle, southeastern American kestrel, Cooper's hawk, St. John's-Susan, Florida mountain mint, Bartram's ixia, variable-leaf crownbeard, and slender-leaf dragonhead. **Black Creek** (north of State Road 21, north of Camp Blanding): Cooper's hawk, Bartram's ixia, hartwrightia, and variable-leaf crownbeard.

Area 4. Wetlands and forested areas of south central Flagler County (south of State Road 305, around Lake Disston, Cody, and east to Interstate 95; contiguous to important forested lands described in the East Central Region). Portions of the area make up a Strategic Habitat Conservation Area for the Florida black bear, American swallow-tailed kite, and rare wading birds. Limpkin and southeastern American kestrel have also been recorded in the area.

Area 5. Forested lands in southeast Putnam and east St. Johns counties. Portions of the area are proposed as a Strategic Habitat Conservation Area for Florida black bear, southern bald eagle, and American swallow-tailed kite. Additional rare species are listed by major drainages. **Murphy and Dunns Creeks, Crescent Lake** (and smaller tributaries): Florida black bear (dispersal corridor), American swallow-tailed kite, white ibis (rookery), little blue heron (rookery), limpkin, and gopher tortoise. **Hell Cat Bay** (contiguous to Area 4 above): American swallow-tailed kite. **Deep Creek:** southern bald eagle, American swallow-tailed kite, great egret (rookery), little blue heron (rookery), St. John's Susan, and Florida mountain-mint.

Area 6. Wetland areas in east St. Johns County (Fish Swamp, Cracker Branch, and Pellicer Creek). Portions of the area are proposed as a Strategic Habitat Conservation Area for wood stork and other rare wading birds (e.g., little blue heron). American swallow-tailed kite also recorded from the area.

Area 7. Forested areas in southeast Duval and northwest Flagler counties that constitute a Strategic Habitat Conservation Area for wood stork and other rare wading birds. Other rare species are listed by major drainage basins. **Twelvemile Swamp and Snowden Bay** (Guana River Wildlife Management Area and Guana River State Park): Florida black bear, American swallow-tailed kite, little blue heron (rookery), wood stork (rookery), white ibis (rookery), eastern indigo snake, and Bartram's ixia. **Durbin Swamp and Pablo Creek** (see coastal areas below): red-cockaded woodpecker, wood stork (rookery), southern bald eagle, limpkin, gopher tortoise, Florida pine snake, and eastern indigo snake. **Julington Creek:** American swallow-tailed kite, yellow-crowned night-heron, southern red lily, variable leaf crownbeard, and Bartram's ixia.

Area 8. Large forested area north of Osceola National Forest. Portions of the area make up a Strategic Habitat Conservation Area for Florida black bear (particularly Moccasin Swamp, Cross Branch, North Prong of the St. Marys River) and rare wading birds (wood stork, white ibis, great egret, and little blue heron). Other species recorded in the area include Florida sandhill crane, American swallow-tailed kite, canebrake rattlesnake, carpenter frog, eastern mud-minnow, and black-banded sunfish.

Area 9. Northwest Nassau County. Rare species are listed by specific geographic areas. **St. Marys River, Orange Bluff to Hampton Lake:** American swallow-tailed kite, red-cockaded woodpecker, eastern indigo snake, gopher tortoise, purple balduina, hartwrightia, heartleaf, and Florida toothache grass. **Cabbage and Clark's Creeks:** American swallow-tailed kite. **Hilliard:** southeastern weasel, southeastern American kestrel, and many-lined salamander. **Callahan:** eastern indigo snake, hartwrightia, spoon-flower, and purple balduina.

Area 10. Areas around Nassau and St. Marys' Rivers, Nassau County. Portions of the area represent a Strategic Habitat Conservation Area for wood stork and Smyrna seaside sparrow. Other rare species are listed by major drainages (but see also coastal areas described below). **Nassau River** (Smith's Point east to Nassauville, including McQueen Creek): West Indian manatee, wood stork (rookery), snowy egret (rookery), great egret (rookery), little blue heron (rookery), southeastern kestrel, limpkin, seaside sparrow, and gopher tortoise. **Alligator and Mills Creeks:** foraging areas for wading birds. **Little St. Marys River and Wilder Swamp:** canebrake rattlesnake and eastern indigo snake. **St. Marys River** (Kings Ferry to Tiger Island): great egret (rookery), great blue heron (rookery), foraging areas for wading birds, seaside sparrow, eastern indigo snake, gopher tortoise, and Florida toothache grass. **Pumpkin Hill Creek:** wood stork (2 rookeries), great egret (2 rookeries), and Smyrna seaside sparrow.

Coastal Areas of Flagler and St. Johns Counties. Several important patches of natural land cover on private lands north of Marineland (St. Johns/Flagler border), around Palm Coast, north of Ft. Matanzas National Monument, and south of Anastasia Island State Recreation Area. Rare species are listed by more specific areas. **Palm Coast South to Flagler Beach State Recreation Area:** Florida scrub jay (Flagler Beach State Recreation Area), leatherback turtle, shorebird aggregation areas, and coastal vervain. **Palm Coast North to Marineland** (including Washington Oaks): Florida scrub jay, gopher tortoise, eastern indigo snake, yellow hibiscus, and coastal vervain. **Marineland to Crescent Beach** (including Ft. Matanzas): Anastasia Island beach mouse, Atlantic salt marsh mink, Wilson's plover, black skimmer,

piping plover, American oystercatcher, shorebird aggregations (Matanzas Inlet, Salt Run, St. Augustine), gopher tortoise, and eastern indigo snake. **Crescent Beach to Anastasia Island:** West Indian manatee, Anastasia Island beach mouse (Anastasia Plaza and north of Vergassi Road), least tern (nesting), eastern indigo snake, and mountain mullet. Vilano Beach to Ponte Vedra Beach: southern bald eagle, wood stork, great egret, Florida pine snake, sand-dune spurge, and coastal vervain.

Coastal Areas of Duval and Nassau Counties. Salt marshes to the north are important to several rare wading birds. Other species are listed by specific geographic areas. **Manhatten Beach:** no occurrence records, potentially important areas of coastal dune, maritime hammocks, and grasslands. **Blount and Nearby Islands:** southern bald eagle, great egret (rookery), least tern (nesting), seaside sparrow, shorebird aggregation area, and gopher tortoise. **Ward's Bank** (Hugenot Park, Mayport Jetties): Wilson's plover, black skimmer (nesting), royal tern, least tern, piping plover, American oystercatcher, and shorebird aggregation area. **Ft. George Island/Talbot Islands:** least tern (nesting), shorebird aggregation areas (Little Talbot), gopher tortoise, loggerhead turtle, eastern indigo snake, terrestrial peperomia, southern lip fern, and green ladies-tresses. **Amelia Island, South Amelia River, and Fernandina Beach:** West Indian manatee congregation area, Smyrna seaside sparrow, least tern (nesting), shorebird aggregations (Ft. Clinch Jetty, Amelia Island drawbridge, Amelia Island, north shore of Ft. Clinch), and gopher tortoise.

Figure 169 (a-c). Distribution of important resources in the South Florida Region.

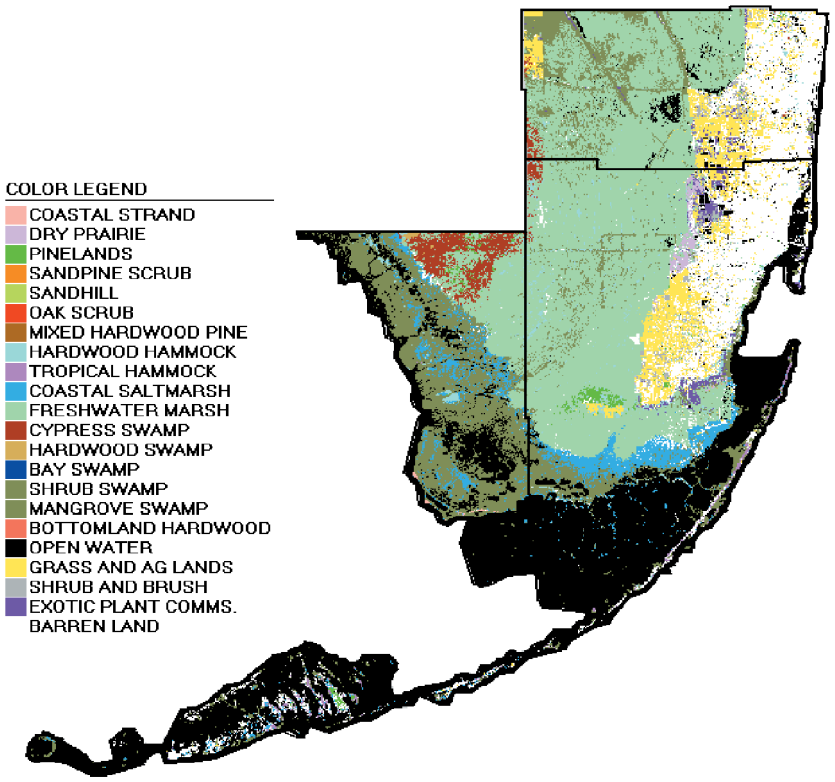


Figure 169a. Landsat land-cover map for the South Florida Region.

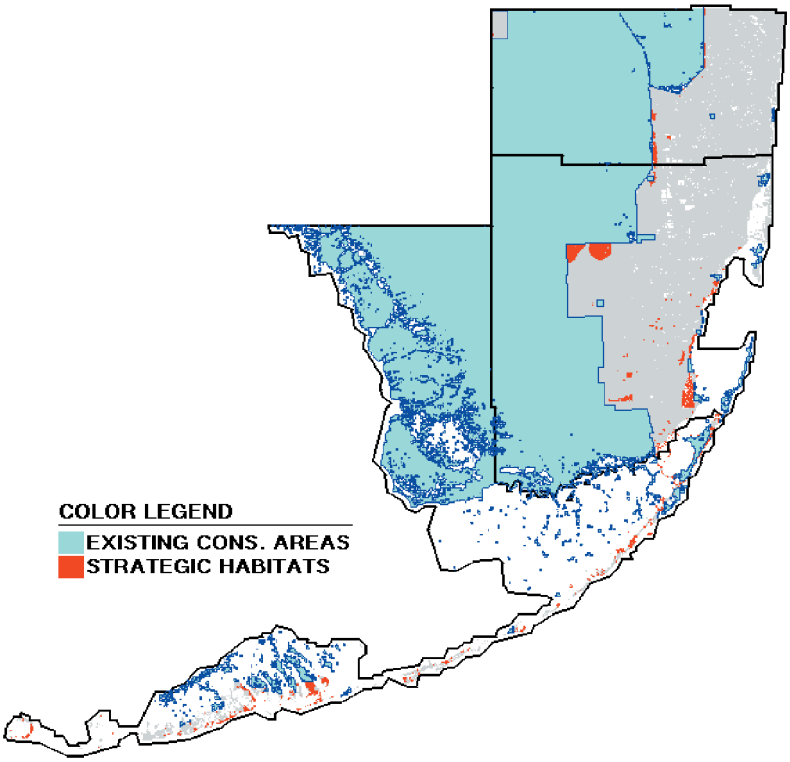


Figure 169b. Strategic Habitat Conservation Areas and existing conservation lands.

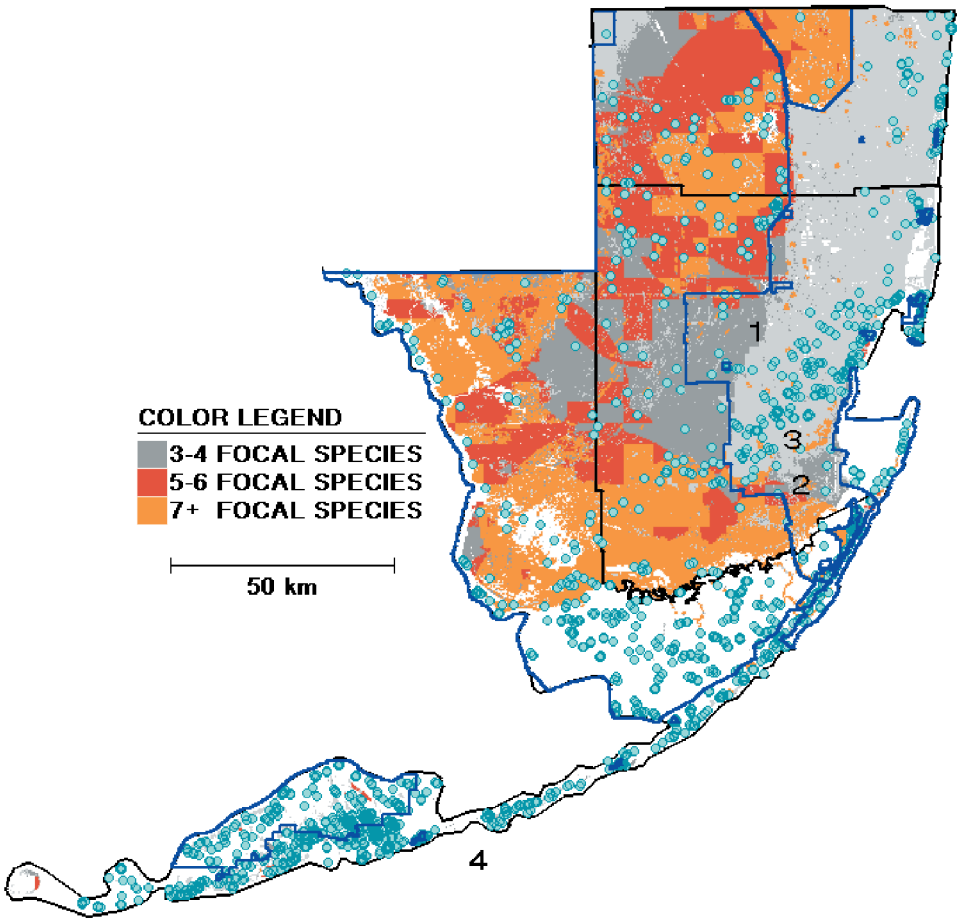


Figure 169c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.6. South Florida Region

Large conservation areas in the South Florida Region capture much of the natural land cover remaining in this region (Figures 169a, 169b, and 169c). Sixty-seven percent of the region falls within some designated conservation area, and all counties are well above the statewide average of 15.6%. Management of these conservation areas, and especially water resources, may prove to be an ongoing struggle in the face of increasing demands from neighboring urban areas. Additional habitat protection and conservation may help to offset some of these pressures. In addition, some rare community types are not well represented on the current system of conservation areas in south Florida. In particular, additional protection of important pine rocklands and tropical hammocks is warranted. Some of the more important features of this region are referenced by number in Figure 169c and discussed in greater detail below. Our discussion of regionally important areas is generally limited to areas falling outside current conservation areas in the region.

Area 1. East edge of the Everglades National Park (between State Roads 997 and 821; also south of Tamiami Trail, west of State Road 997). Patches of freshwater marsh and dry prairie occur within 12-20 km of at least 15 known wading bird rookeries. Potentially important foraging areas for species such as wood stork, snowy egret, tricolored heron, great egret, and little blue heron. Other species known for the area include Florida burrowing owl and Florida sandhill crane.

Area 2. Areas north of Card Sound. Large area of freshwater marsh, salt marsh, and mangrove swamp east and west of U.S. 1, primarily south of Aerojet Canal Number C-111. Portions of the area make up a Strategic Habitat Conservation Area for the American crocodile. Other species recorded in the area include white-crowned pigeon, southern bald eagle, mangrove terrapin, eastern indigo snake, and mangrove gambusia.

Area 3. Critically endangered areas consisting of pine rockland and rockland hammock communities (see Section 6.3.5). Important patches occur around Homestead, Goulds, and Florida City. Rare species recorded in these areas include Florida evening bat, mastiff bat, Florida burrowing owl, gopher tortoise, eastern indigo snake, rim-rock crowned snake, Florida atala butterfly, twinberry, Krug's holly, Eaton's spikemoss, Wright's anemia, bicolor tetrazygia,

Bahama brake, pineland jacquemontia, Florida five-petaled leaf-flower, silver palm, Florida gama grass, a queen's delight, Porter's broom spurge, Small's milkpea, Florida lantana, Boykin's few-leaved milkwort, Florida thoroughwort brickellbush, Florida pinewood privet, wild potato morning-glory, Bahama sachsia, rocklands morning-glory, pineland noseburn, Porter's broad-leaved spurge, small-leaved melanthera, whitetop sedge, little strongbark, coastal vervain, Blodgett's wild-mercury, fragrant maidenhair fern, Florida bristle fern, Ames' halberd fern, brittle maidenhair fern, powdery catopsis, many-flowered catopsis, Fuch's bromeliad, night-scented orchid, banded wild-pine, Cuban snake-bark, spurred neottia, deltoid spurge, Florida thatch palm, deltoid spurge, sand flax, blunt-leaved peperomia, Florida bristle fern, brown-haired snout-bean, Okeechobee gourd, Garber's spurge, tiny polygala, cow-horned orchid, golden leather fern, slender spleenwort, dollar orchid, Carter's small-flowered flax.

Area 4. Tropical hardwood hammocks, pinelands, and mangrove islands of the Florida Keys. Some of the more important tracts occur on Key Largo and Elliott Key; and on Big Pine Key, No Name Key, the Torch keys, Ramrod Key, Summerland Key, Cudjoe Key, and Sugarloaf Key in the Lower Keys. A series of tropical hardwood hammocks in the mainline Keys make up a Strategic Habitat Conservation Area for white-crowned pigeon. An important raptor roost site occurs on Boot Key; Ohio Key is important to wintering piping plovers; hammocks and mangrove swamps often are important wintering and stop-over habitat areas for neotropical migrants. Several vertebrate species also have unique, disjunct populations in the Lower Keys. These include American alligator, striped mud turtle, Big Pine ringneck snake, red rat snake, brown snake, Florida ribbon snake, Lower Keys marsh rabbit, Key deer, Florida mole skink, and Key silverside.

Coastal Areas in Broward County. Due to tremendous urban development, some coastal records may be dated. Occurrences are listed by precise geographic areas. **Hillsboro Beach:** maritime beach star. **Fisherman's Wharf Pier** (and nearby areas): burrowing four-o'clock and beach jacquemontia. **South Anglin's Pier:** green turtle and loggerhead turtle nesting records. **Hugh Taylor Birch State Park:** gopher tortoise, broad-leaved spider lily, golden leather fern, necklace pod, large-flowered rosemary, and silver palm. **John Lloyd State Recreation Area:** least tern (nesting), shorebird aggregation area (and at nearby West Lake Park), burrowing four-o'clock, beach-star, and sea lavender.

Coastal Areas in Dade County. Due to tremendous urban development, some coastal records may be dated. Occurrences are listed by precise geographic areas. **Oleta River State Park:** black-crowned night-heron, mangrove gambusia, coastal vervain, Florida lantana; shorebird aggregation area at nearby Greynolds Park seawall. **Fisher Key, Virginia Key, Key Biscayne:** southern bald eagle, piping plover, royal tern, loggerhead turtle, rivulus, spottail goby, broad-leaved spiderlily, Florida lantana, necklace pod, beach-star, prickly ash, silver palm, burrowing four-o'clock, and Johnson's seagrass; shorebird aggregation areas (West Bear cut, Seaquarium flats, and Virginia Key). **Matheson Hammock County Park and Chapman Field Park** (and private lands north and south): mangrove gambusia, slender spleenwort, mountain mullet, rim-rock crowned snake, and little strongbark; shorebird aggregation areas (Matheson Park, Black Point Park, and Homestead Bayfront Park), and several pine rockland associates (see Area 3) on eastern Cutler Ridge.

Figure 170 (a-c). Distribution of important resources in the Southwest Florida Region.

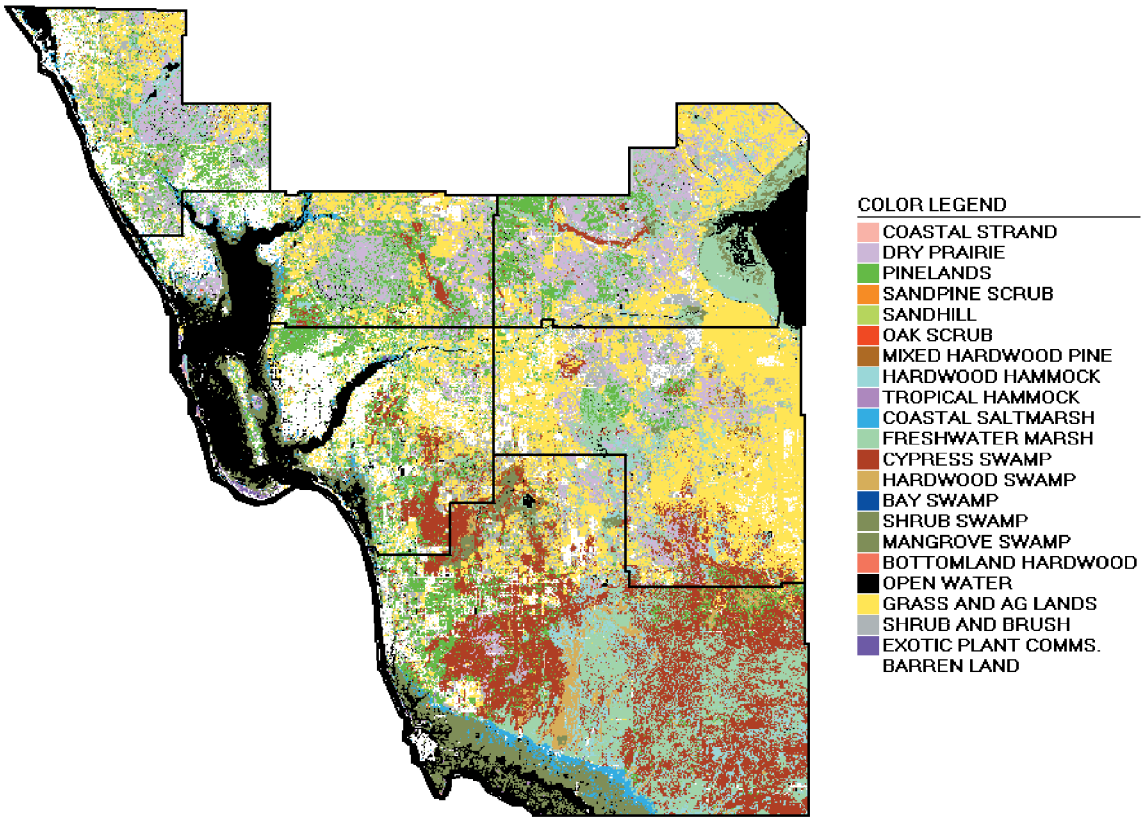


Figure 170a. Landsat land-cover map for the Southwest Florida Region.

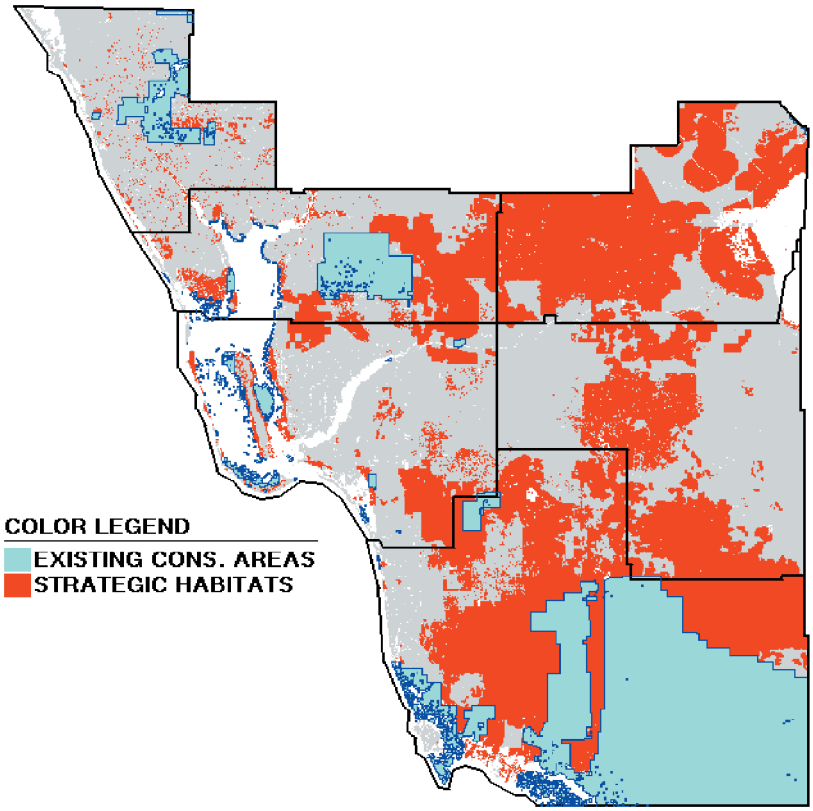


Figure 170b. Strategic Habitat Conservation Areas and existing conservation lands.

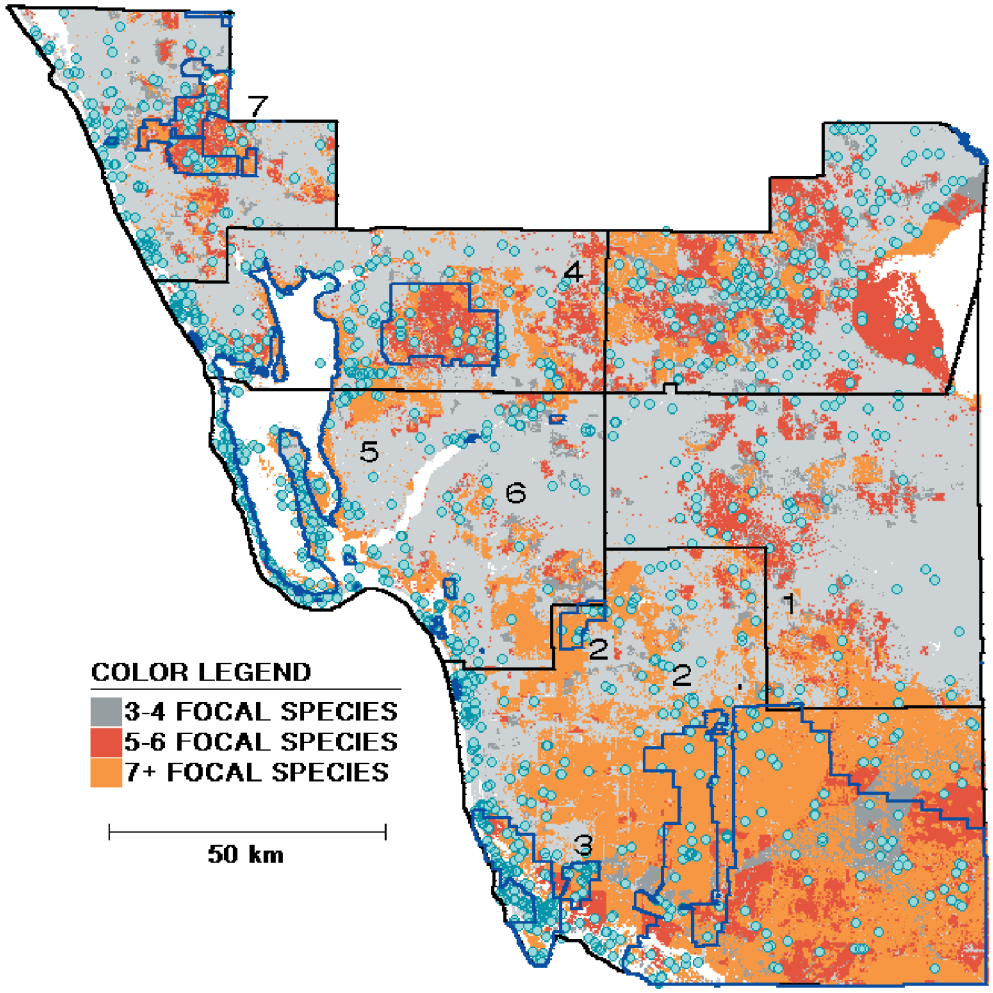


Figure 170c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.7 Southwest Florida Region

In terms of maintaining several wide-ranging species that make up an important component of wildlife diversity in Florida, the Southwest Florida Region (Figures 170a, 170b, and 170c) probably represents the most important region in Florida. This region has the only stable population of panther found east of the Mississippi River; it has the only stable population of black bear south of Lakeland; it has the greatest concentration of territories of Audubon's crested caracara in all of the United States; the region supports core populations of sandhill cranes, swallow-tailed kites, and burrowing owls; and the region also contains areas that provide important foraging and nesting habitat for large, diverse wading bird colonies. In addition to these features, the climate of the region provides appropriate conditions for several species of tropical plants that are rare elsewhere in Florida (Ward 1979). Despite the outstanding biological richness of the remaining natural areas in this region, the region falls just below the statewide average for percentage of conservation lands (19.1% versus 19.6%). Hendry, Sarasota, and Glades counties fall well below the statewide average for individual counties. Some of the more important features of this region are referenced by number in Figure 170c and are discussed in greater detail below.

Area 1. Areas northeast of Big Cypress National Preserve. Mixture of cypress swamp, hardwood swamp, dry prairie, and pineland extending northeast through Kissimmee Billy Strand, Cow Bell Strand, and California Slough to central Hendry County. Large portions of the area are proposed as a Strategic Habitat Conservation Area for Florida panther, Florida black bear, wood stork, American swallow-tailed kite, Florida sandhill crane, snail kite, or Audubon's crested caracara. Other species are listed by precise geographic areas. **West of Devil's Garden** (north and south of Keri Road, including Graham Marsh, Devil's Garden Slough, Collins Slough, and Grassy Marsh): Strategic Habitat Conservation Area for Florida panther, wood stork (rookeries), and other rare wading birds; other rare species recorded in the area include Florida sandhill crane, Audubon's crested caracara, Florida scrub jay, snowy egret (rookery), little blue heron (rookery), glossy ibis (rookery), great egret (rookery), mottled duck, eastern indigo snake, and large flowered flax. **Kissimmee Billy Strand** (extending north of State Road 833): Strategic Habitat Conservation Area for Florida panther, Florida black bear, Audubon's crested caracara, and wood stork; other rare species recorded in the area include little blue heron (rookery), mottled duck, eastern indigo snake, gopher tortoise, Florida lantana, and narrow-leaved Carolina scalystem.

Area 2. Areas northwest of Big Cypress National Preserve. This mixture of cypress swamp, hardwood swamp, dry prairie, and pineland represents one of the most important wildlife areas remaining in Florida. This broad area extends northwest through Catherine and Smallwood islands to Lake Trafford and Corkscrew Swamp, and northwest of Corkscrew Sanctuary to I-75 and Corkscrew Swamp Road. Large portions of the area make up a Strategic Habitat Conservation Area for Florida panther, Florida black bear, wood stork, and American swallow-tailed kite. Additional rare species are listed by specific geographic areas. **Catherine Island, Okaloacochee Slough, Smallwood Island, and Sick Island** (and surrounding areas east and west of State Road 29): Strategic Habitat Conservation Area for Florida panther, Florida black bear, American swallow-tailed kite, wood stork (3 rookeries), and other wading birds; other rare species recorded in the area include Audubon's crested caracara, American swallow-tailed kite, limpkin, mottled duck, night-scented orchid, great egret (rookery), snowy egret (3 rookeries), white ibis (2 rookeries), little blue heron (5 rookeries), southern bald eagle, and eastern indigo snake. **Corkscrew Swamp Sanctuary and Surroundings** (north to Corkscrew Road, west to I-75, south to Randall Boulevard; includes Bird Rookery Swamp): Strategic Habitat Conservation Area for Florida panther, Florida black bear, and American swallow-tailed kite (late-summer roosts); other species recorded in the area include Florida burrowing owl, mottled duck, limpkin, snowy egret (rookery), eastern indigo snake, and nodding pinweed.

Area 3. West of Fakahatchee Strand. Portions of the area make up a Strategic Habitat Conservation Area for Florida panther, Florida black bear, red-cockaded woodpecker, and several rare wading birds that nest elsewhere. Other rare species are listed by more specific geographic areas. **Southern Golden Gate Estates** (south of I-75, east of State Road 951): American swallow-tailed kite, southern bald eagle, hairy woodpecker, mottled duck, eastern indigo snake, ghost orchid, cow-horned orchid, bird's nest spleenwort, cypress peperomia, Fuch's bromeliad, banded wild pine, blunt-leaved peperomia, auricled spleenwort, and narrow-leaved strap fern. **Central Golden Gate Estates** (east of State Road 951, north of I-75 to White Boulevard): American swallow-tailed kite, red-cockaded woodpecker, mottled duck, gopher tortoise, eastern indigo snake, ghost orchid, banded wild pine, and cow-horned orchid. **Belle Meade** (northeast of Naples Manor, west of Country Barn road, north to I-75, east of Golden Gate): Strategic Habitat Conservation Area for red-cockaded woodpecker; other species in the area include Big Cypress fox squirrel, American swallow-tailed kite, mottled duck, eastern indigo snake, gopher tortoise, ghost orchid, and cow-horned orchid.

Area 4. East Charlotte and west Glades counties (extending along Fisheating Creek and west along State Road 74). Mixture of prairies, cypress swamp, pinelands, rangeland, and upland hardwood forests that make up a Strategic Habitat Conservation Area for Florida panther, red-cockaded woodpecker, Florida sandhill crane, short-tailed hawk, Florida grasshopper sparrow, American swallow-tailed kite, and Audubon's crested caracara. Occurrences of rare species are listed by specific geographic areas. **East of Palmdale** (Cowbone Marsh, north and east of U.S. 27): Florida panther, fox squirrel, Florida scrub jay, Florida sandhill crane, southern bald eagle, Audubon's crested caracara, red-cockaded woodpecker, white ibis (rookery), wood stork, short-tailed hawk, American swallow-tailed kite (late-summer roost), tricolored heron (rookery), Florida burrowing owl, limpkin, mottled duck, gopher tortoise, south Florida rainbow snake, eastern indigo snake, and Edison's ascyrum. **Northwest of Palmdale** (north of State Road 74, west of U.S. 27, east of County Road 731): Florida panther, fox squirrel, Audubon's crested caracara, short-tailed hawk, Florida scrub jay, Florida grasshopper sparrow, mottled duck, little blue heron (rookery), Florida burrowing owl, limpkin, gopher tortoise, south Florida rainbow snake, eastern indigo snake, and gopher frog. **Ortona, Citrus Center, Hall City** (area defined by State Roads 25, 74, and 80 and County Road 731): Florida panther, fox squirrel, Audubon's crested caracara (10+ territories), Florida scrub jay, wood stork, southern bald eagle, Florida burrowing owl, mottled duck, eastern indigo snake, and gopher tortoise. **Jacks Branch and Bee Branch** (west of County Road 731 to Glades County line): Audubon's crested caracara, Florida grasshopper sparrow, Florida burrowing owl, limpkin, Florida sandhill crane, southern bald eagle, wood stork (rookery), great egret (rookery), and mottled duck. **Eastern Charlotte County and Telegraph Swamp** (county line to Cecil Webb Wildlife Management Area, extending south into Lee County): Florida black bear, wood stork (rookery), great egret (rookery), white ibis (rookery), Audubon's crested caracara, southern bald eagle, limpkin, mottled duck, red-cockaded woodpecker, Florida burrowing owl, Florida sandhill crane, Florida scrub jay, eastern indigo snake, and banded wild-pine.

Area 5. Prairie and forested lands southwest of Cecil Webb Wildlife Management Area (north of Gator Slough Canal, east of County Road 765). Portions of the area make up a Strategic Habitat Conservation Area for red-cockaded woodpecker. Other species recorded in the area include Florida black bear, fox squirrel, Florida mastiff bat, southern bald eagle, southeastern American kestrel, American swallow-tailed kite, limpkin, mottled duck, eastern indigo snake, gopher tortoise, beautiful pawpaw, sleeping-beauty water-lily.

Area 6. Near Lehigh Acres (Able Marsh, north to Hickey Creek, Twelvemile Slough, Fussel Slough). Strategic Habitat Conservation Area for the Everglades snail kite. Other species recorded in the area include American swallow-tailed kite, limpkin, mottled duck, southern bald eagle, Florida scrub jay, and eastern indigo snake.

Area 7. Dry prairie, freshwater marsh, and pineland areas in east Sarasota County (surrounding Myakka River State Park and other conservation areas in the region, extending south along Big Slough Canal and Deer Prairie Slough). Portions of the area constitute Strategic Habitat Conservation Areas for the Florida sandhill crane. Other rare species recorded in the area include Florida panther, Florida burrowing owl, mottled duck, Florida scrub jay, American swallow-tailed kite, southeastern American kestrel, Audubon's crested caracara, wood stork (rookeries), tricolored heron (rookery), little blue heron (rookery), snowy egret (rookery), great egret

(rookery), least bittern, limpkin, Bachman's sparrow, gopher tortoise, eastern indigo snake, gopher frog, and sleeping-beauty water-lily.

Coastal Areas of Sarasota County. Occurrences of rare species are listed by more specific geographic areas. **Longboat Key:** shorebird aggregation area (Beer Can Island), Sanibel lovegrass, and prickly-apple. **Lido Key:** Cuban snowy plover, shorebird aggregation areas (Lido Beach and south end), Sanibel lovegrass, and hairy beach sunflower. **Little Sarasota Bay:** West Indian manatee congregation area and southern bald eagle. **Siesta Key** (north of Point O'Rocks and Turtle Beach): least tern (nesting), shorebird aggregation area (Midnight Pass), Sanibel lovegrass, and hairy beach sunflower. **Casey Key:** loggerhead turtle nesting area, shorebird aggregation area (Midnight Pass and near County Road 789), Sanibel lovegrass. **North of Venice Airport:** Florida scrub jay. **Brohard and Caspersen Park Beaches:** coastal forests important to migratory birds. **Manasota Key** (around Manasota): loggerhead turtle (nesting area), shorebird aggregation area (north beach), and prickly-apple. **Lemon Bay:** southern bald eagle.

Coastal Areas of Charlotte County. Portions of the area make up Strategic Habitat Conservation Areas for southern bald eagle and Cuban snowy plover. Additional occurrences of rare species are listed by specific areas. **Manasota Key** (including Charlotte Beach State Recreation Area): loggerhead turtle (nesting area), gopher tortoise, necklace pod, and coastal dunes and forests important to migratory birds; shorebird aggregation areas (Charlotte Beach State Recreation Area and Palm Island Resort). **Grove City:** southern bald eagle and Florida pine snake. **Don Pedro Island:** Cuban snowy plover and coastal grasslands and forests important to migratory birds. **Buck Creek:** Florida scrub jay and southern bald eagle. **Placida:** brown pelican (rookery), Florida scrub jay, tricolored heron (rookery). **Gasparilla Island:** gopher tortoise, prickly apple, and coastal forests important to migratory birds. **Gasparilla Sound:** great egret (rookeries). **Catfish and Whidden Creek Area:** southern bald eagle. **El Jobean:** southern bald eagle. **Peace River, Charlotte Harbor:** West Indian manatee, southern bald eagle. **Charlotte Harbor:** Atlantic sturgeon.

Coastal Areas of Lee County. Portions of the area are included in Strategic Habitat Conservation Areas for southern bald eagle. Additional occurrences of rare species are listed by specific geographic areas. **Gasparilla Island/Boca Grande:** southern bald eagle and shorebird aggregation area. **Cayo Costa** (including Cayo Costa State Park and nearby islands in Pine Island Sound): piping plover, southern bald eagle (4 nests), least tern (nesting), snowy egret (rookery), great egret (rookery), little blue heron (rookery), brown pelican (rookery), shorebird aggregation area (Cayo Costa State Preserve), gopher tortoise, loggerhead turtle (nesting), joewood, spiny hackberry, Florida lantana, banded wild-pine, and prickly apple. **North Captiva Island** (including Cayo Costa State Preserve): piping plover, shorebird aggregation area, gopher tortoise, Sanibel lovegrass, and joewood. **Captiva Island:** shorebird aggregation area, loggerhead turtle, gopher tortoise, eastern indigo snake, prickly-apple, joewood, and necklace pod. **Sanibel Island** (including Ding Darling National Wildlife Refuge): insular cotton rat, Sanibel Island rice rat, southern bald eagle, piping plover, least tern (nesting), great egret (rookery), brown pelican (rookery), black-crowned night-heron (rookery), white ibis (rookery), shorebird aggregation area (Gulf and bay sides), gopher tortoise, eastern indigo snake, loggerhead turtle, Florida pinewood privet, necklace pod, hackberry, Sanibel lovegrass, and sand-dune spurge. **Pine Island** (and Little Pine Island and Matlacha Pass): insular cotton rat, southern bald eagle (Strategic Habitat Conservation Area), magnificent frigatebird, brown pelican (3 rookeries), snowy egret (rookery), white ibis (rookery), tricolored heron (rookery), shorebird aggregation area (Little Bokeelia Island), eastern indigo snake, broad-leaved spiderlily, hackberry, and beautiful pawpaw. **Punta Rassa** (and islands to west): black skimmer (nesting), least tern (nesting), brown pelican (rookery), and shorebird aggregation area. **Ft. Myers Beach:** Florida scrub lizard. **Estero Island and Estero Bay:** brown pelican (rookery), tricolored heron (rookery), snowy egret (rookery), great egret (rookery), black skimmer (nesting), least tern (nesting), Cuban snowy plover, piping plover, southern bald eagle, and shorebird aggregation areas (Little Estero Island Critical Wildlife Area, south end and east end of Carl Johnson Park).

Coastal Areas of Collier County. Occurrences of rare species are listed by specific geographic areas. **Barefoot Beach State Preserve and Delnor-Wiggins Pass State Recreation Area:** black-whiskered vireo, southern bald eagle, least tern, shorebird aggregation area (Wiggins Pass), gopher tortoise, loggerhead turtle, and sand-dune spurge. **North Naples** (south of County Road 862): gopher tortoise and rivulus. **Naples Municipal Pier** (and nearby areas): southern bald eagle, shorebird aggregation area (Naples Bay). **Dollar Bay and Gordon Pass:** southern bald eagle, shorebird aggregation area, gopher tortoise, banded wild-pine, broad-leaved spider lily, nodding pinweed, and golden leather fern. **Rookery Bay/Big and Little Marco Passes/Johnson Bay:** Florida black bear, peregrine falcon, yellow-crowned night-heron (rookery), least tern (nesting), snowy plover (nesting), brown pelican (rookery), shorebird aggregation area, loggerhead turtle, gopher tortoise, and banded wild-pine. **Tigertail Beach/Marco Island:** black skimmer (nesting), snowy plover (nesting), great white heron, Florida burrowing owl, American oystercatcher, southern bald eagle, shorebird aggregation areas (Tigertail Beach, North Marco Island, and Marco River), gopher tortoise, Florida scrub lizard, rivulus, sand-dune spurge, necklace pod, golden leather fern, southern lip fern, hackberry, and banded wild-pine. **Barfield Bay/Caxambas Pass:** piping plover, brown pelican (rookery), southern bald eagle, least tern (nesting), shorebird aggregation areas (Caxambas Pass east and west), broad-leaved spiderlily, banded wild-pine, and scrub bay. **Helen Key, Kice Island, and Cape Romano:** southern bald eagle, least tern (nesting), peregrine falcon, shorebird aggregation areas (Kice Island, Cape Romano, Coon Key), and loggerhead turtle (nesting area). **Ten Thousand Islands:** a discussion of this area is omitted due to its protected status.

Figure 171 (a-c). Distribution of important resources in the Tampa Bay Region.

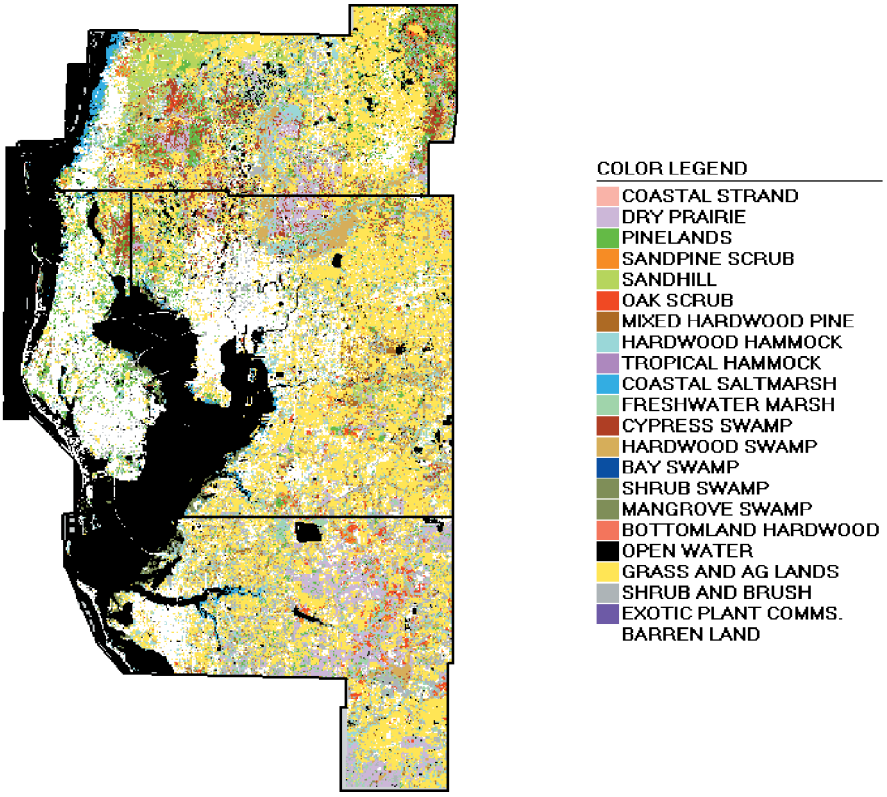


Figure 171a. Landsat land-cover map for the Tampa Bay Region.

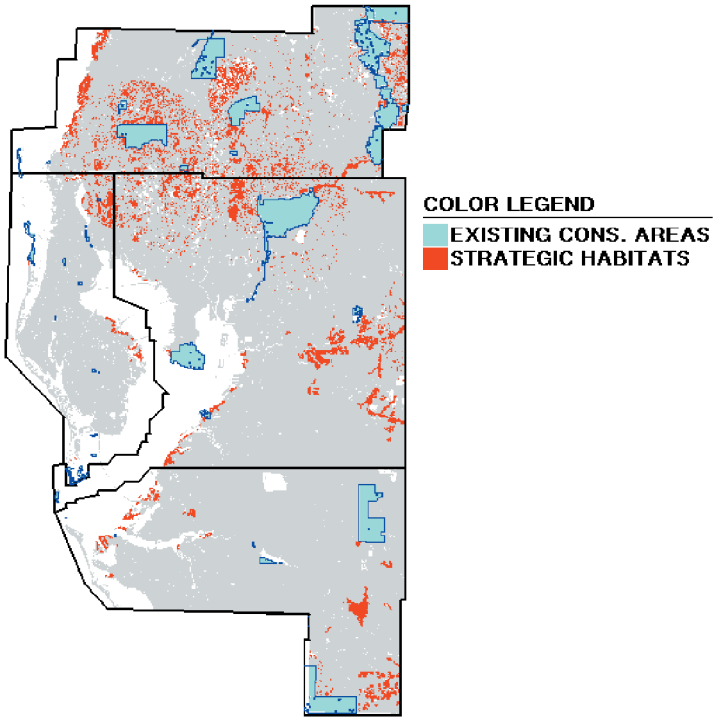


Figure 171b. Strategic Habitat Conservation Areas and existing conservation lands.

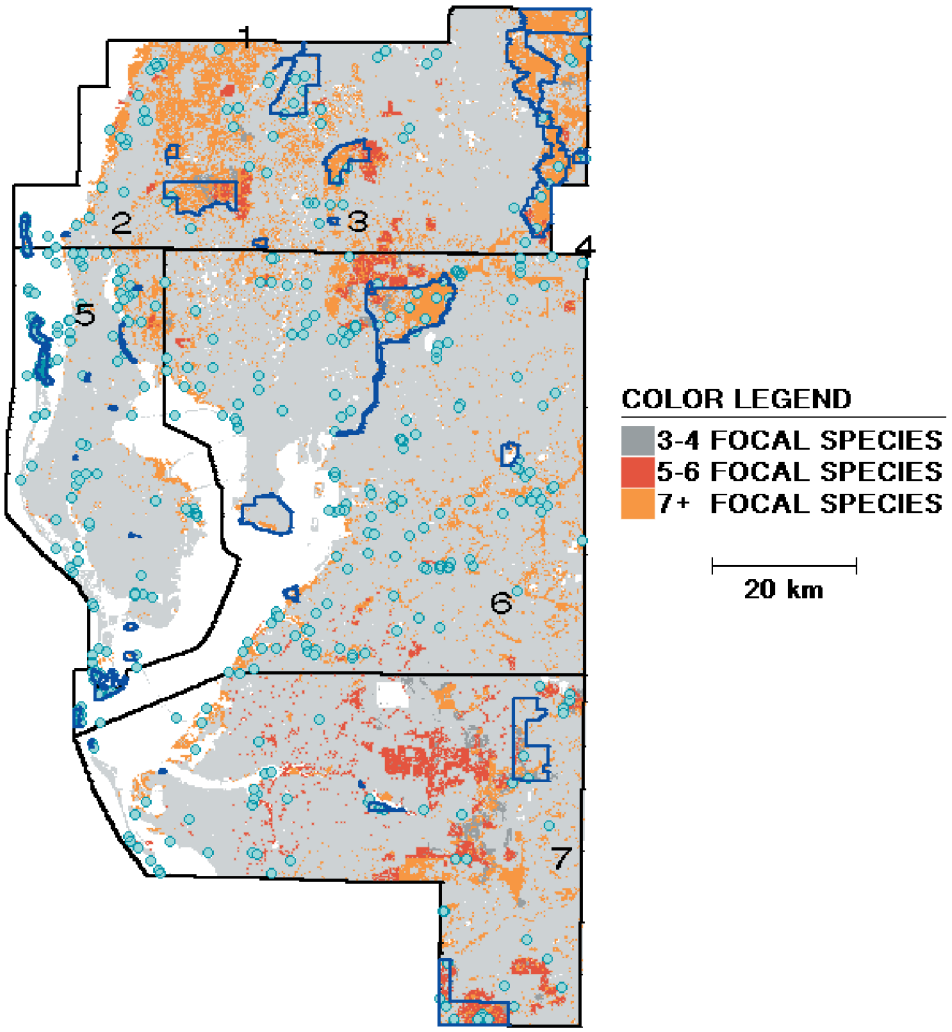


Figure 171c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.8. Tampa Bay Region.

The Tampa Bay Region contains one of Florida's fastest growing human populations, but there are still many areas that contain natural cover and rare species of wildlife (Figures 171a, 171b, and 171c). The proportion of conservation lands in this region is well below the statewide average (5.5% versus 19.6%), and all four counties in the region are well below the statewide average for individual counties. Pasco County comes closest with slightly more than 10% of its total area in some conservation status. Some of the more important features of this region are referenced by number in Figure 171c and discussed in greater detail below.

Area 1. Northwest Pasco County. Sandhill and scrub tracts in the area defined by the county line and State Roads 52, 55, and 45. Species recorded include Florida black bear, fox squirrel, southeastern American kestrel, Florida scrub jay, Cooper's hawk, Florida burrowing owl, southern bald eagle, Florida sandhill crane, limpkin, mottled duck, gopher tortoise, and Leitheuser's cave crayfish.

Area 2. Southwest Pasco County. Pineland, dry prairie, wetlands, and rangeland west of U.S. 41. Portions of the area are within a Strategic Habitat Conservation Area for Florida sandhill crane and several wading birds (great egret, wood stork, tricolored heron). Florida black bear, Cooper's hawk, southeastern American kestrel, limpkin, and American swallow-tailed kite are also known from the area.

Area 3. Central Pasco and north central Hillsborough counties. Pineland, dry prairie, wetlands, and rangeland east of U.S. 41 and extending to Morris Bridge Road. Strategic Habitat Conservation Area for rare wading birds (wood stork, great egret, white ibis, and little blue heron colonies nearby), short-tailed hawk, and Florida sandhill crane. Other records are listed by specific geographic areas. **Big Cypress Swamp:** short-tailed hawk, Cooper's hawk, American swallow-tailed kite, southeastern American kestrel, Tampa vervain, hand fern, and auricled spleenwort. **Cypress Creek, Trout Creek, and Hillsborough River:** fox squirrel, Florida mouse, American swallow-tailed kite, southern bald eagle, limpkin, little blue heron (rookery), mottled duck, short-tailed snake, eastern indigo snake, gopher tortoise, auricled spleenwort, hand fern, and Tampa vervain.

Area 4. East Pasco County (public and private lands north of U.S. 98). Portions of the area constitute a Strategic Habitat Conservation Area for several rare wading birds (wood stork, little blue heron, snowy egret, great egret), American swallow-tailed kite, and Florida sandhill crane. Other species recorded in the area include Florida black bear, Florida burrowing owl, Cooper's hawk, limpkin, and sand butterfly pea.

Area 5. Northeast Pinellas County. Species recorded in the area include Florida mouse, fox squirrel, southern bald eagle, little blue heron (rookery), limpkin, sandhill crane, eastern indigo snake, and Tampa vervain.

Area 6. Southeast Hillsborough County. Scrub, pineland, and prairie areas important to southeastern American kestrel and Florida burrowing owl. Additional species are listed by specific geographic areas. **Areas North of County Road 672** (near Balm): Florida scrub jay, spoonflower, sand butterfly pea, nodding pinweed, Curtiss' milkweed, wild coco, Florida golden aster. **Alafia River Near Lithia:** short-tailed snake and Florida golden aster. **Alafia River Near Keysville:** Florida golden aster, southern bald eagle, white ibis (rookery), great blue heron (rookery), great egret (rookery), black-crowned night-heron (rookery), limpkin, mottled duck, and eastern indigo snake.

Area 7. East Central Manatee County. Portions of the area make up Strategic Habitat Conservation Area for Florida sandhill crane and mottled duck. Other rare species area listed by specific geographic areas. **Peacock Hammock** (south and north of State Road 62): fox squirrel, Florida scrub jay, Florida burrowing owl, Audubon's crested caracara, southern bald eagle, Florida burrowing owl, gopher tortoise, Florida golden aster, and nodding pinweed. **Myakka River** (including Mud Lake Slough, west of Sugar Bowl Road): fox squirrel, Florida burrowing owl, Florida scrub jay, Audubon's crested caracara, southeastern American kestrel, American swallow-tailed kite, red-cockaded woodpecker, great egret (rookery), great blue heron (rookery), Cooper's hawk, and limpkin.

Coastal Areas in Pinellas and Pasco Counties. Caladesi Island, Honeymoon Island, Anclote Key, and Three Rooker Bar are included in the Strategic Habitat Conservation Areas proposed for Cuban snowy plover. Other records are listed by specific geographic areas. **South Pasco County:** great egret (rookery), American oystercatcher, Wilson's plover, shorebird aggregation areas, and sand butterfly pea. **North Pinellas County** (north of Clearwater Beach Island): sandwich tern (rookery), least tern (nesting), tricolored heron (rookery), great egret (rookery), reddish egret (rookery), brown pelican (rookery), snowy egret (rookery), American oystercatcher, Wilson's plover, mangrove cuckoo, shorebird aggregation areas, gopher tortoise, hairy beach sunflower, and necklace pod. **South Pinellas County** (south of Cabbage Key): sandwich tern (nesting), American oystercatcher, Wilson's plover, hairy beach sunflower, Tampa vervain, and Sanibel lovegrass.

Coastal Areas in Hillsborough and Manatee Counties. Portions of the area make up a proposed Strategic Habitat Conservation Area for rare wading birds (primarily near Gibsonton). Other species are listed by specific geographic areas. **Anna Maria Island** (and nearby areas): brown pelican (rookery), southern bald eagle, mangrove cuckoo, Cuban snowy plover, Wilson's plover, loggerhead turtle, hairy beach sunflower, Sanibel lovegrass, and sand butterfly pea. **Southeast Tampa Bay:** manatee congregation area, brown pelican (rookery), mangrove cuckoo, American oystercatcher, Wilson's plover, eastern indigo snake, necklace pod, hairy beach sunflower, and Tampa vervain. **Hillsborough Bay** (from Simmons park to MacDill Air Force Base): manatee congregation areas, American oystercatcher, Wilson's plover, roseate spoonbill (rookery), white ibis (rookery), tricolored heron, snowy egret (rookery), great egret (rookery), little blue heron (rookery), brown pelican (rookery), yellow-crowned night-heron (rookery), mangrove cuckoo, southern bald eagle, and shorebird aggregation areas (islands in Hillsborough Bay). **Old Tampa Bay** (Weedon Island to MacDill Air Force Base): southern bald eagle, American oystercatcher, Wilson's plover, shorebird aggregation areas, and gopher tortoise.

Figure 172 (a-c). Distribution of important resources in the Treasure Coast Region.

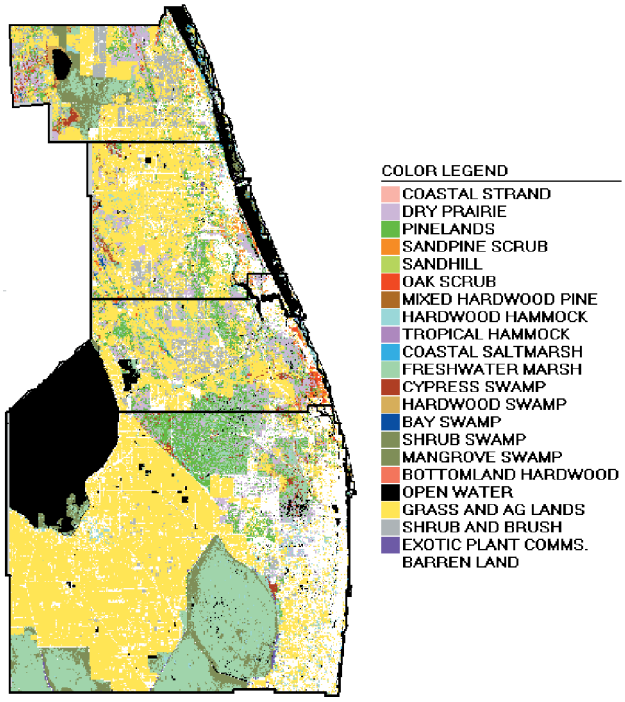


Figure 172a. Landsat land-cover map for the Treasure Coast Region.

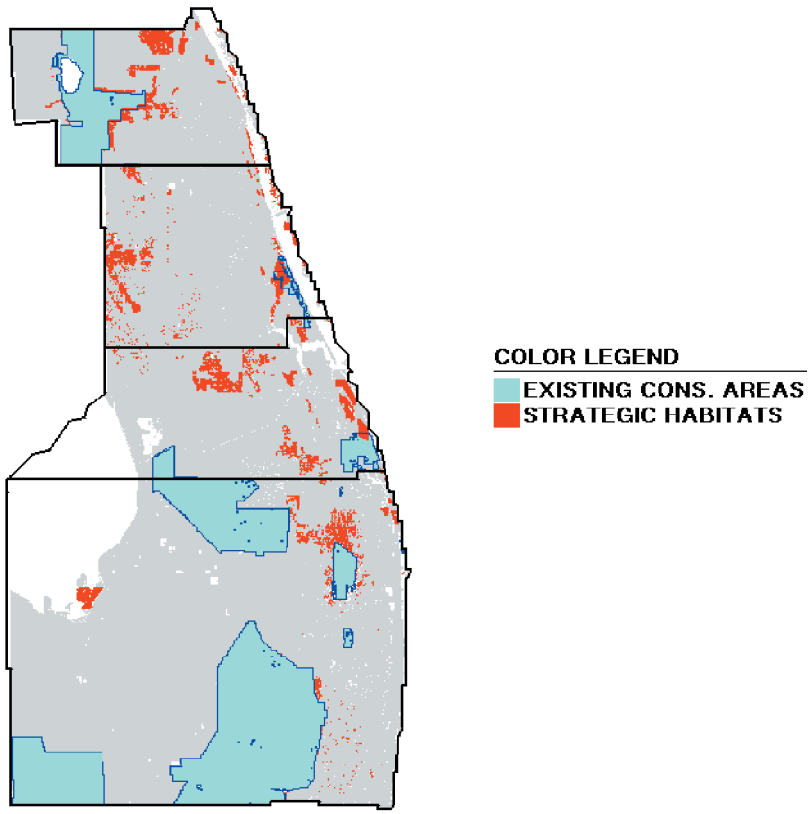


Figure 172b. Strategic Habitat Conservation Areas and existing conservation lands.

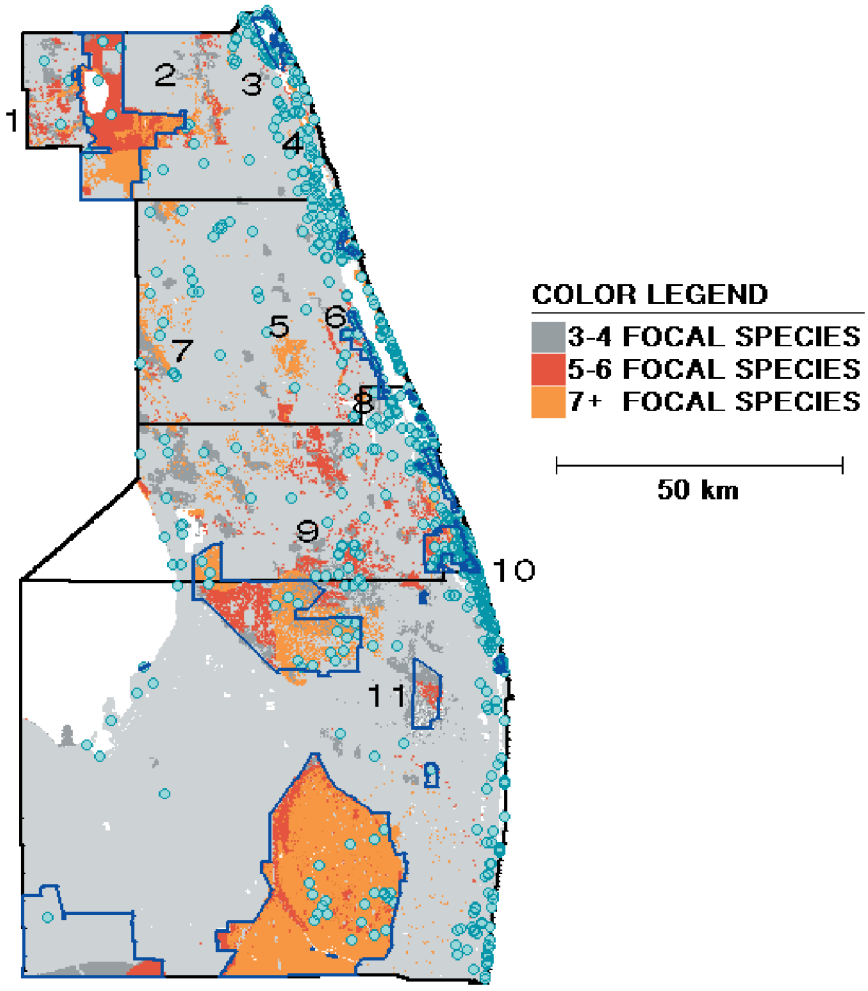


Figure 172c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.9. Treasure Coast Region

Although expanding urban areas and agricultural land conversions have eliminated much of the natural habitat in this region, the regional analyses highlighted several patches of natural land cover outside of current conservation areas (Figures 172a, 172b, and 172c). Most highlighted areas consist of stands of prairie, wet flatwoods, and hardwood and cypress swamp that were once part of the more extensive St. Johns Marsh, Allapattah Flats, Loxahatchee Slough, and their tributaries. There are also several smaller tracts of scrub and natural coastal areas that persist and warrant formal protection. This region falls below the statewide average for the percentage of conservation lands found in the region (18.4% versus 19.6%). Martin and St. Lucie counties are below the statewide average for individual counties. Some of the more important features of this region are referenced by number in Figure 172c and discussed in greater detail below.

Area 1. West of Blue Cypress Lake (around water management district lands and also to southeast). Portions of the area make up a Strategic Habitat Conservation Area for Audubon's crested caracara, snail kite, American swallow-tailed kite, sandhill crane, wood stork, and mottled duck. Other occurrences are listed by major drainages. **Blue Cypress Creek:** wood stork (rookery), American swallow-tailed kite, mottled duck, and limpkin. **Padgett Branch:** wood stork (rookery), American swallow-tailed kite, and limpkin. **St. Johns Marsh** (southeast of district lands): Florida burrowing owl, snail kite, Cooper's hawk, mottled duck, and limpkin.

Area 2. Fellsmere Marshes. Area defined roughly by State Road 60, Interstate 95, north to the county line. Portions of the area make up a Strategic Habitat Conservation Area for snail kite. Additional records include southern bald eagle, Audubon's crested caracara, snail kite, mottled duck, American swallow-tailed kite, Florida sandhill crane, and limpkin.

Area 3. Near Sebastian municipal airport (and South Prong Sebastian River). Known occurrences include southern bald eagle, American swallow-tailed kite, Florida scrub jay, mottled duck, Florida scrub lizard, gopher tortoise, river goby, nodding pinweed, and large-flowered rosemary.

Area 4. Scrub and dry prairie along U.S. 1, Indian River County. Species recorded for the area include Florida scrub jay, eastern indigo snake, Florida pine snake, gopher tortoise, large-flowered rosemary, and Lakela's mint. The area with the highest number of occurrences of known rare species is near Winter Beach.

Area 5. Areas near Carlton. Records of fox squirrel and eastern indigo snake from this area.

Area 6. North and west of Savannas State Preserve. Freshwater marsh, dry prairie, scrub, and scrubby flatwoods (also south and west around County Roads 732 and 723). Portions of this area make up a proposed Strategic Habitat Conservation Area for Florida scrub jay and Florida sandhill crane. Other species recorded for the area include fox squirrel, snowy egret (rookery), mottled duck, snail kite, Florida pine snake, Florida scrub lizard, four-petal pawpaw, large-flowered rosemary, Florida three-awn, Piedmont jointgrass, and fragrant prickly apple.

Area 7. West St. Lucie County. Remnant freshwater marsh, xeric pines, dry prairie, and hardwood swamps north and south of State Road 70. Portions of the area make up a proposed Strategic Habitat Conservation Area for wood stork, white ibis, great blue heron, little blue heron, and snowy egret, which nest in nearby rookeries. Other rare species recorded include Audubon's crested caracara, southeastern kestrel, American swallow-tailed kite, mottled duck, Florida burrowing owl, and limpkin.

Area 8. Remnant patches of scrub and dry prairie in north Martin County (particularly areas south of Savannas State Preserve; see Area 6 above) and north and south of Jonathan Dickinson State Park. Portions of this area make up a proposed Strategic Habitat Conservation Area for Florida scrub jays. Other rare species are listed by more specific geographic areas. **Near Jonathan Dickinson State Park:** Florida scrub jay, Florida sandhill crane, gopher tortoise, Florida scrub lizard, large-flowered rosemary, perforate reindeer lichen, Piedmont jointgrass, sand-dune spurge, Curtiss' milkweed, and nodding pinweed. **Between Interstate 95 and Florida Turnpike:** Great egret, Carter's large-flowered flax, and Florida threeawn.

Area 9. Northeast of J. W. Corbett Wildlife Management Area. Wet flatwoods, prairie, and freshwater marsh important to several rare species. Records for this area include great egret (rookery), mottled duck, limpkin, and Florida threeawn.

Area 10. Northeast Palm Beach County. Remnant scrub patches (see Fernald 1989). Records for the area include Florida mouse, Florida scrub jay, gopher tortoise, scrub bay, large-flowered rosemary, and four-petal pawpaw.

Area 11. Southeast and east of J. W. Corbett Wildlife Management Area (including Loxahatchee Slough). Portions of this area make up a Strategic Habitat Conservation Area for limpkins and short-tailed hawk. Other records for the area include great egret (rookery), American swallow-tailed kite, snail kite, mottled duck, gopher tortoise, indigo snake, and Florida three-awn.

Coastal Areas in Palm Beach County. Most records occur in the northern third of the county. Records are listed by specific geographic areas. **South of Lake Worth Pier:** least tern (nesting), black-whiskered vireo, loggerhead turtle (nesting), sea lavender, burrowing four-o'clock, and beach jacquemontia. **MacArthur State Recreation Area:** leatherback turtle, hand fern, Johnson's seagrass, sea lavender, and burrowing four-o'clock. **North of Lake Worth Beach Pier** (including Jupiter ridge scrub): manatee congregation areas, Florida scrub jay, least tern, black-whiskered vireo, shorebird aggregation areas, hawksbill turtle, loggerhead turtle, gopher tortoise, beach jacquemontia, necklace pod, burrowing four-o'clock, dancing lady orchid, coastal vervain, spottail goby, and four-petal pawpaw.

Coastal Areas in Martin County. Rare species are listed by specific geographic areas. **County Line to St. Lucie Inlet** (Hobe Sound National Wildlife Refuge, in part): black-whiskered vireo, Wilson's plover, shorebird aggregation area (west of Sailfish Point and St. Lucie Inlet State Park), leatherback turtle, green turtle, necklace pod, Johnson's seagrass, beach-star, and sea lavender. **St. Lucie River** (including North and South forks): least tern (nesting), black skimmer (nesting), southern bald eagle, and shorebird aggregation area. **St. Lucie Inlet to Jensen Beach Park:** snowy egret (rookery), Wilson's plover, gopher tortoise, beach star, necklace pod, and sea lavender.

Coastal Areas in St. Lucie County. Most records occur south of Middle Point (near Douglas Memorial Park). Occurrences are listed by specific geographic areas. **County Line to Ft. Pierce Inlet** (Herman's Bay Beach Access): least tern (nesting), black skimmer (nesting), black-whiskered vireo, shorebird aggregation area (near Middle Point and south of Ft. Pierce), leatherback turtle, striped croaker, coastal vervain, coastal hoary pea, sea lavender, burrowing four-o'clock, Johnson's seagrass, beach star, necklace pod, and sea lavender. **Ft. Pierce Inlet to County Line:** southeastern beach mouse, brown pelican (rookery), peregrine falcon (migratory), osprey, black-whiskered vireo, shorebird aggregation area (Ft. Pierce Inlet Recreation Area), eastern indigo snake, Florida scrub lizard, necklace pod, sand-dune spurge, and Johnson's seagrass.

Coastal Areas in Indian River County. Portions make up a Strategic Habitat Conservation Area for rare wading birds and southeastern beach mouse (beginning at approximately Wabasso Beach). Other rare species are listed by specific geographic areas. **South County Line to Vero Beach:** manatee congregation area, southeastern beach mouse (potential habitat), reddish egret (rookery), snowy egret (rookery), shorebird aggregation area (South Beach Park), and mangrove rivulus. **South Wabasso Beach to North County Line:** southeastern beach mouse, great egret (rookery), white ibis (rookery), tricolored heron (rookery), black-crowned night-heron (rookery), snowy egret (rookery), least tern (nesting), black skimmer (nesting), brown pelican (rookery), osprey, shorebird aggregation area (Wabasso Beach and south side of Sebastian Inlet), eastern indigo snake, leatherback turtle (proposed Archie Carr National Wildlife Refuge), Florida scrub lizard, rivulus, coastal vervain, coastal hoary pea, prickly apple, large-flowered rosemary, and nodding pinweed.

Figure 173 (a-c). Distribution of important resources in the West Florida Region.

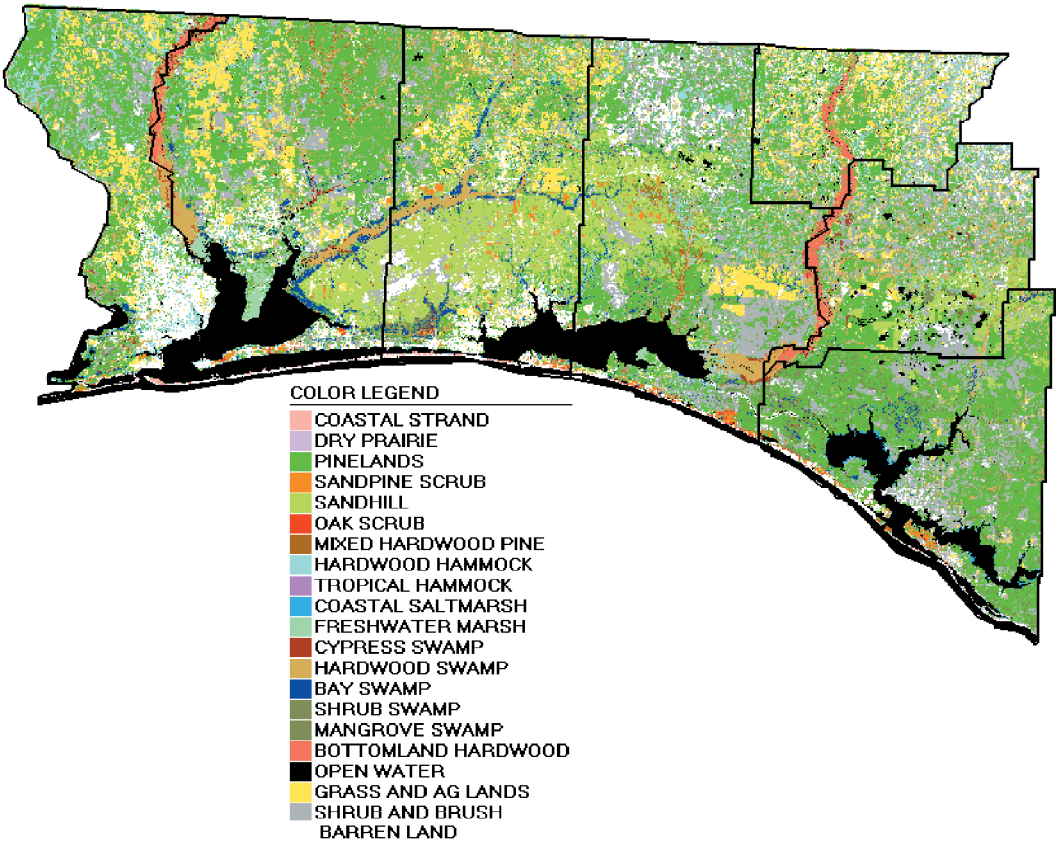


Figure 173a. Landsat land-cover map for the West Florida Region.

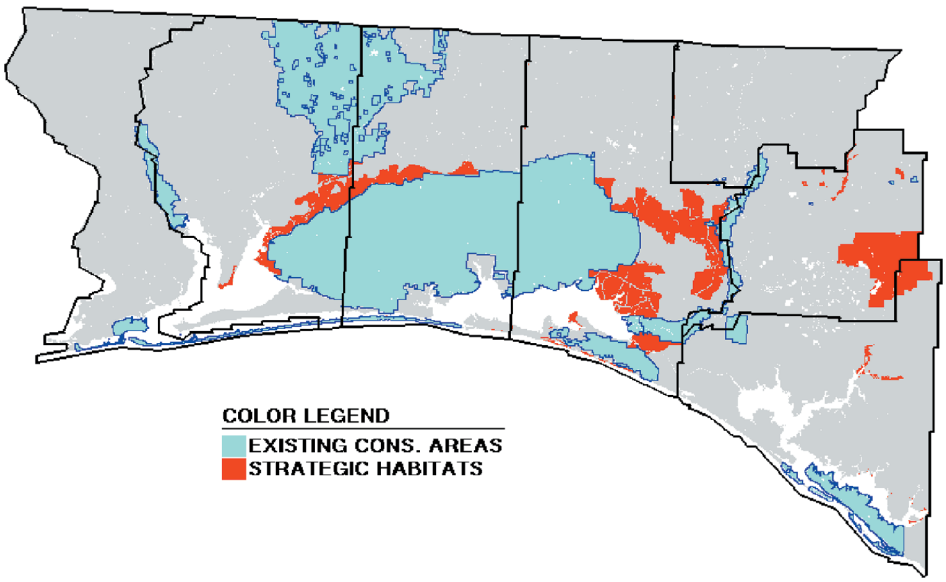


Figure 173b. Strategic Habitat Conservation Areas and existing conservation lands.

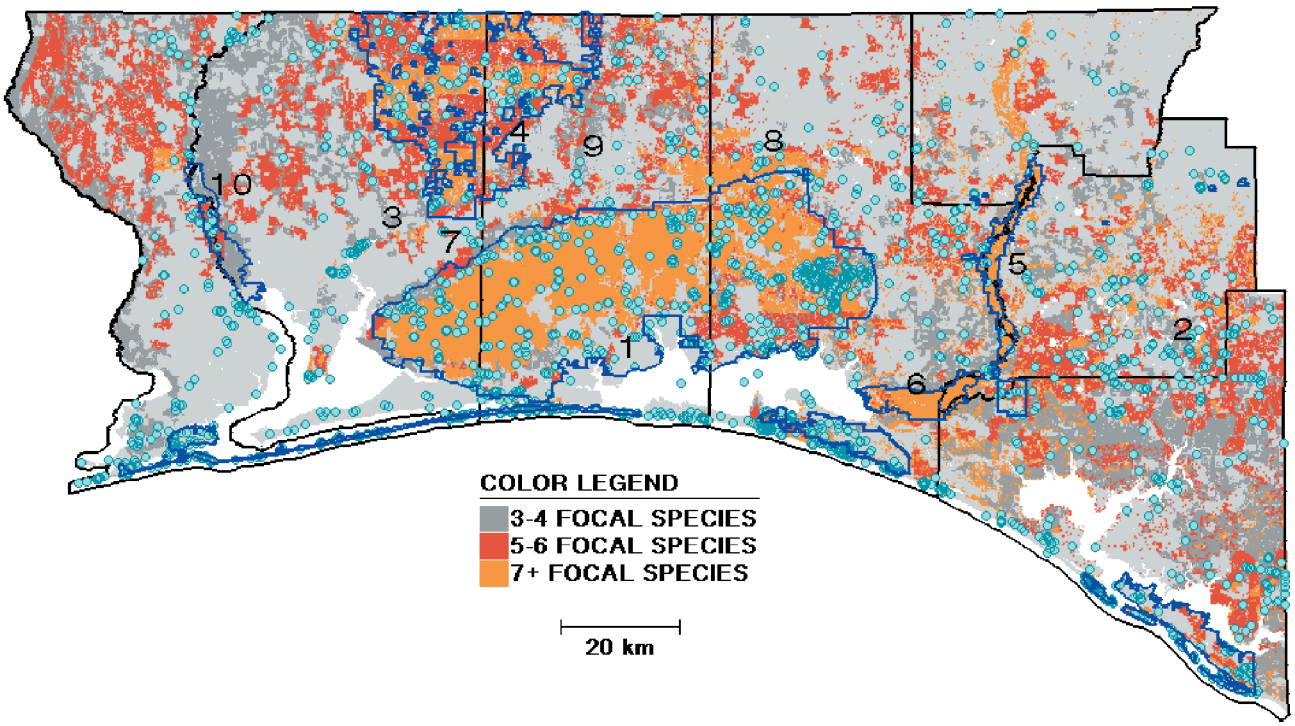


Figure 173c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.10. West Florida Region

The total percentage of conservation lands in the West Florida Region (Figures 173a, 173b, and 173c) is slightly greater than the statewide average. However, Bay, Washington, Holmes, and Escambia counties are well below the statewide average for individual counties (15.6%). Residential and urban development of fragile coastal areas threatens many of the important biological resources remaining in this region. Many important coastal areas of the West Florida Region are found in conservation areas. The protection offered by these different classes of public lands varies, and more definitive management agreements need to be devised based on a broader regional perspective. Residential and urban development do not pose as significant a threat to other inland areas, but forestry and agricultural operations pose a threat to some of the remaining natural areas described below. Some of the more important features of this region are referenced by number in Figure 173c and discussed in greater detail below.

Area 1. Eglin Air Force Base (formerly Choctawhatchee National Forest). Although this area is the largest publicly owned tract of sandhill land cover in Florida, it is not in the geographic range of several vertebrate species dependent on sandhill communities (see Gap Analysis, Section 6.3.4). Important vertebrate species recorded here include Florida black bear, fox squirrel, red-cockaded woodpecker, southeastern American kestrel, eastern indigo snake, Florida pine snake, gopher tortoise, American alligator, Florida bog frog, gopher frog, pine barrens treefrog, one-toed amphiuma, four-toed salamander, Atlantic sturgeon, river goby, and Okaloosa darter. Rare plants include white-top pitcher-plant, sweet pitcher-plant, West's flax, Chapman's butterwort, Curtiss' sandgrass, panhandle lily, spoon-leaved sundew, Drummond's yellow-eyed grass, west Florida cowlily, pineland hoary-pea, hairy wild indigo, gulf coast lupine, orange azalea, Baltzell's sedge, silky camellia, Ashe's magnolia, panhandle meadowbeauty, karst pond xyris, southern three-awned grass, Coville's rush, spoon-flower, Arkansas oak, pondspice, pyramid magnolia, mountain laurel, hairy-peduncled beak-rush, toothed savory, large-leaved jointweed, bog-button, naked-stemmed panic grass, heartleaf, Harper's yellow-eyed grass, violet-flowered butterwort, smooth-barked St. John's-wort, and Florida anise. This conservation area has the capacity to sustain viable populations of most of these species (but see discussion of Florida black bear), but management activities need to be improved. Hardwood encroachment has occurred in many areas and affected populations of rare species (Green 1993). Annual acreage targets for burning schedules should be approximately 50,000 acres per year (Green 1993).

Area 2. Patches of sandhill in Washington, Jackson, and Bay counties. Portions of this area include a Strategic Habitat Conservation Area for sandhill communities in Florida. Rare species are listed by more precise geographic areas. **Sweetwater, Buckhorn, and Econfina Creeks:** gopher tortoise, limpkin, southeastern American kestrel, American swallow-tailed kite, hairy woodpecker, pyramid magnolia, mountain laurel, smooth-barked St. John's-wort, toothed savory. **Porter, Gap, and Deadening Lakes** (east of State Road 77, north of State Road 20): gopher tortoise, eastern

indigo snake, Florida pine snake, gopher frog, toothed savory, white-topped pitcher plant, Harper's yellow-eyed grass, panhandle meadowbeauty, smooth-barked St. John's-wort, and Gulf coast lupine. **Hicks, Lucas, and Big Blue Lakes** (west of State Road 77, east of State Road 79, north of State Road 20): eastern indigo snake (several records), gopher tortoise (several records), smooth-barked St. John's-wort, panhandle meadowbeauty, silky camellia, karst pond xyris, Piedmont water-milfoil, pyramid magnolia, heartleaf, and mountain laurel. **Court Martial and White Western Lakes** (east of State Road 79 and south of State Road 20): Cooper's hawk, hairy woodpecker, gopher tortoise, eastern indigo snake, white-topped pitcher plant, smooth-barked St. John's-wort, Cruise's golden aster, gulf coast lupine, panhandle meadowbeauty, and karst pond xyris.

Area 3. Patches of sandhill and xeric pinelands west and southwest of Blackwater River State Forest (east and west of U.S. 191). Rare species are listed by precise geographic regions. **South of Springhill** (surrounding East Fork and Big Coldwater creeks): fox squirrel, southeastern American kestrel, hairy woodpecker, Cooper's hawk, gopher tortoise, hairy-peduncled beak-rush, and panhandle lily. **South of Berrydale** (surrounding East Fork and Manning creeks): southeastern American kestrel, gopher tortoise, flatwoods salamander, hairy-peduncled beak rush, and serviceberry holly.

Area 4. Blackwater River State Forest. Important conservation area that supports several rare species. Species recorded for the area include eastern chipmunk, red-cockaded woodpecker, gopher tortoise, Florida pine snake, eastern indigo snake, tiger salamander, pine barrens treefrog, black-tip shiner, panhandle lily, white-top pitcher-plant, orange azalea, spoon-leaved sundew, hummingbird flower, yellow fringeless orchid, southern red lily, sweet pitcher-plant, Say's spike-tail dragonfly, Harper's yellow-eyed grass, bog-button, Chapman's butterwort, yellow-eyed grass, and meadowbeauty.

Area 5. Upper Choctawhatchee River and Holmes Creek. Wetland areas associated with these rivers, and the isolated wetlands that lie between these rivers, are important foraging areas for nearby wading bird rookeries consisting of great egret, snowy egret, little blue heron, and white ibis. Other species are reported by major drainages. **Choctawhatchee River** (north of Caryville): eastern chipmunk, short-tailed hawk, Cooper's hawk, black-tip shiner, cypress darter, Florida logperch, Florida chub, Clench's elimia, and wild indigo. **Holmes Creek North** (Interstate 10 south to Vernon): bluenose shiner, dusky shiner, Clench's elimia, Washington thorn, and variable-leaved Indian-plantain. **Holmes Creek and Choctawhatchee River South** (confluence south of Vernon and Barker Store): American swallow-tailed kite, limpkin, goldstripe darter, Florida logperch, orange azalea, yellow cowlily, variable-leaved Indian-plantain, and Ashe's magnolia. **Lands Between Choctawhatchee River and Holmes Creek** (Washington County): white ibis (rookery), great egret (rookery), anhinga (rookery), flatwoods salamander, and serviceberry holly. **Wright's and Tenmile Creeks:** black-tip shiner, fuzzy pigtoe, variable-leaved Indian-plantain, and southern sandshell.

Area 6. Lower Choctawhatchee River. Portions of the area are included in a Strategic Habitat Conservation Area for Florida black bear. Other species are listed by precise geographic areas. **South of State Road 20** (including Black Creek and nearby Pine Log State Forest): round-tailed muskrat, little blue heron (rookery), white ibis (rookery), American swallow-tailed kite, hairy woodpecker, gopher tortoise, coal skink, flatwoods salamander, one-toed amphiuma, Florida logperch, white-topped pitcher-plant, Apalachicola dragon-head, Curtiss' sandgrass, and Chapman's crownbeard. **North of State Road 20:** Cooper's hawk, hairy woodpecker, Florida logperch, orange azalea, variable-leaved Indian-plantain, fluted elephant-ear, smooth-barked St. John's-wort, and southern sandshell.

Area 7. Weaver, Garnier, Julian Mill, and Burnt Grocery creeks. Strategic Habitat Conservation Area for the Florida bog frog and Florida black bear. Other rare species recorded along these creeks include American swallow-tailed kite, Florida pine snake, flatwoods salamander, black-mouth shiner, panhandle lily, hairy wild indigo, and sweet pitcher-plant.

Area 8. Large area of sandhill land cover northeast of Eglin Air Force Base (north of I-10, east of Dorcas). Rare species recorded for this area include southeastern American kestrel, gopher tortoise, pine barrens treefrog, eastern indigo snake, Florida pine snake, Florida panhandle lily, and yellow fringeless orchid.

Area 9. Yellow River, east of Blackwater River State Forest (north and south of State Road 2). Rare species recorded in this area include eastern chipmunk, gopher tortoise, pine barrens treefrog, panhandle lily, and Coville's rush.

Area 10. Floodplain forests of the Escambia River and its tributaries. Rare species are listed by specific geographic areas. **North Escambia River and Escambia Creek** (north of Chumuckla Springs): eastern chipmunk, American swallow-tailed kite, Alabama map turtle, Gulf coast smooth softshell, alligator gar, cypress darter, Florida chub, black-tip shiner, cypress minnow, crystal darter, saddle-back darter, orange azalea, heartleaf, southern pocketbook, flat floater, and narrow pigtoe. **Canoe Creek:** American swallow-tailed kite, copperhead, seal salamander, rough shiner, bluenose shiner, striped shiner, harlequin darter, and saddle-back darter. **South Escambia River** (south of Chumuckla Springs): American swallow-tailed kite, Cooper's hawk, indigo snake, river redhorse, starhead topminnow, cypress darter, cypress minnow, Florida chub, Florida logperch, panhandle lily, mountain laurel, Florida anise, and narrow pigtoe.

Coastal Areas of Escambia County. Important resources are listed by precise geographic areas. **Perdido Key State Preserve and Private Lands to West:** least tern (nesting), Godfrey's golden aster; patches of scrub and coastal strand on private lands west of Perdido Key State Recreation Area support Godfrey's golden aster and are important to migratory birds. **Big Lagoon State Recreation Area:** Cruise's golden aster, black skimmer (nesting), Godfrey's golden aster, and salt marsh topminnow. **Pensacola Naval Air Station:** Wilson's plover, spoon-flower sundew, white-topped pitcher plant, Godfrey's golden aster, large-leaved jointweed, Gulf rockrose, and Carolina lilaeopsis. **Gulf Island National Seashore** (Perdido Key portion): least tern

(nesting), Wilson's plover, Cuban snowy plover, Godfrey's golden aster, and Gulf rockrose; coastal scrub and grasslands important to migratory birds. **Ft. Pickens State Park** (Santa Rosa Island): Santa Rosa Island beach mouse, Cuban snowy plover, piping plover, gopher tortoise; coastal grasslands, scrub, and mesic and scrubby flatwoods of value to coastal migrants; least tern (nesting) at Pensacola Beach. **Gulf Island National Seashore** (Pensacola Beach to Navarre Beach): Santa Rosa Island beach mouse, American oystercatcher (rare in western panhandle), Cuban snowy plover, piping plover, least tern (nesting), black skimmer (nesting; east of Langdon Beach), shorebird aggregation areas, Cruise's golden aster, and Godfrey's golden aster; coastal grasslands and maritime hammocks important to migratory birds.

Coastal Areas of Walton and Santa Rosa Counties. Important resources are listed by more specific geographic areas. **Santa Rosa Island National Seashore and Eglin Air Force Base** (Navarre Beach to Destin): Santa Rosa beach mouse, Cuban snowy plover, piping plover, least tern (nesting colonies), black skimmer (Ocean City), shorebird aggregation areas, green turtle, Cruise's golden aster, Godfrey's golden aster, perforate reindeer lichen, Gulf rockrose; coastal grasslands, scrub, and mesic flatwoods important to migratory. **Moreno Point:** indigo snake, Curtiss' sandgrass, large-leaved jointweed, and Gulf coast lupine. **Henderson Beach State Recreation Area:** gopher tortoise, large-leaved jointweed, Gulf coast lupine; coastal grasslands important to migratory birds. **Four Prong Lake** (and private lands to east): panhandle meadowbeauty and Curtiss' sandgrass. **Topsail Hill** (mix of private and recently acquired public lands): Choctawhatchee beach mouse, Cuban snowy plover, piping plover, red-cockaded woodpecker, gopher tortoise, Curtiss' sandgrass, spoon-leaved sundew, Gulf coast lupine; coastal strand, grasslands, and mesic flatwoods important to migratory birds. **Four Mile Point** (private lands): gopher tortoise, red-cockaded woodpecker, southern red lily. **Point Washington** (mix of private and public lands, includes Blue Mountain Beach): round-tailed muskrat, red-cockaded woodpecker, Strategic Habitat Conservation Area for western seaside sparrows (also at Fluffy Landing across Choctawhatchee Bay), gopher tortoise, southern red lily, Gulf coast lupine, large-leaved jointweed, Curtiss' sandgrass, panhandle spider lily; coastal scrub and scrubby pinelands important to migratory birds. **Grayton Beach State Recreation Area:** Strategic Habitat Conservation Area for Choctawhatchee beach mouse (includes private lands), least tern, gopher tortoise, large-leaved jointweed, Godfrey's golden aster, Cruise's golden aster, Gulf coast lupine; coastal scrub, maritime hammock, and beach dune habitats important to migratory birds. **Seagrove Beach:** private tract of coastal strand and scrub to the east constitutes critical habitat for the Choctawhatchee beach mouse. **Deer Lake** (private lands): least tern (nesting), Cuban snowy plover, piping plover, shorebird aggregation area, large-leaved jointweed, Godfrey's golden aster, Gulf coast lupine; coastal scrub habitat. **Inlet Beach** (private lands): piping plover, black skimmer, Gulf coast lupine, southern red lily; coastal grassland, scrub, and maritime hammock important to migratory birds.

Coastal Areas of Bay County. Important resources are listed by more precise geographic areas. **Powell Lake:** Strategic Habitat Conservation Area for Cuban snowy plover; other species include Godfrey's golden aster, Gulf coast lupine, and large-leaved jointweed. **Panama City Beach** (private lands north of U.S. Highway 98): historic record for red-cockaded woodpecker, Chapman's crownbeard, and southern red lily. **St. Andrews Bay:** black skimmer, Strategic Habitat Conservation Areas for western seaside sparrows (coastal marshes along Easy Bay); other species include Wilson's plover (West Bay Point, North Bay, and Goose Point), southern bald eagle, and shorebird aggregation areas. **Tyndall Air Force Base/St. Andrews State Recreation Area:** Strategic Habitat Conservation Area for St. Andrews beach mouse; piping plover, Cuban snowy plover, Wilson's plover, black skimmer, least tern, least bittern, sandwich tern, Wilson's plover, loggerhead turtle, southern red lily, Harper's yellow-eyed grass, Drummond's yellow-eyed grass, Gulf coast lupine, Godfrey's golden aster, Gulf rockrose, Chapman's butterwort, Chapman's crownbeard, giant water-dropwort, and southern milkweed; coastal habitats also important to migratory birds.

Figure 174 (a-c). Distribution of important resources in the Withlacoochee Region.

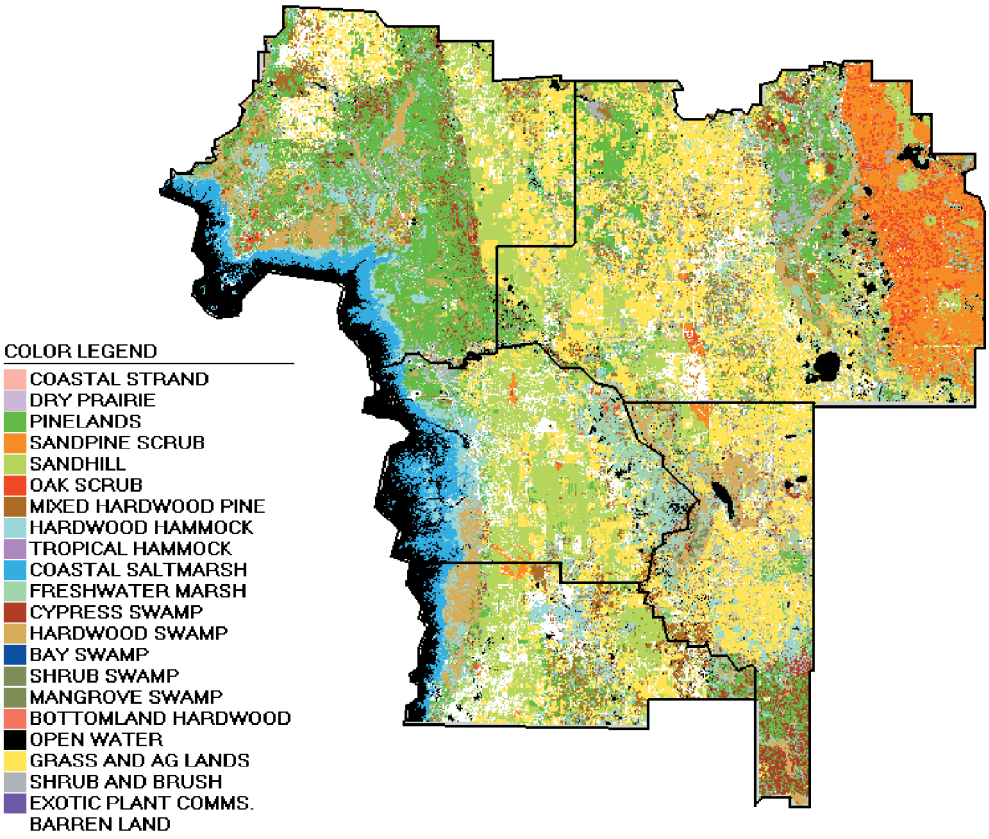


Figure 174a. Landsat land-cover map for the Withlacoochee Region.

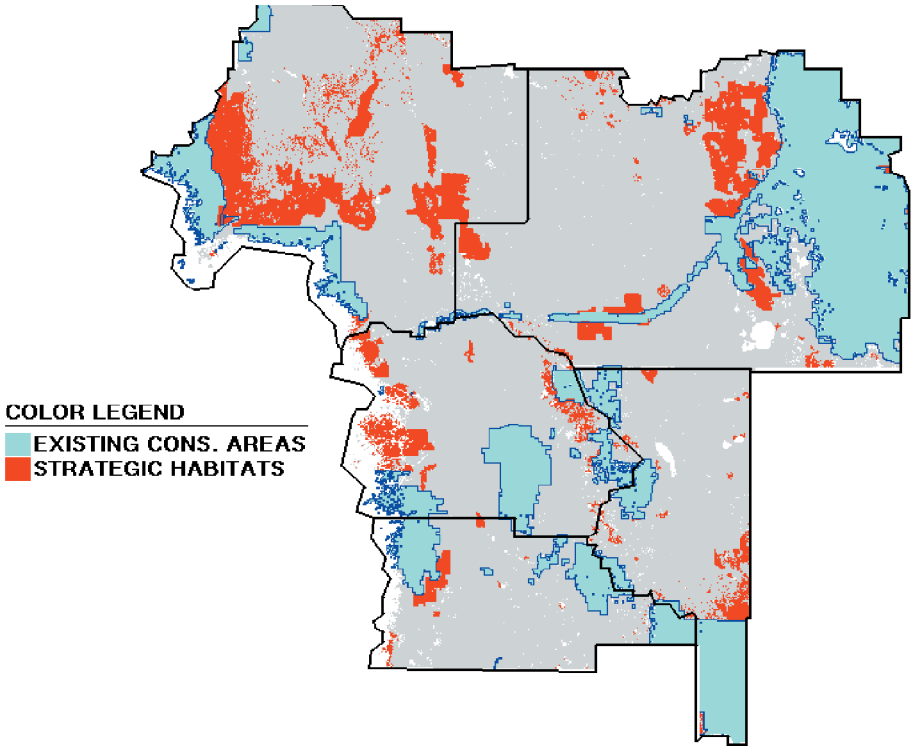


Figure 174b. Strategic Habitat Conservation Areas and existing conservation lands.

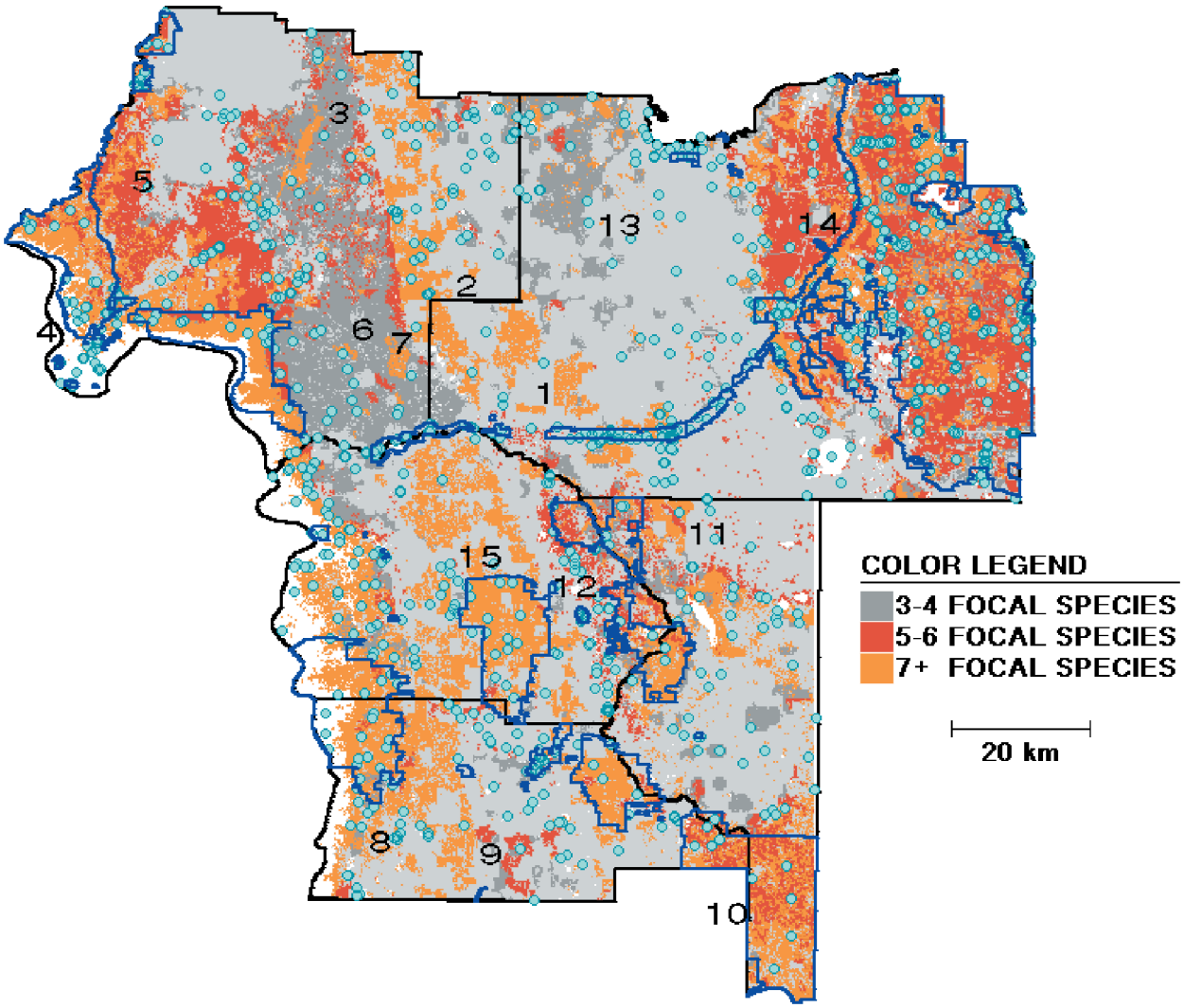


Figure 174c. Hot spots of biological resources and rare species occurrence records.

Section 8.1.11. Withlacoochee Region

Some of Florida's best remaining examples of natural sandhill and scrub are found in the Withlacoochee region (Figures 174a, 174b, and 174c). Throughout Levy, Citrus, Hernando, Marion, and Sumter counties, sizeable tracts of these dwindling natural communities still exist, and many are high in quality. However, most such areas are being developed or else have undergone the permitting process required for large-scale developments, and logging has removed the trees from some of these areas. The prospects for adequately protecting the remaining patches of these rare community types dwindle each day. The proportion of land in the Withlacoochee region in some type of conservation status (22.1%) is slightly higher than the statewide average (19.6%). However, Levy County, with only 11.8% of its total acreage in some type of conservation area, is well below the statewide average of 15.2% for Florida counties. The remaining counties in the region are above the statewide average. Some of the more important features of this region are referenced by number in Figure 174c and discussed in greater detail below.

Area 1. Southwest Marion County. Large tracts of sandhill land cover that are threatened by expanding urban development. Many of the important areas described below have received permits for large-scale development projects, but smaller preservation areas may be feasible and are very important to species such as Florida scrub jay, southeastern kestrel, and southeastern bat. Species occurrences are listed by more specific geographic areas. **Near Barge Canal Lands** (Marion Oaks, near County Roads 484 and 200): Strategic Habitat Conservation Area for Florida scrub jay and southeastern American kestrel; other species include fox squirrel, Florida sandhill crane, Bachman's sparrow, short-tailed snake, gopher tortoise, gopher frog, Florida scrub lizard, scrub bay, and longspurred mint. **Westwood Acres** (area defined by County Road 328 and State Roads 40 and 54): fox squirrel, southeastern kestrel, Florida pine snake, gopher tortoise, and gopher frog. **Rolling Hills:** fox squirrel, southeastern American kestrel, Florida pine snake, gopher tortoise, and gopher frog. **Rainbow Lake Estates:** fox squirrel, Cooper's hawk, southeastern American kestrel, gopher tortoise, and gopher frog.

Area 2. Levy County sandhills. Large sandhill tracts stretching from Romeo (Marion County) to Fanning Springs. Occurrences of rare species are listed by more specific geographic areas. **South of Williston Highlands** (from County Road 316 south, east, and west of County Road 121; including Lake Stafford): fox squirrel, Bachman's sparrow, Cooper's hawk, southeastern American kestrel, Florida burrowing owl, red-cockaded woodpecker, Florida sandhill crane, Florida burrowing owl, Florida pine snake, eastern indigo snake, gopher tortoise, and gopher frog. **Williston Heights to Alternate 27** (west of County Road 121): fox squirrel, southeastern American kestrel, Florida burrowing owl, gopher tortoise, and Florida pine snake. **Bronson and Surroundings** (north of Alternate 27 to county line): fox squirrel, southeastern American kestrel, Florida sandhill crane, Florida scrub jay, Florida burrowing owl, eastern indigo snake, Florida pine snake, and gopher tortoise.

Area 3. Wetlands in northeast Levy County (Waccasassa River, Station Pond, etc). Strategic Habitat Conservation Area for wood stork, other rare wading birds (little blue heron and snowy egret), and Florida sandhill crane. Mottled duck also recorded in this area.

Area 4. Tracts of oak scrub and xeric upland hardwood forest near Cedar Key State Preserve. Portions of the area make up a Strategic Habitat Conservation Area for the Florida scrub jay. Other rare species recorded in unprotected areas include gopher tortoise and eastern indigo snake.

Area 5. West Levy County. Areas of hardwood swamp, pinelands, and upland hardwood forest along the Suwannee River (unprotected areas are east of County Road 347). Portions of this area are included in a Strategic Habitat Conservation Area designed for the American swallow-tailed kite. Other species recorded on unprotected lands in this area include little blue heron (rookery), limpkin, Florida pine snake, and gopher tortoise.

Area 6. East Levy County. Pinelands, upland hardwood forest, cypress swamp, and hardwood swamp surrounding Gulf Hammock, Devil's Hammock, Otter Creek, and Waccasassa River. Portions of this area are part of the Strategic Habitat Conservation Area proposed for the American swallow-tailed kite and red-cockaded woodpecker. Additional rare species occur in the following geographic areas. **Gulf Hammock:** southeastern weasel, Gulf salt marsh mink, southern bald eagle, little blue heron (rookery), great egret (rookery), eastern indigo snake, one-toed amphiuma, Gulf hammock dwarf siren, Texas anemone, pine-wood dainties, pinkroot, Florida water-parsnip, cedar elm, corkwood, and slender-leaved dragonhead. **West of Otter Creek** (Rocky Hammock, south State Road 24): fox squirrel, southeastern weasel, Cooper's hawk, gopher tortoise, eastern indigo snake, Florida pine snake, one-toed amphiuma, slender-leaved dragonhead. **East of Otter Creek**: Florida black bear, wood stork (rookery), little blue heron (rookery), eastern indigo snake, and gopher tortoise.

Area 7. North of Lebanon. Old-growth pine forests that support fox squirrel, red-cockaded woodpecker, eastern indigo snake, gopher tortoise, and pine-wood dainties.

Area 8. South and east of Chassahowitzka National Wildlife Refuge (east of U.S. 98). High quality tracts of sandhill, upland hardwood forest, and hardwood swamp land cover. Species recorded in the area include black bear, fox squirrel, Cooper's hawk, short-tailed hawk, southeastern American kestrel, southern bald eagle, American swallow-tailed kite, limpkin, hairy woodpecker, Florida scrub jay, Florida sandhill crane, white ibis (rookery), great egret (rookery), gopher tortoise, one-toed amphiuma, Hobbs' cave amphipod, Leitheuser's cave crayfish, McLane's cave crayfish, sand butterfly pea, and pine pinweed.

Area 9. Central Hernando County. Mixture of sandhill, mixed pine-hardwood, upland hardwood hammock, pineland, and forested and herbaceous wetland types. Occurrences are listed by specific geographic areas. **South of Cortez Boulevard** (west of U.S. 41): fox squirrel, Florida sandhill crane, Florida burrowing owl, southeastern American kestrel, limpkin, mottled duck, gopher tortoise, Leitheuser's cave crayfish, and pine pinweed. **North of Cortez Boulevard** (around Bailey Hill and County Road 491): fox squirrel, gopher tortoise, Florida sandhill crane, mottled duck, limpkin, white ibis (rookery), snowy egret (rookery), Florida burrowing owl, and southeastern American kestrel.

Area 10. Southeast Hernando and south Sumter counties. Forested wetlands and mesic pinelands (south of State Road 50) associated with Green Swamp and the Withlacoochee River. Strategic Habitat Conservation Areas for limpkin and several species of wading birds (breeding colonies contain white ibis, wood stork, little blue heron, great egret, and snowy egret) and Florida sandhill crane. Other species recorded for the area include Florida black bear, fox squirrel, Florida long-tailed weasel, American swallow-tailed kite, bald eagle, southeastern American kestrel, southern bald eagle, mottled duck, gopher tortoise, and terrestrial peperomia.

Area 11. North Sumter County. Diverse mixture of sand pine scrub, oak scrub, sandhill, freshwater marsh, and forested wetlands in close proximity. Portions of the area constitute a Strategic Habitat Conservation Area for Florida scrub jay and rare species of wading birds (little blue heron, white ibis, snowy egret, and great egret). Occurrences of rare species are listed by specific geographic areas. **North of State Road 44** (east of Carlton Halfmoon Ranch): Florida scrub jay, southeastern American kestrel, and gopher tortoise. **Lake Panasoffkee** (south of State Road 44): southern bald eagle, Florida scrub jay, limpkin, and little blue heron (rookery). **Wildwood** (and nearby areas): little blue heron (rookeries), snowy egret (rookeries), tricolored heron (rookery), limpkin, and southeastern American kestrel.

Area 12. Lake Tsala Apopka (Citrus County). Strategic Habitat Conservation Area for limpkin and several rare wading birds (white ibis, wood stork, tricolored heron, little blue heron, snowy egret, and great egret) associated with nearby breeding colonies. Important patches of unprotected habitat occur south of State Road 48 (near Bayhill and extending south to Pineola), east of Floral City, and northwest of Carlson. Other rare species recorded in the area include southern bald eagle, American swallow-tailed kite, Florida sandhill crane, limpkin, gopher tortoise, nodding caps, creeping-leaf stalkgrass, brittle maidenhair fern, and dwarf spleenwort.

Area 13. Broad area containing a mixture of rangeland and small forest tracts in north and west Marion County (gen-

erally north of U.S. 27). Rare species recorded in the area include fox squirrel, southeastern American kestrel, Florida sandhill crane, Florida burrowing owl, Florida scrub jay, Florida pine snake, Florida mountain-mint.

Area 14. West of Ocala National Forest. Broad area of pineland, upland hardwood forest, cypress swamp, hardwood swamp, and rangeland. Strategic Habitat Conservation Area for Florida black bear. Other rare species are listed by specific geographic areas. **North of Ft. McCoy** (north of County Road 316, east of County Roads 318 and 200A, including Blacksink Prairie): Florida scrub jay, Florida sandhill crane, southeastern American kestrel, limpkin, American swallow-tailed kite, white ibis (rookery), little blue heron (rookery), eastern indigo snake, gopher tortoise, gopher frog, and Ashe's savory. **South of Ft. McCoy** (east of County Road 200A, north of State Road 40, including Indian Lake and Grassy prairies): southeastern weasel, fox squirrel, hoary bat, American swallow-tailed kite, southeastern American kestrel, Florida sandhill crane, limpkin, least bittern, little blue heron (rookery), Florida pine snake, gopher frog, gopher tortoise, Florida pine snake, Florida scrub lizard, flatwoods salamander, tiger salamander, snail bullhead, and Florida cave amphipod.

Area 15. Sandhill and scrub land cover in central Citrus County (including Withlacoochee State Forest). Occurrences are listed by specific geographic areas. **Citrus Springs/Beverly Hills** (north of State Road 44): fox squirrel, southeastern American kestrel, red-cockaded woodpecker, southern bald eagle. **West of Lecanto:** fox squirrel, Florida mouse, southeastern American kestrel, Florida burrowing owl, gopher tortoise, gopher frog, eastern indigo snake, short-tailed snake, southern lip fern, green ladies'-tresses, and wild coco. **South of Cleveland Boulevard:** fox squirrel, Florida burrowing owl, southeastern American kestrel, gopher tortoise, and short-tailed snake. **Withlacoochee State Forest, Citrus Tract:** fox squirrel, red-cockaded woodpecker, southeastern American kestrel, scrub bay, eastern indigo snake, short-tailed snake, incised groove-bur, and green ladies'-tresses. **East of Citrus Tract** (south of Inverness): fox squirrel, southeastern bat (maternity cave), southern bald eagle, southeastern American kestrel, eastern indigo snake, and Hobbs' cave amphipod.

Coastal Areas of Levy County. Portions of the area constitute Strategic Habitat Conservation Areas for several rare wading birds and Scott's seaside sparrow. Occurrences of rare additional species are listed by specific geographic areas. **Horseshoe Beach to Cedar Keys** (includes Lower Suwannee River National Wildlife Refuge): Cedar keys mole skink, Gulf salt marsh mink, American oystercatcher, least tern, shorebird aggregation areas (spoil islands and oyster bars throughout the area), southern bald eagle, brown pelican (rookery), white ibis (rookery), great egret (rookery), seaside sparrow, Gulf salt marsh snake, Atlantic sturgeon, smooth beach sunflower, and maritime hammocks important to migratory birds. **Cedar Keys to Yankeetown:** salt marsh vole, southern bald eagle, Wilson's plover, black skimmer (nesting), shorebird aggregation areas (oyster bars and spoil islands throughout the area), seaside sparrow (Strategic Habitat Conservation Area at Withlacoochee Bay).

Coastal Areas of Citrus and Hernando Counties. Portions of these counties constitute a Strategic Habitat Conservation Area for the southern bald eagle and seaside sparrow. Occurrences of rare additional species are listed by specific geographic areas. **Crystal Bay** (Chambers Island to Ozello): West Indian manatee congregation areas, least tern (nesting areas), American oystercatcher, southern bald eagle, seaside sparrow, tricolored heron (rookeries), great egret (rookeries). **St. Martins River/Homosassa Bay/Pompano Key:** West Indian manatee congregation areas, seaside sparrow, southern bald eagle, Tampa vervain. **Hernando County:** southern bald eagle, little blue heron (rookery), tricolored heron (rookery), Wilson's plover, American oystercatcher, and seaside sparrow.

SECTION 8.2. TECHNIQUES FOR PROTECTING VALUED NATURAL RESOURCES

The resource maps described for each region provide a quick guide to locally important wildlife habitats and other natural resources. Digital copies of these maps are available for use in a wide range of local land-use planning efforts. Incorporating these data into a geographical information system or other computerized mapping program permits a quick initial review of current land uses, proposed land use changes, proposed road projects, and a variety of other applications. These data sets can be provided in either SPANS or ERDAS formats.

Among the various instruments that might be used to expand upon the minimum habitat conservation goals outlined in this document are land acquisition, partial development, transfer of development rights, recreation and conservation easements, and "green lining." Land acquisition and the purchase of conservation easements are perhaps the most effective and least controversial of these techniques, and at least 20 Florida counties are considering or have established local land acquisition programs. The focus of such programs is typically environmentally sensitive or endangered lands and recreation lands. County programs range in magnitude from $2-100 million with a mean of about $30 million and are typically based on ad valorem tax increases. Several cities also have active land acquisition programs (e.g., Boca Raton and Tallahassee).

Local governments and regional planning councils play an important role in natural resource protection within their respective jurisdictions. Under the Developments of Regional Impact (DRI) program, local governments must consider whether "the development will have a favorable or unfavorable impact on the environment and natural and historical resources of the region." Local governments have at least two other sources of authority for enacting environmental protection requirements. First, cities and counties have home rule powers granted by the Florida Constitution (Article VIII). Second, local governments also have comprehensive planning and regulatory powers set forth in the Local Government Comprehensive Planning and Land Development Regulation Act (Chapter 163.3161 Florida Statutes). These same acts also grant powers to individuals residing within the areas of jurisdiction.

A useful habitat conservation technique that has grown out of regional and local government growth management efforts is off-site mitigation. Through this process, land development projects are required to contribute funds to "mitigation banks" that are used to purchase valuable lands separate from the impact areas. The Florida Game and Fresh Water Fish Commission has established three off-site mitigation "parks" primarily for upland habitats and species. Off-site mitigation banks are often selected in consultation with other conservation groups, and funds are also secured to provide for the long-term management of the areas. Off-site mitigation is an important option to consider when biological resources in an area are of local significance, yet not critical to maintaining statewide populations of rare species.

A thorough description of other land conservation techniques goes beyond the scope of this document, but brief mention is made here to provide references to more lengthy discussion of some of these topics. Diehl and Barrett (1988) prepared a manual on conservation easements that includes a discussion of the problems inherent in these procedures. Brenneman and Bates (1984) describe methods for establishing a local land trust that can help to secure conservation easements. The transfer of development rights has been applied in several areas of the country (Banach and Canavan 1987, Conant and Pizor 1988) with apparent success. Green lining has been used in the Pinelands National Reserve in New Jersey (Corbett 1983). Land banking, which involves land acquisition by government for future use or disposal without advance specification of the purpose of the acquisition (Strong 1979), may also occasionally be used as a method for protecting valued natural resources.

LITERATURE CITATIONS

Adams, L. W., and L. E. Dove. 1989. Wildlife reserves and corridors in the urban environment. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Alt, G. 1979. Dispersal patterns of black bears in northeastern Pennsylvania—a preliminary report. Pages 186-199 in Hugie, R. D. (ed.). Fourth Eastern Black Bear Workshop, Bangor, Maine.

Ambuel, B., and S. Temple. 1983. Area-dependent changes in bird communities and vegetation of southern Wisconsin forests. Ecology 64:1057-1068.

Andren, H., and P. Angelstam. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. Ecology 69:544-547.

Anonymous. 1988. Blackwater-Eglin Connector. File No. 880131-57-1, Conservation and Recreation Lands Program. Florida Department of Natural Resources, Tallahassee, Florida.

Anonymous. 1991. A species by county by habitat matrix. Florida Natural Areas Inventory, Tallahassee, Florida.

Anonymous. 1992. Conservation and recreation lands program annual report. Office of Land Use Planning and Biological Services, Florida Department of Natural Resources, Tallahassee, Florida.

Anonymous. 1993. Conservation and recreation lands program annual report. Office of Land Use Planning and Biological Services, Florida Department of Natural Resources, Tallahassee, Florida.

Baker, W. W. 1983. Decline and extirpation of a population of red-cockaded woodpeckers in northwest Florida. Pages 51-58 in Wood, D. A. (ed.). Red-cockaded woodpecker symposium II. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Baker, W. W. 1993. Status and distribution of the red-cockaded woodpecker in Georgia: a 1992 update. Proceedings of the third red-cockaded woodpecker symposium. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Ballou, J., and K. Ralls. 1982. Inbreeding and juvenile mortality in small populations of ungulates: a detailed analysis. Biological Conservation 24:239-272.

Ballou, J. D., T. J. Foose, R. C. Lacy, and U. S. Seal. 1989. Florida panther (*Felis concolor coryi*). Population viability analysis and recommendations. Captive Breeding Specialist Group, Species Survival Commission, I.U.C.N., Gland, Switzerland.

Banach, M., and D. Canavan. 1987. Montgomery County agricultural preservation program. Pages 244-268 in Brower, D., and D. Carol (eds.). Managing land-use conflicts: case studies in special area management. Duke University Press, Durham, North Carolina.

Bancroft, T. (project director). 1989. Relationship between the reproductive ecology of the white-crowned pigeon and the fruiting phenology of tropical hardwood hammock trees. Final report. Project Number GFC-86-031. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Bancroft, G. T., S. D. Jewel, and A. M. Strong. 1990. Foraging and nesting ecology of herons in the Lower Everglades relative to water conditions. Final Report. Environmental Sciences Division, South Florida Water Management District, West Palm Beach, Florida.

Bancroft, G. T., A. Strong, and M. Carrington. In preparation. Deforestation and its effects on forest nesting birds in the Florida Keys. National Audubon Society, Miami, Florida.

Bechtold, W. A., M. J. Brown, and R. M. Sheffield. 1990. Florida's forests, 1987. Resource Bulletin SE-62. U.S.D.A. Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina.

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94-108.

Belden, R. C. 1989. The Florida panther. Pages 515-532 in Audubon 1988/1989 Wildlife Report. National Audubon Society, New York, New York.

Belden, R. C., T. C. Hines, and T. H. Logan. 1986. Florida panther re-establishment. A discussion of the issues. Final performance report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Belden, R. C., W. B. Frankenberger, R. T. McBride, and S. T. Schwikert. 1988. Panther habitat use in southern Florida. Journal Wildlife Management 52:660-663.

Belden, R. C., and W. Frankenberger. 1988. Florida panther captive breeding/reintroduction feasibility. Annual Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Belden, R. C., and B. Hagedorn. 1992. Feasibility of translocating panthers into northern Florida. Final performance report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Bellrose, F. C. 1976. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pennsylvania.

Bennett, A. J. 1989. Movements and home ranges of Florida sandhill cranes. Journal of Wildlife Management 53:830-836.

Bildstein, K. L., G. T. Bancroft, P. J. Dugan, D. H. Gordon, R. M. Erwin, E. Nol, C. Payne, and S. E. Senner. 1991. Approaches to the conservation of coastal wetlands in the western hemisphere. Wilson Bulletin 103:218-254

Bishop, M. 1987. Selection of potential reintroduction sites and foster parents for whooping crane reintroduction. Final performance report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Blair, W. F. 1951. Population structure, social behavior, and environmental relations in a natural population of the beach mouse *Peromyscus polionotus leucocephalus*. Contributions of the Laboratory of Vertebrate Biology, University of Michigan 48:1-47.

Bonnel, M. L., and R. K. Selander. 1974. Elephant seals: Genetic variation and near extinction. Science 184:908-909.

Brady, A. J., and M. R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildlife Society Bulletin 17:5-10.

Brady, J. R., and D. S. Maehr. 1985. Distribution of black bears in Florida. Florida Field Naturalist 13:1-7.

Brenneman, R. L., and S. M. Bates (eds.). 1984. Land-saving action. Island Press, Covelo, California.

Browder, J. 1984. Wood stork feeding areas in southwest Florida. Florida Field Naturalist 12:81-96.

Bryan, D. 1982. Social organization and territoriality in the limpkin. M.S. Thesis. Florida State University, Tallahassee, Florida.

Bryan, A. L., Jr., and M. Coulter. 1987. Foraging flight characteristics of wood storks in east-central Georgia, U.S.A. Colonial Waterbirds 10:157-161.

Burke, R. L., J. Tasse, C. Badgley, S. R. Jones, N. Fishbein, S. Phillips, and M. E. Soulé. 1991. Conservation of the Stephens' kangaroo rat (*Dipodomys stephensi*): planning for persistence. Bulletin of the Southern California Academy of Science 90(1):10-40.

Burt, W. H., and R. P. Grossenheider. 1976. A field guide to the mammals. Houghton Mifflin Company, Boston, Massachusetts.

Carlock, D. M. 1984. Georgia status report. Pages 3-4 in Maehr, D., and J. R. Brady (eds.). Proceedings of the eastern workshop on black bear management and research 7. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Carlson, D., and J. Rey. 1991. Multipurpose management of Florida's mosquito control impoundments. Pages 163-177 in Jennings, D. (compiler). Proceedings of the coastal nongame workshop. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Cely, J. 1993. Status of the red-cockaded woodpecker in South Carolina. Proceedings of the third red-cockaded woodpecker symposium. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Chamberlain, E. B., Jr. 1960. Florida waterfowl populations, habitats and management. Technical Bulletin 7. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Chesser, R. 1981. Chapter 4. Isolation by distance: relationship to the management of genetic resources. Pages 66-77 in Schoenwald-Cox, C., S. Chambers, B. MacBryde, and L. Thomas (eds.). Genetics and conservation. A reference for managing wild animals and plant populations. Benjamin Cummings Publishing Company, Menlo Park, California.

Chesser, R., C. Reuterwall, and N. Ryman. 1982. Genetic differentiation of Scandinavian moose (*Alces alces alces*) populations over short geographical distances. Oikos 39:125-130

Chesser, R. K., and N. Ryman. 1986. Inbreeding as a strategy in subdivided populations. Evolution 40:616-624.

Christman, S. P. 1988. Endemism and Florida's interior sand pine scrub. Final Report. GFC-81-101. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Conant, R. 1975. Reptiles and amphibians of east central North America. Third Edition. Houghton Mifflin Company, Boston, Massachusetts.

Conant, H. K., and P. J. Pizor. 1988. Economic and fiscal support programs. Pages 232-258 in Collins, B. R., and E. W. Russel (eds.). Protecting the New Jersey Pinelands: a new direction in landuse management. Rutgers University Press, New Brunswick, New Jersey.

Corbett, M. R. 1983. Greenline parks: land conservation trends for the eighties and beyond. National Parks and Conservation Association, Washington, D.C.

Cox, J. A. 1987. Status and distribution of the Florida scrub jay. Florida Ornithological Society Special Publication No. 3.

Cox, J., W. R. Baker, and D. Wood. 1993. Status and distribution of the red-cockaded woodpecker in Florida: a 1992 update. Proceedings of the third red-cockaded woodpecker symposium. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Cox, J., D. Inkey, and R. Kautz. 1987. Ecology and habitat protection needs of gopher tortoise (*Gopherus polyphemus*) populations found on lands slated for large-scale developments in Florida. Nongame Wildlife Program Technical Report 4. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Crow, J. F., and M. Kimura. 1970. An introduction to population genetics theory. Harper and Row Publishing Company, New York, New York.

Cruz, A., T. Manolis, and J. Wiley. 1988. The shiny cowbird: a brood parasite expanding its range in the Caribbean region. Ornithological Monographs 36:607-620.

Custer, T. W., and R. G. Osborn. 1978. Feeding-site description of three heron species near Beaufort, North Carolina. Pages 255-360 in Sprunt, A., IV, J. C. Ogden, and S. Winckler (eds.). Wading birds. National Audubon Society Research Report 7. National Audubon Society, New York, New York.

Dalrymple, G. H. 1988. The herptofauna of Long Pine Key, Everglades National Park, in relation to vegetation and hydrology. Pages 72-86 in Szaro, R. C., K. E. Severson, and D. R. Patton (technical coordinators). Management of amphibians, reptiles, and small mammals in North America. General Technical Report RM-166. U.S. Forest Service, Ft. Collins, Colorado.

Davis, J. H. 1967. General map of natural vegetation of Florida. Circular S-178. Agricultural Experiment Station, Institute of Food and Agricultural Science, University of Florida, Gainesville, Florida.

DeGange, A. R. 1978. American oystercatcher. Pages 37-39 in Kale, H. W., II (ed.). Rare and endangered biota of Florida. Volume 2. Birds. University Presses of Florida, Gainesville, Florida.

deHaven-Smith, L., and D. Gatlin. 1985. The Florida voter. Florida Environment and Urban Issues 12(3):14-18.

Delany, M. 1991. Florida grasshopper sparrow habitat management needs. Final performance report. Study No. 7513. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Delany, M. 1993. Florida grasshopper sparrow population survey. Final performance report. Study No. 7514. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Delany, M., and J. Cox. 1986. Florida grasshopper sparrow breeding distribution and abundance in 1984. Florida Field Naturalist 14:100-104.

Delany, M., H. Stevenson, and R. McCracken. 1985. Distribution, abundance, and habitat of the Florida grasshopper sparrow. Journal of Wildlife Management 49:626-631.

Delorme Mapping Company. 1989. Florida atlas and gazetteer. Third edition. DeLorme Mapping Company, Freeport, Maine.

DeLotelle, R., J. Newman, and A. Jerauld. 1983. Habitat use by red-cockaded woodpeckers in central Florida. Pages 59-67 in Wood, D. (ed.). Proceedings. Red-cockaded woodpecker symposium II. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Diehl, J., and T. Barrett. 1988. The conservation easement handbook. The Land Trust Exchange and The Trust for Public Land, Alexandria, Virginia.

Doren, R. F., D. R. Richardson, and R. E. Roberts. 1987. Prescribed burning of the sand pine scrub community: Yamato scrub, a test case. Florida Scientist 50:184-192.

Duda, M. D. 1987. Floridians and wildlife. Sociological implications for wildlife conservation in Florida. Nongame Wildlife Program Technical Report No. 2. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Dueser, R. D., J. L. Dooley, Jr., and G. J. Taylor. 1988. Habitat structure, forest composition, and landscape dimensions as components of habitat suitability for the Delmarva fox squirrel. Pages 414-421 in Szaro, R. C., K. E. Severson, and D. R. Patton (technical coordinators). Management of amphibians, reptiles, and small mammals in North America. General Technical Report RM-166. U.S. Forest Service, Ft. Collins, Colorado.

Dwyer, N., and G. Tanner. 1992. Nesting success in Florida sandhill cranes. Wilson Bulletin 104:2231.

East, R. 1981. Area requirements and conservation status of large African mammals. Nyala 7:3-20.

Eisenberg, J. 1980. The density of biomass of tropical mammals. Pages 25-55 in Soulé, M., and B. Wilcox (eds.). Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Inc., Sunderland, Massachusetts.

Eisner, T., K. D. McCormick, M. Sakaino, M. Eisner, S. R. Smedley, D. J. Aneshansley, M. Deyrup, R. L. Myers, and H. Meinwald. 1990. Chemical defense of a rare mint plant. Chemoecology 1:30-37.

Endler, J. 1972. Geographic variation, speciation, and clines. Princeton Monographs in Population Biology 10. Princeton University Press, Princeton, New Jersey.

Enge, K., M. Bentzien, and H. F. Percival. 1986. Florida scrub lizard status survey. Florida Cooperative Fish and Wildlife Research Unit Technical Report No. 26. University of Florida, Gainesville, Florida.

Extine, D., and J. Stout. 1987. Dispersion and habitat occupancy of the beach mouse, *Peromyscus polionotus niveiventris*. Journal of Mammalogy 68:297-304.

Exum, J. H., J. A. McGliney, D. W. Speake, J. L. Buckner, and F. M. Stanley. 1987. Ecology of the eastern wild turkey in an intensively managed pine forest in southern Alabama. Bulletin of the Tall Timbers Research Station 23:1-78.

Faeth, S. H., and T. C. Kane. 1978. Urban biogeography: city parks as islands for Diptera and Coleoptera. Oecologia 32:127-133.

Fernald, R. 1989. Coastal xeric scrub communities of the Treasure Coast Region, Florida: A summary of their distribution and ecology, with guidelines for their preservation and management. Nongame Wildlife Program Technical Report No. 6. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Fitzpatrick, J., G. Woolfenden, and M. Kopeny. 1991. Ecology and development-related habitat requirements of the Florida scrub jay (*Aphelocoma coerulescens coerulescens*). Nongame Wildlife Program Technical Report No. 8. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Florida Natural Areas Inventory. 1990. Guide to the natural communities of Florida. Florida Natural Areas Inventory, Tallahassee, Florida.

Florida Natural Areas Inventory. 1992. Element rank explanations. Florida Natural Areas Inventory, Tallahassee, Florida.

Florida Ornithological Society. 1992. Field observation committee winter report. Florida Field Naturalist 20:73-78.

Foster, M., and S. Humphrey. 1993. Effectiveness of wildlife crossings in reducing animal/auto collisions on Interstate 75, Big Cypress Swamp, Florida. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Frank, P., and S. Humphrey. 1992. Anastasia Island beach mouse study. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Franklin, I. 1980. Evolutionary change in small populations. Pages 135-149 in Soulé, M., and B. Wilcox (eds.). Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Frederick, P., and M. Collopy. 1988. Reproductive ecology of wading birds in relation to water conditions in the Florida Everglades. Technical Report No. 30. Florida Cooperative Fish and Wildlife Research Unit, School of Forest Resources and Conservation, University of Florida, Gainesville, Florida.

Futuyma, D. 1979. Evolutionary biology. Sinauer Associates, Inc., Sunderland, Massachusetts.

Gilbert, L. 1980. Food web organization and the conservation of neotropical diversity. Pages 11-33 in Soulé, M., and B. Wilcox (eds.). Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Inc., Sunderland, Massachusetts.

Gilpin, M. E. 1987. Spatial structure and population vulnerability. Pages 125-139 in Soulé, M. (ed.). Viable populations for conservation. Cambridge University Press, Cambridge, Massachusetts.

Goodman, D. 1987a. Consideration of stochastic demography in the design and management of biological reserves. Natural Resources Modeling 1:205-234.

Goodman, D. 1987b. The demography of chance extinction. Pages 11-34 in Soulé, M. (ed.). Viable populations for conservation. Cambridge University Press, Cambridge, Massachusetts.

Gore, J. 1992. Gray bat. *Myotis grisescens*. Pages 63-70 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Gore, J., and C. Chase, III. 1989. Snowy plover breeding distribution. Final performance report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Gore, J., and T. Schaefer. 1993. Santa Rosa beach mouse survey. Annual performance report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Graves, G., and N. Gotelli. 1983. Neotropical land-bridge avifaunas: new approaches to null hypotheses in biogeography. Oikos 41:322-333.

Green, D. 1993. Overview of red-cockaded woodpecker habitat on Eglin Air Force Base. Florida Department of Natural Resources, Resource Management Notes 5(2):22.

Haig, S., and J. Plissner. 1993. Distribution and abundance of piping plovers: results and implications of the 1991 international census. Condor 95:145-156.

Hall, H., and J. Newsome. 1976. Summer home ranges and movements of bobcats in bottomland hardwoods of southern Louisiana. Proceedings of the Annual Conference of the Southeastern Association Fish and Wildlife Agencies 30:427-436.

Hamel, P. 1992. The land manager's guide to the birds of the south. General Technical Report SE-22. U.S. Forest Service, Atlanta, Georgia.

Harris, L. D. 1984. The fragmented forest; island biogeographic theory and the preservation of biotic diversity. University of Chicago Press, Chicago, Illinois.

Harris, L. D. 1985. Conservation corridors: A highway system for wildlife. ENFO Report 85-5. Environmental Information Center of the Florida Conservation Foundation, Inc., Winter Park, Florida.

Harris, L. D. 1988. Edge effects and conservation of biotic diversity. Conservation Biology 2:330-332.

Harris, L. D. , L. D. White, J. E. Johnston, and D. G. Milchunas. 1974. Impact of forest plantations on North Florida wildlife and habitat. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 38:87-96.

Harris, R., and F. W. Allendorf. 1989. Genetically effective population sizes of large mammals: assessment of estimators. Conservation Biology 2:181-191.

Harris, R. B., L. A. Maguire, and M. L. Shaffer. 1987. Sample sizes for minimum viable population estimation. Conservation Biology 1:72-76.

Harrison, S., and J. F. Quinn. 1989. Correlated environments and the persistence of metapopulations. Oikos 56:293-298.

Hartman, B. J. 1978. Description of major terrestrial and wetland habitats of Florida. Pages xvi-xix in Kale, H. W., II. (ed.). Rare and endangered biota of Florida. Volume two. Birds. University Presses of Florida, Gainesville, Florida.

Hellgren, E. C., and M. R. Vaughn. 1989. Demographic analysis of a black bear population in the Great Dismal Swamp. Journal of Wildlife Management 53:969-977.

Hellgren, E. C., M. R. Vaughan, and D. F. Stauffer. 1991. Macrohabitat use by black bears in a southeastern wetland. Journal of Wildlife Management 55:442-448.

Hill, E. A. 1989. Population dynamics, habitat, and distribution of the Alabama beach mouse. M.S. thesis, Auburn University, Auburn, Alabama.

Hillman, L. L., and D. L. Yow. 1986. Timber management for black bear. Proceedings of the Eastern Workshop on Black Bear Research and Management 8:125-136.

Hiscock, J. W. 1986. Protecting national park system buffer zones: existing, proposed, and suggested authority. Journal of Energy Law Policy 7:35-94.

Holler, N. 1992a. Choctawhatchee beach mouse. *Peromyscus polionotus allophrys*. Pages 76-86 in Humphrey, S. (ed). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Holler, N. 1992b. Perdido Key beach mouse. *Peromyscus polionotus trissyllepsis*. Pages 102-109 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Holler, N. R., and D. W. Mason. 1987. Reestablishment of Perdido Key and Choctawhatchee beach mice into areas of unoccupied critical habitat. Journal of the Alabama Academy of Science 58:66.

Holt, E. G. 1930. Nesting of the sandhill crane in Florida. Wilson Bulletin 42:163-183.

Hovis, J., and J. Gore. 1993. Southeastern bat maternity caves. A proposal to the Conservation and Recreation Lands Committee. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Howard, W. E. 1949. Dispersal, amount of inbreeding, and longevity in a local population of prairie deer mice on the George Reserve, southern Michigan. Contributions to the Laboratory of Vertebrate Biology, University of Michigan 43:1-50.

Howe, R., G. Davis, and V. Mosca. 1991. The demographic significance of "sink" populations. Biological Conservation 57:239-255.

Humphrey, S. R. 1992a. Pallid beach mouse. *Peromyscus polionotus decoloratus*. Recently extinct. Pages 19-23 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Humphrey, S. R. 1992b. Chadwick Beach cotton mouse. *Peromyscus polionotus decoloratus*. Recently extinct. Pages 24-28 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Humphrey, S. R. (ed.). 1992c. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida.

Humphrey, S. R., and D. B. Barbour. 1979. Status and habitat of eight kinds of endangered and threatened rodents in Florida. Special Scientific Report No. 2. Florida State Museum, University of Florida, Gainesville, Florida.

Humphrey, S. R., and D. Barbour. 1981. Status and habitat of three subspecies of *Peromyscus polionotus* in Florida. Journal of Mammalogy 62:840-844.

Humphrey, S. R., J. F. Eisenberg, and R. Franz. 1985. Possibilities for restoring wildlife of a longleaf pine savanna in an abandoned citrus grove. Wildlife Society Bulletin 13:487-496.

Humphrey, S. R., and P. Frank. 1992. Anastasia Island beach mouse. *Peromyscus polionotus phasma*. Pages 94-101 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Humphrey, S. R., and J. Gore. 1992. Southeastern brown bat. *Myotis austroriparius*. Pages 335-243 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Humphrey, S. R., and P. G. R. Jodice. 1992. Big Cypress fox squirrel. *Sciurus niger avicennia*. Pages 224-233 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida.

Jackson, D., and E. Milstrey. 1989. The fauna of gopher tortoise burrows. Pages 86-98 in Diemer, J., D. Jackson, J. Landers, J. Layne, and D. Wood (eds.). Proceedings: gopher tortoise relocation symposium. Nongame Wildlife Program Technical Report No. 5. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

James, F. C. 1992. St. Andrews beach mouse. *Peromyscus polionotus peninsularis*. Pages 87-93 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

James, F. C. 1993. Status of the red-cockaded woodpecker on the Apalachicola National Forest. Proceedings of the third red-cockaded woodpecker symposium. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Jansen, D. 1993. Status of the red-cockaded woodpecker in the Big Cypress National Preserve. Proceedings of the third red-cockaded woodpecker symposium. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Janzen, D. 1983. No park is an island: increase in interference from outside as park size decreases. Oikos 41:402-410.

Janzen, D. 1986. The external threat. Pages 286-303 in Soulé, M. (ed.). Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, Massachusetts.

Johnson, A. F., and M. G. Barbour. 1990. Dunes and maritime forests. Pages 249-480 in Myers, R., and J. Ewel (eds.). Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

Johnson, A. F., and J. Muller. 1993. An assessment of Florida's remaining coastal upland natural communities: final summary report. Florida Natural Areas Inventory, Tallahassee, Florida.

Johnson, F. A., F. Montalbano, and T. Hines. 1984. Population dynamics and status of the mottled duck in Florida. Journal of Wildlife Management 48:1137-1143.

Johnson, F. A., F. Montalbano, J. Truitt, and D. Eggeman. 1991. Distribution, abundance, and habitat preferences of mottled ducks in Florida. Journal of Wildlife Management 55:476-487.

Juday, G. P. 1983. The problem of large mammals in natural areas selection: examples from the Alaska ecological reserves system. Natural Areas Journal 3:24-30.

Kahl, M. 1964. Food ecology of the wood stork (*Mycteria americana*) in Florida. Ecological Monographs 34:97-117.

Kale, H. W., II (ed.). 1978. Rare and endangered biota of Florida. Volume two. Birds. University Presses of Florida, Gainesville, Florida.

Kale, H. W., II, B. Pranty, B. Stith, and W. Biggs. 1992. An atlas of Florida's breeding birds. Final report. Nongame Wildlife Program, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Kantola, A. T. 1986. Fox squirrel home range and mast crops in Florida. M.S. thesis, University of Florida, Gainesville.

Kantola, A. T. 1992. Sherman's fox squirrel. *Sciurus niger shermani*. Pages 234-241 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume 1. Mammals. University Press of Florida, Gainesville, Florida.

Kautz, R. S. 1984. Criteria for evaluating impacts of development on wildlife habitats. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 38:121-136.

Kautz, R. S. 1993. Trends in Florida wildlife habitat 1936-1987. Florida Scientist 56:7-24.

Kautz, R. S., D. T. Gilbert, and G. M. Mauldin. 1993. Vegetative cover in Florida based on 1985-1989 Landsat Thematic Mapper imagery. Florida Scientist 56:135-154.

Keiter, R. B. 1985. On protecting the national parks from the external threats dilemma. Land and Water Law Review 20:255-420.

Keiter, R. B., and W. A. Hubert. 1987. Legal consideration in challenging external threats to Glacier National Park, Montana, U.S.A. Environmental Management 11:121-126.

Kochman, H., and S. Christman. 1992a. Atlantic salt marsh snake. *Nerodia clarkii taeniata*. Pages 111-116 in Moler, P. (ed.). Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida.

Kochman, H., and S. Christman. 1992b. Gulf salt marsh snake. *Nerodia clarkii clarkii*. Pages 237-241 in Moler, P. (ed.). Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida.

Koenig, W. 1988. On determination of viable population size in birds and mammals. Wildlife Society Bulletin 16:230-234.

Kushlan, J. 1976. Feeding behavior of North American herons. Auk 96:114-122.

Lacy, R. C. 1987. Loss of genetic diversity from managed populations: interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology 1:143-158.

Land Acquisition Advisory Council. 1991. Addendum 6. Final report. Florida Preservation 2000 needs assessment, land management needs and costs committee. Florida Department of Natural Resources, Tallahassee, Florida.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241:1455-1460.

Lande, R., and G. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management. Pages 87-124 in Soulé, M. (ed.). Viable populations for conservation. Cambridge University Press, Cambridge, Massachusetts.

Landin, M. 1991. Need, construction, and management of dredged material islands for wildlife. Pages 99-117 in Jennings, D. (compiler). Proceedings of the coastal nongame workshop. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Laurance, W. F. 1991. Edge effects in tropical forest fragments: application of a model for the design of nature reserves. Biological Conservation 57:205-219.

LaVal, R. K., R. L. Clawson, M. L. LaVal, and W. Caire. 1977. Foraging behavior and nocturnal activity patterns of Missouri bats, with special emphasis on the endangered species *Myotis grisescens* and *Myotis sodalis*. Journal of Mammalogy 58:592-599.

Layne, J. N. 1974. The land mammals of south Florida. Pages 386-413 in Gleason, P. (ed.). Environments of south Florida: present and past. Miami Geological Society Memoir No. 2, Miami, Florida.

Layne, J. N. 1978a. Audubon's crested caracara. Pages 34-36 in Kale, H. W., II (ed.). Rare and endangered biota of Florida. Volume two. Birds. University Presses of Florida, Gainesville, Florida.

Layne, J. N. (ed.). 1978b. Rare and endangered biota of Florida. Volume one. Mammals. University Presses of Florida, Gainesville, Florida.

Layne, J. N., and D. A. Wassmer. 1988. Records of the panther in Highlands County, Florida. Florida Field Naturalist 16:70-72.

Leberg, P. 1991. Influence of fragmentation and bottlenecks on genetic divergence of wild turkey populations. Conservation Biology 5:522-530.

Loope, L. L. 1992. An overview of problems with introduced plant species in national parks and reserves of the United States. Pages 115-137 in Stone, C. P., S. W. Smith, and H. T. Tunison (eds.). Alien plant invasions in Hawaii: management and research in near-native ecosystems. Cooperative National Park Resources Studies Unit, University of Hawaii, Honolulu.

Lotter, C. F., and G. W. Cornwell. 1969. Comparison of airplane, airboat, and helicopter censusing Florida ducks, *Anas platyrhynchos fulvigula*. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 23:97-101.

Maehr, D. S. 1987. Florida panther movements, social organization, and habitat utilization. Annual performance report (E-1-11). Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Maehr, D. S. 1990. The Florida panther and private lands. Conservation Biology 4:167-170.

Maehr, D. S. 1992. Florida panther. *Felis concolor coryi*. Pages 176-189 in Humphrey, S. (ed.). Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida.

Maehr, D. S., E. D. Land, and J. C. Roof. 1991. Florida panthers. National Geographic Research and Exploration 7:414-431.

Maehr, D. S., J. N. Layne, E. D. Land, J. W. McCown, and J. Roof. 1988. Long distance movement of a Florida black bear. Florida Field Naturalist 16:1-6.

Maehr, D. S., and J. Wooding 1992. Florida black bear. *Ursus americanus floridanus*. Pages 265-275 in Humphrey, S. (ed.). Rare and Endangered Biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida.

Malecot, G. 1975. Heterozygosity and relationship in regularly subdivided populations. Theoretical Population Biology 8:212-241.

Manlove, R., P. Ramsey, J. Avise, and M. Smith. 1979. Genetics of white-tailed deer in South Carolina. Journal of Wildlife Management 43:136-142.

McComb, W. C., S. A. Bonney, R. M. Sheffield, and N. D. Cost. 1986. Den tree characteristics and abundance in Florida and South Carolina. Journal of Wildlife Management 50:584-591.

McCord, C., and J. Cardoza. 1982. Chapter 39. Bobcat and lynx. Pages 728-766 in Chapman, J., and G. Feldhamer (eds.). Wild mammals of North America. University of Chicago Press, Chicago, Illinois.

Means, D. 1992. Pine barrens treefrog. *Hyla andersoni*. Pages 20-25 in Moler, P. (ed.). Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida.

Meyer, K., and M. W. Collopy. 1990. Status, distribution, and habitat requirements of the American swallow-tailed kite (*Elanoides forficatus*) in Florida. Final report. Nongame Wildlife Program, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Mills, L., M. Soulé, and D. Doak. 1993. The keystone-species concept in ecology and conservation. BioScience 43:219-224.

Millsap, B. 1987. Summer concentration of American swallow-tailed kites at Lake Okeechobee, Florida, with comments on post-breeding movements. Florida Field Naturalist 15:85-92.

Millsap, B. 1991. Crested caracara population survey. Final progress report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Millsap, B., and C. Bear. 1989. Annual performance report. Cape Coral burrowing owl population monitoring. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Millsap, B., J. Gore, D. Runde, and S. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs 111.

Moler, P. E. (ed.). 1992a. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida.

Moler P. 1992b. American crocodile. *Crocodylus acutus*. Pages 83-89 in Moler, P. E. (ed.). Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida.

Moler P. 1992c. Florida bog frog. *Rana okaloosae*. Pages 30-33 in Moler, P. E. (ed.). Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida.

Mollohan, C., and A. LeCount. 1989. Problems of maintaining a viable black bear population in a fragmented forest. Pages 149-159 in Tecle, A., W. Covington, and R. Hamre (technical coordinators). Multi-resource management of ponderosa pine forests. General Technical Report RM-185. U.S. Forest Service, Ft. Collins, Colorado.

Moore, F. 1992. Migrant songbirds at a stopover site in Mississippi. Wilson Bulletin 104:32-40.

Moore, J. C. 1956. Variation in the fox squirrel in Florida. American Midland Naturalist 55:41-56.

Moore, J. C. 1957. The natural history of the fox squirrel *Sciurus niger shermani*. Bulletin of the American Museum of Natural History 113:1-71.

Muller, J. W., E. D. Hardin, D. R. Jackson, S. E. Gatewood, and N. Caire. 1989. Summary report on the vascular plants, animals, and plant communities endemic to Florida. Nongame Wildlife Program Technical Report No. 7, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Myers, R. L. 1990. Scrub and high pine. Pages 150-193 in Myers, R., and J. Ewel (eds.). Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

Mykytka, J., and M. Pelton. 1989. Management strategies for Florida black bears based on home range habitat composition. International Conference on Bear Research and Management 8:161-167.

Nesbitt, S. 1978. Limpkin. Pages 7-88 in Kale, H. W., II (ed.). Rare and endangered biota of Florida. Volume two. Birds. University Presses of Florida, Gainesville, Florida.

Nesbitt, S., and J. Carpenter. 1993. Survival and movements of greater sandhill cranes experimentally released in Florida. Journal of Wildlife Management 57:673-679.

Nesbitt, S., A. Jerauld, and B. Harris. 1983. Red-cockaded woodpecker summer range sizes in southwest Florida. Pages 68-71 in Wood, D. (ed.). Proceedings: red-cockaded woodpecker symposium II. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Nesbitt, S., and K. Williams. 1990. Home range and habitat use of Florida sandhill cranes. Journal of Wildlife Management 25:92-96.

Noon, B. 1992. Corridor use by small vertebrates. Bulletin of the Ecological Society of America 73:247.

Norse, E. A., K. L. Rosenbaum, D. S. Wilcove, B. A. Wilcox, W. H. Romme, D. W. Johnston, and M. L. Stout. 1986. Conserving biological diversity in our National Forests. The Wilderness Society, Washington D.C.

Noss, R. 1983. A regional landscape approach to maintain diversity. BioScience 3:700-706.

Noss, R. 1991. From endangered species to biodiversity. Pages 227-246 in Kohm, K. (ed.). Balancing on the brink of extinction. Island Press, Washington, D.C.

Noss, R., and L. Harris. 1986. Nodes, networks, and MUM's: Preserving diversity at all scales. Environmental Management 10:299-309.

O'Brien, S., and J. Evermann. 1988. Interactive influence of infectious diseases and genetic diversity in natural populations. Trends in Ecology and Evolution 3:254-259.

O'Meara, T., and J. Gore. 1988. Guidelines for conservation and management of least tern colonies in Florida. Nongame Wildlife Program, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Osterhoff, D., R. Schoeman, J. Op't Hof, and E. Young. 1983. Genetic differentiation of the African elephant in the Kruger National Park. South African Journal of Science 70:245-247.

Owre, O. 1978. Black-whiskered vireo. Pages 59-61 in Kale, H. W., II (ed.). Rare and endangered biota of Florida. Volume two. Birds. University Presses of Florida, Gainesville, Florida.

Page, G., L. Stenzel, D. Winkler, and C. Swarth. 1983. Spacing out at Mono Lake: breeding success, nest density, and predation in the snowy plover. Auk 100:13-24.

Paul, R., and T. Below. 1991. Populations, distribution, habitats, and migration of gulls, terns, and shorebirds in coastal Florida: an overview. Pages 66-75 in Jennings, D. (compiler). Proceedings of the coastal nongame workshop. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Pearlstine, L., and W. Kitchens. 1992. Boundaries and status of permitted citrus areas. Pages 19-25 in An evaluation of the regional effects of new citrus development on the ecological integrity of wildlife resources in southwest Florida. Volume II. Contract #C89-0186. South Florida Water Management District, West Palm Beach, Florida.

Pearson, P. 1954. Mammals of Gulf Hammock, Levy County, Florida. American Midland Naturalist 51:468-480.

Pelton, M. R. 1985. Habitat needs of black bears in the East. Pages 49-53 in Kulhavy, D. L., and R. N. Conner, (eds.). Wilderness and natural areas in the eastern United States: a management challenge. Center for Applied Studies, Stephen F. Austin State University, Nacogdoches, Texas.

Peroni, P. A., and W. G. Abrahamson. 1985. Post-settlement vegetation loss on the southern Lake Wales Ridge, Florida. Palmetto 5:6-7.

Quinn, J. F., and A. Hastings. 1987. Extinction in subdivided habitats. Conservation Biology 1:198-208.

Ralls, K., J. Ballou, and A. Templeton. 1988. Estimates of lethal equivalents and the cost of inbreeding in mammals. Conservation Biology 2:185-193.

Ralls, K., K. Bruger, and J. D. Ballou. 1979. Inbreeding and juvenile mortality in small populations of ungulates. Science 206:1101-1103.

Reed, J. M., P. D. Doerr, and J. R. Walters. 1988. Minimum viable population size of the red-cockaded woodpecker. Journal of Wildlife Management 50:239-247.

Repenning, R. W., and R. F. Labisky. 1985. Effects of even-age timber management on bird communities of the longleaf pine forest in northern Florida. Journal of Wildlife Management 49:1088-1098.

Robertson, W., Jr. 1978. Mangrove cuckoo. Pages 57-58 in Kale, H. W., II (ed.). Rare and endangered biota of Florida. Volume two. Birds. University Presses of Florida, Gainesville, Florida.

Robson, M. S. 1989. Southeastern beach mouse survey. Final performance report. Florida Game and Freshwater Fish Commission, Tallahassee, Florida.

Rodgers, J. 1992. Annual snail kite survey and habitat assessment. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Rodgers, J. In prep. Snail kite. In Rodgers, J. (ed.). Rare and endangered biota of Florida. Volume 4. Birds. University Press of Florida, Gainesville, Florida.

Rodgers, J., S. Schwikert, and A. Wenner. 1988. The status of the snail kite in central and south Florida: 1981-1985. American Birds 42:30-35.

Rogers, L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northern Minnesota. Wildlife Monographs 97.

Roof, J. C., and D. S. Maehr. 1988. Sign surveys for Florida panthers in peripheral areas of their known range. Florida Field Naturalist 16:81-85.

Runde, D., J. Gore, J. Hovis, M. Robson, and P. Southall. 1991. Florida atlas of breeding sites for herons and their allies: update 1986-1989. Nongame Wildlife Program Technical Report No. 10. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Ryti, R. 1992. Effect of the focal taxon on the selection of nature reserves. Ecological Applications 2:404-410.

Samson, F., F. Perez-Trejo, H. Salwasser, and T. Russ. 1985. On determining and managing minimum population size. Wildlife Society Bulletin 13:425-533.

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erichia, T. Edwards, Jr., J. Ullman, and R. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. Wildlife Monographs 123.

Shaffer, M. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

Shaffer, M. 1987. Minimum viable populations: coping with uncertainty. Pages 69-86 in Soulé, M. (ed.). Viable populations for conservation. Cambridge University Press, Cambridge, Massachusetts.

Shermyen, A. H., S. S. Floyd, G. H. Thompson, and D. A. Evans (eds). 1991. Florida statistical abstract. University Press of Florida, Gainesville, Florida.

Simberloff, D. 1988. The contribution of population and community biology to conservation science. Annual Review of Ecology and Systematics 19:473-511.

Simberloff, D., and L. Abele. 1976. Island biogeography theory and conservation practice. Science 191:285-286.

Simberloff, D., and J. Cox. 1987. Consequences and costs of conservation corridors. Conservation Biology 1:63-71.

Simberloff, D., J. Farr, J. Cox, and D. Mehlman. 1992. Movement corridors: conservation bargains or poor investments? Conservation Biology 6:492-503.

Snyder, J. R., M. Herndon, and W. B. Robertson, Jr. 1990. South Florida rockland. Pages 230-277 in Myers, R., and J. Ewel (eds.). Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

Soil Conservation Service. Undated. 26 ecological communities of Florida. U.S. Department of Agriculture, Fort Worth, Texas.

Soulé, M. E., and M. Gilpin. 1991. The theory of wildlife corridor capability. Pages 3-8 in Saunders, D., and R. J. Hobbs (eds.). The role of corridors in nature conservation. Surrey Beatty and Sons, Sydney, Australia.

Soulé, M. E., and D. Simberloff. 1986. What do genetics and ecology tell us about the design of nature preserves? Biological Conservation 35:19-40.

Spalding, M. 1991. Water bird diseases. Pages 177-181 in Jennings, D. (compiler). Proceedings of the coastal nongame workshop. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Stevenson, H., and B. Anderson. 1992. Florida birds. Final project report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Strong, A., 1979. Land banking: European reality, American prospect. John Hopkins University Press, Baltimore, Maryland.

Strong, A., and T. Bancroft. In prep. Patterns of deforestation and fragmentation of mangrove and deciduous seasonal forests in the Upper Florida Keys. National Audubon Society, Tavernier, Florida.

Stys, B. 1993. Ecology and habitat protection needs of the southeastern American kestrel (*Falco sparverius paulus*) on large-scale development sites in Florida. Nongame Wildlife Technical Report No. 13. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Sykes, P. W., Jr. 1984. The range of the Everglade snail kite and its history in Florida. Bulletin of the Florida State Museum, Biological Sciences 29:211-264.

Takekawa, J. E., and S. R. Beissinger. 1989. Cyclic drought, dispersal, and the conservation of the snail kite in Florida: lessons in critical habitat. Conservation Biology 3:302-311.

Tebeau, C. W. 1971. A history of Florida. University of Miami Press, Coral Gables, Florida.

Thomas, J. W., E. D. Forsman, J. B. Lint, E. C. Meslow, B. R. Noon, and J. Verner. 1990. A conservation strategy for the northern spotted owl. U.S. Department of Agriculture and U.S. Department of the Interior, Portland, Oregon.

Turner, D., and J. Laerm. 1993. Systematic relationships of populations of the fox squirrel (*Sciurus niger*) in the southeastern United States. Pages 21-37 in N. Moncried, J. Edwards, and P. Tappe (eds.). Proceedings of the second symposium on southeastern fox squirrels, *Sciurus niger*. Virginia Museum of Natural History Special Publication No. 1. Martinsville, Virginia.

TYDAC. 1991. SPANS spatial analysis system. Intera Tydac Technologies, Inc., Ottawa, Canada.

Umber, R. W., and L. D. Harris. 1974. Effects of intensive forestry on succession and wildlife in Florida sandhills. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 28:686-693.

U.S. Department of Agriculture. 1991. State soil geographic database (STATSGO). Data users guide. Soil Conservation Service, National Soil Survey Center, Lincoln, Nebraska.

U.S. Fish and Wildlife Service. 1986a. Hurricanes damage southeastern beach mouse habitat. Endangered Species Technical Bulletin 11:7-8.

U.S. Fish and Wildlife Service. 1986b. Everglade kite (*Rostrhamus sociabilis plumbeus*, Ridgway) revised recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1987a. 1985 national survey of fishing, hunting, and wildlife-associated recreation, Florida. U.S. Department of the Interior and U.S. Department of Commerce, Bureau of the Census, Washington, D.C.

U.S. Fish and Wildlife Service. 1987b. Habitat management guidelines for the bald eagle in the southeast region. Third revision. U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1987c. Recovery plan for the Alabama beach mouse (*Peromyscus polionotus ammobates*), Perdido Key beach mouse (*P. p. trissyllepsis*), and Choctawhatchee beach mouse (*P. p. allophrys*). U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1987d. Recovery plan for the Florida panther. U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1988. Recovery plan for Florida grasshopper sparrow. U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1992. Proposed establishment of Lake Wales Ridge National Wildlife Refuge. Draft environmental assessment and land protection plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

van Noordwijk, A. J., and W. Scharloo. 1981. Inbreeding in an island population of the great tit. Evolution 35:674-688.

Verner, J., M. L. Morrison, and C. J. Ralph. 1986. Wildlife 2000. Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin.

Walkinshaw, L. H. 1976. The sandhill crane on and near the Kissimmee Prairie, Florida. Pages 1-18 in Lewis, J. (ed.). Proceedings of the international crane workshop. Oklahoma State University Publication and Printing, Stillwater, Oklahoma.

Walter, H. S. 1990. Small viable populations: the red-tailed hawk of Socorro Island. Conservation Biology 4:441-443.

Walters, J. R., P. D. Doerr, and J. H. Carter III. 1988a. The cooperative breeding system of the red-cockaded woodpecker. Ethology 78:275-305.

Walters, J. R., S. K. Hansen, J. H. Carter, III, P. D. Manor, and R. J. Blue. 1988b. Long-distance dispersal of an adult red-cockaded woodpecker. Wilson Bulletin 100:494-496.

Ward, D. (ed.). 1979. Rare and endangered biota of Florida. Volume five. Plants. University Presses of Florida, Gainesville, Florida.

Weaver, K. M., D. T. Tabberer, L. U. Moore, Jr., G. A. Chandler, J. C. Posey, and M. R. Pelton. 1990. Bottomland forest management for black bears in Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 44:342-350.

Weigl, P. D., M. A. Steele, L. J. Sherman, J. C. Ha, and T. S. Sharpe. 1989. The ecology of the fox squirrel (*Sciurus niger*) in North Carolina: implications for survival in the Southeast. Bulletin of the Tall Timbers Research Station 24:1-93.

Wenner, A. S., and S. A. Nesbitt. 1984. The fate of translocated sandhill cranes after 10 years. Florida Field Naturalist 12:19-20.

Williams, K. S., and S. R. Humphrey. 1979. Distribution and status of the endangered Big Cypress fox squirrel (*Sciurus niger avicennia*) in Florida. Florida Scientist 42:201-205.

Williams, L. 1981. The book of the wild turkey. Winchester Press, Tulsa, Oklahoma.

Wilson, E. 1988. The current state of biological diversity. Pages 3-18 in Wilson, E. (ed.). Biodiversity. National Academic Press, Washington, D.C.

Winchester, B. H. 1987. Hydroecology of wetlands on the Ringling MacArthur Reserve. Technical Report 2, CH2M Hill, Inc., Gainesville, Florida.

Winchester, B. H., J. S. Bays, J. C. Higman, and R. L. Knight. 1985. Physiography and vegetation zonation of shallow emergent marshes in southeastern Florida. Wetlands 5:99-118.

Wood, D. A. 1992. Official list of endangered and potentially endangered fauna and flora in Florida. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Wood, P. W., T. C. Edwards, Jr., and M. W. Collopy. 1989. Distribution, ownership status, and habitat characteristics of bald eagle nest sites in Florida. Nongame Wildlife Program final report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Wood, D. A., and S. Wenner. 1983. Status of the red-cockaded woodpecker in Florida: 1983 update. Pages 89-91 in Wood, D. (ed.). Proceedings: red-cockaded woodpecker symposium II. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Wooding, J. B. Unpublished. Possible black bear dispersal corridor. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Wooding, J. B., and J. R. Brady. 1987. Black bear roadkills in Florida. Proceedings of the Annual Conference of the Southeastern Association Fish and Wildlife Agencies 41:438-442.

Wooding, J. B., and T. S. Hardisky. 1988. Black bear habitat study. Final performance report W-41-35. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Wooding, J. B., S. M. Shea, M. L. Richardson, and D. Y. Dowling. 1992. Movements of a female black bear in northwestern Florida. Florida Field Naturalist 20:46-48.

Woolfenden, G., and J. Fitzpatrick. 1984. The Florida scrub jay: demography of a cooperative-breeding bird. Princeton University Press, Princeton, New Jersey.

Wright, S. 1969. Evolution and the genetics of populations. Volume 2. The theory of gene frequencies. University of Chicago Press, Chicago, Illinois.

Zimmerman, B., and R. Bierregaard. 1986. Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Amazona. Journal of Biogeography 13:133-143.

APPENDICES

APPENDIX 1. Common and scientific names of species that appear in the text.

FISH	
Mud sunfish	*Acantharchus pomotis*
Shortnose sturgeon	*Acipenser brevirostrum*
Atlantic sturgeon	*Acipenser oxyrhynchus*
Mountain mullet	*Agonostomus monticola*
Snail bullhead	*Ameiurus brunneus*
Spotted bullhead	*Ameiurus serracanthus*
Alligator gar	*Atractosteus spatula*
River goby	*Awaous tajasica*
Striped croaker	*Bairdiella sanctaeluciae*
Crystal darter	*Crystallaria asprella*
Bluestripe shiner	*Cyprinella callitaenia*
Bannerfin shiner	*Cyprinella leedsi*
Lake Eustis pupfish	*Cyprinodon variegatus hubbsi*
Florida Keys sheepshead minnow	*Cyprinodon variegatus*
Blackbanded sunfish	*Enneacanthus chaetodon*
Harlequin darter	*Etheostoma histrio*
Okaloosa darter	*Etheostoma okaloosae*
Tessellated darter	*Etheostoma olmstedi*
Goldstripe darter	*Etheostoma parvipinne*
Cypress darter	*Etheostoma proeliare*
Florida chub	*Extrarius* sp.
Blair's starhead topminnow	*Fundulus blairae*
Southern gulf killifish	*Fundulus grandis saguanus*
Saltmarsh topminnow	*Fundulus jenkinsi*
Florida Keys southern longnose killifish	*Fundulus similis*
Mangrove gambusia	*Gambusia rhizophorae*
Spottail goby	*Gobionellus stigmaturus*
Cypress minnow	*Hybognathus hayi*
Florida Keys rainwater killifish	*Lucania parva*
Striped shiner	*Luxilus chrysocephalus*
Bandfin shiner	*Luxilus zonistius*
Blacktip shiner	*Lythrurus atrapiculus*
Key silverside	*Menidia conchorum*
Opossum pipefish	*Microphis brachyurus*
Suwannee bass	*Micropterus notius*
Shoal bass	*Micropterus* sp.
River redhorse	*Moxostoma carinatum*
Grayfin redhorse	*Moxostoma* sp.
Bluehead chub	*Nocomis leptocephalus*
Rough shiner	*Notropis baileyi*
Dusky shiner	*Notropis cummingsae*
Blackmouth shiner	*Notropis melanostomus*
Florida logperch	*Percina* sp.
Saddleback darter	*Percina vigil*
Sea lamprey	*Petromyzon marinus*
Florida Keys sailfin molly	*Poecilia latipinna*
Bluenose shiner	*Pteronotropis welaka*
Mangrove rivulus	*Rivulus marmoratus*
Key blenny	*Starksia starcki*
Eastern mudminnow	*Umbra pygmaea*
AMPHIBIANS	
Flatwoods salamander	*Ambystoma cingulatum*
Tiger salamander	*Ambystoma tigrinum*
One-toed amphiuma	*Amphiuma pholeter*
Apalachicola dusky salamander	*Desmognathus apalachicolae*
Seal salamander	*Desmognathus monticola*
Georgia blind salamander	*Haideotriton wallacei*
Four-toed salamander	*Hemidactylium scutatum*
Pine barrens treefrog	*Hyla andersonii*
Striped newt	*Notophthalmus perstriatus*

Gulf hammock dwarf siren	*Pseudobranchus striatus lustricolus*
Gopher frog	*Rana capito*
Florida bog frog	*Rana okaloosae*
Carpenter frog	Rana virgatipes
Many-lined salamander	*Stereochilus marginatus*

REPTILES

Copperhead	*Agkistrodon contortrix*
American alligator	*Alligator mississippiensis*
Gulf coast smooth softshell	*Apalone mutica calvata*
Loggerhead	*Caretta caretta*
Green turtle	*Chelonia mydas*
Spotted turtle	*Clemmys guttata*
American crocodile	*Crocodylus acutus*
Canebrake rattlesnake	*Crotalus horridus*
Leatherback turtle	*Dermochelys coriacea*
Key ringneck snake	*Diadophis punctatus acricus*
Eastern indigo snake	*Drymarchon corais couperi*
Lower Keys red rat snake	*Elaphe guttata*
Hawksbill	*Eretmochelys imbricata*
Coal skink	*Eumeces anthracinus*
Florida Keys mole skink	*Eumeces egregius egregius*
Cedar Keys mole skink	*Eumeces egregius insularis*
Blue-tailed mole skink	*Eumeces egregius lividus*
South Florida rainbow snake	*Farancia erytrogramma seminola*
Gopher tortoise	*Gopherus polyphemus*
Barbour's map turtle	*Graptemys barbouri*
Key mud turtle	*Kinosternon baurii*
Mole kingsnake	*Lampropeltis calligaster*
Apalachicola kingsnake	*Lampropeltis getula goini*
Atlantic ridley	*Lepidochelys kempii*
Alligator snapping turtle	*Macroclemys temminckii*
Mangrove terrapin	*Malaclemys terrapin rhizophorarum*
Sand skink	*Neoseps reynoldsi*
Gulf salt marsh snake	*Nerodia clarkii clarkii*
Atlantic salt marsh snake	*Nerodia clarkii taeniata*
Mississippi green water snake	*Nerodia cyclopion*
Midland water snake	*Nerodia sipedon pleuralis*
Florida pine snake	*Pituophis melanoleucus mugitus*
Suwannee cooter	*Pseudemys concinna suwanniensis*
Florida scrub lizard	*Sceloporus woodi*
Short-tailed snake	*Stilosoma extenuatum*
Lower Keys brown snake	*Storeria dekayi*
Rim rock crowned snake	*Tantilla oolitica*
Lower Keys ribbon snake	*Thamnophis sauritus*

BIRDS

Cooper's hawk	*Accipiter cooperii*
Bachman's sparrow	*Aimophila aestivalis*
Roseate spoonbill	*Ajaia ajaja*
Louisiana seaside sparrow	*Ammodramus maritimus fisheri*
Wakulla seaside sparrow	*Ammodramus maritimus juncicolus*
Cape Sable seaside sparrow	*Ammodramus maritimus mirabilis*
Dusky seaside sparrow	*Ammodramus maritimus nigrescens*
Smyrna seaside sparrow	*Ammodramus maritimus pelonotus*
Scott's seaside sparrow	*Ammodramus maritimus peninsulae*
Florida grasshopper sparrow	*Ammodramus savannarum floridanus*
Brown noddy	*Anous stolidus*
Florida scrub jay	*Aphelocoma coerulescens coerulescens*
Limpkin	*Aramus guarauna*
Great white heron	*Ardea herodias occidentalis*
Florida burrowing owl	*Athene cunicularia floridana*
Short-tailed hawk	*Buteo brachyurus*
Ivory-billed woodpecker	*Campephilus principalis*
Great egret	*Casmerodius albus*
Snowy plover	*Charadrius alexandrinus*

Piping plover	*Charadrius melodus*
Antillean nighthawk	*Chordeiles gundlachii*
Worthington's marsh wren	*Cistothorus palustris griseus*
Marian's marsh wren	*Cistothorus palustris marianae*
Mangrove cuckoo	*Coccyzus minor*
White-crowned pigeon	*Columba leucocephala*
Carolina parakeet	*Conuropsis carolinensis*
Florida prairie warbler	*Dendroica discolor paludicola*
Stoddard's yellow-throated warbler	*Dendroica dominica stoddardi*
Kirtland's warbler	*Dendroica kirtlandii*
Cuban yellow warbler	*Dendroica petechia gundlachi*
Passenger pigeon	*Ectopistes migratorius*
Little blue heron	*Egretta caerulea*
Reddish egret	*Egretta rufescens*
Snowy egret	*Egretta thula*
Tricolored heron	*Egretta tricolor*
American swallow-tailed kite	*Elanoides forficatus*
White ibis	*Eudocimus albus*
Merlin	*Falco columbarius*
Peregrine falcon	*Falco peregrinus*
Southeastern American kestrel	*Falco sparverius paulus*
Magnificent frigatebird	*Fregata magnificens*
Whooping crane	*Grus americana*
Florida sandhill crane	*Grus canadensis pratensis*
American oystercatcher	*Haematopus palliatus*
Bald eagle	*Haliaeetus leucocephalus*
Least bittern	*Ixobrychus exilis*
Black rail	*Laterallus jamaicensis*
Wood stork	*Mycteria americana*
Yellow-crowned night-heron	*Nyctanassa violacea*
Black-crowned night-heron	*Nycticorax nycticorax*
Osprey	*Pandion haliaetus*
Brown pelican	*Pelecanus occidentalis*
Red-cockaded woodpecker	*Picoides borealis*
Hairy woodpecker	*Picoides villosus*
Glossy ibis	*Plegadis falcinellus*
Crested caracara	*Polyborus plancus*
Mangrove clapper rail	*Rallus longirostris insularum*
Florida clapper rail	*Rallus longirostris scottii*
American avocet	*Recurvirostra americana*
Snail kite	*Rostrhamus sociabilis plumbeus*
Black skimmer	*Rynchops niger*
Least tern	*Sterna antillarum*
Caspian tern	*Sterna caspia*
Roseate tern	*Sterna dougallii*
Sooty tern	*Sterna fuscata*
Royal tern	*Sterna maxima*
Sandwich tern	*Sterna sandvicensis*
Black-whiskered vireo	*Vireo altiloquus*

MAMMALS

Sherman's short-tailed shrew	*Blarina carolinensis shermani*
Big brown bat	*Eptesicus fuscus*
Florida mastiff bat	*Eumops glaucinus floridanus*
Florida panther	*Felis concolor coryi*
Bobcat	*Felis rufus*
Hoary bat	*Lasiurus cinereus*
Saltmarsh vole	*Microtus pennsylvanicus dukecampbelli*
Southeastern weasel	*Mustela frenata olivacea*
Florida long-tailed weasel	*Mustela frenata peninsulae*
Gulf salt marsh mink	*Mustela vison halilimnetes*
Atlantic salt marsh mink	*Mustela vison lutensis*
Southern mink	*Mustela vison mink*
Southeastern bat	*Myotis austroriparius*
Gray bat	*Myotis grisescens*
Indiana bat	*Myotis sodalis*
Round-tailed muskrat	*Neofiber alleni*

Key Largo woodrat	*Neotoma floridana smalli*
Key deer	*Odocoileus virginianus clavium*
Pine Island rice rat	*Oryzomys palustris*
Sanibel Island rice rat	*Oryzomys palustris*
Silver rice rat	*Oryzomys argentatus*
Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*
Anastasia Island cotton mouse	*Peromyscus gossypinus anastasae*
Chadwick Beach cotton mouse	*Peromyscus gossypinus restrictus*
Choctawhatchee beach mouse	*Peromyscus polionotus allophrys*
Pallid beach mouse	*Peromyscus polionotus decoloratus*
Santa Rosa beach mouse	*Peromyscus polionotus leucocephalus*
Southeastern beach mouse	*Peromyscus polionotus niveiventris*
St. Andrews beach mouse	*Peromyscus polionotus peninsularis*
Anastasia Island beach mouse	*Peromyscus polionotus phasma*
Perdido Key beach mouse	*Peromyscus polionotus trissyllepsis*
Southeastern big-eared bat	*Plecotus rafinesquii*
Florida mouse	*Podomys floridanus*
Key Vaca raccoon	*Procyon lotor auspicatus*
Mangrove fox squirrel	*Sciurus niger avicennia*
Sherman's fox squirrel	*Sciurus niger shermani*
Southeastern fox squirrel	*Sciurus niger niger*
Lower Keys cotton rat	*Sigmodon hispidus exsputus*
Insular cotton rat	*Sigmodon hispidus insulicola*
Homosassa shrew	*Sorex longirostris eionis*
Southeastern shrew	*Sorex longirostris longirostris*
Lower Keys rabbit	*Sylvilagus palustris hefneri*
Eastern chipmunk	*Tamias striatus*
West Indian manatee	*Trichechus manatus*
Florida black bear	*Ursus americanus floridanus*

MOLLUSCS

Blue Spring aphaostracon	*Aphaostracon asthenes*
Loose-coiled snail	*Aphaostracon chalarogyrus*
Wekiwa Spring aphaostracon	*Aphaostracon monas*
Thick-shelled aphaostracon	*Aphaostracon pycnum*
Sulfur Spring aphaostracon	*Aphaostracon theiocrenetum*
Fenney Spring aphaostracon	*Aphaostracon xynoelictum*
Helicoid Spring snail	*Cincinnatia helicogyra*
Sand grain snail	*Cincinnatia mica*
Enterprise Spring snail	*Cincinnatia monroensis*
Blue Spring snail	*Cincinnatia parva*
Ponderosa Spring snail	*Cincinnatia ponderosa*
Seminole Spring snail	*Cincinnatia vanhyningi*
Wekiwa Spring snail	*Cincinnatia wekiwae*
Florida tree snail	*Liguus fasciatus matecumbensis*
Florida tree snail	*Liguus fasciatus septentrionalis*
Florida tree snail	*Liguus fasciatus solidus*
Banded tree snail	*Orthalicus floridensis*
Florida Keys tree snail	*Orthalicus reses nesodryas*
Stock Island tree snail	*Orthalicus reses reses*
Keys vertigo	*Vertigo hebardi*
Triangle floater	*Alasmidonta undulata*
Florida arc mussel	*Alasmidonta wrightiana*
Fat threeridge	*Amblema neislerii*
Roundlake	*Amblema plicata perplicata*
Apalachicola floater	*Anodonta* sp.
Flat floater	*Anodonta suborbiculata*
Rayed creekshell	*Anodontoides radiatus*
Florida shiny spike	*Elliptio buckleyi*
Fluted elephant-ear	*Elliptio macmichaeli*
Purple bankclimber	*Elliptoideus sloatianus*
Narrow pigtoe	*Fusconaia escambia*
Round ebonyshell	*Fusconaia rotulata*
Round pearlshell	*Glebula rotundata*
Southern sandshell	*Lampsilis australis*
Haddleton's lampsilid clam	*Lampsilis haddletoni*
Southern pocketbook	*Lampsilis ornata*

Gulf moccasinshell	*Medionidus penicillatus*
Ochlockonee moccasinshell	*Medionidus simpsonianus*
Round washboard	*Megalonaias boykiniana*
Atlantic geoduck	*Panopea bitruncata*
Bankclimber	*Plectomerus dombeyanus*
Oval pigtoe	*Pleurobema pyriforme*
Fuzzy pigtoe	*Pleurobema strodeanum*
Jones' lampsilid clam	*Ptychobranchus jonesi*
Southern creekmussel	*Strophitus subvexus*
Athearn's villosa	*Villosa choctawensis*
Shiny rayed-pocketbook	*Villosa subangulata*

ARTHROPODS

Key gnaphosid spider	*Cesonia irvingi*
Torreya trap-door spider	*Cyclocosmia torreya*
Orb weaver	*Eustala eleuthra*
Rosemary wolf spider	*Lycosa ericeticola*
Hobbs' Cave isopod	*Caecidotea hobbsi*
Rock Springs cave isopod	*Caecidotea* sp.
Dougherty Plain cave crayfish	*Cambarus cryptodytes*
Florida cave amphipod	*Crangonyx grandimanus*
Hobbs' cave amphipod	*Crangonyx hobbsi*
Squirrel Chimney cave shrimp	*Palaemonetes cummingi*
Palm Springs cave crayfish	*Procambarus acherontis*
Silver Glen Springs crayfish	*Procambarus attiguus*
Alexander Springs cave crayfish	*Procambarus delicatus*
Econfina crayfish	*Procambarus econfinae*
Red-eyed cave crayfish	*Procambarus erythrops*
Orange Lake cave crayfish	*Procambarus franzi*
Horst's cave crayfish	*Procambarus horsti*
Leitheuser's cave crayfish	*Procambarus leitheuseri*
Light-fleeing cave crayfish	*Procambarus lucifugus*
Miller's cave crayfish	*Procambarus milleri*
Devil's Sink cave crayfish	*Procambarus morrisi*
Woodville cave crayfish	*Procambarus orcinus*
Pallid cave crayfish	*Procambarus pallidus*
Black Creek crayfish	*Procambarus pictus*
Mclane's cave crayfish	Troglocambarus maclanei
Say's spiketail dragonfly	*Cordulegaster sayi*
Maidencane cruiser	*Didymops floridensis*
Eastern ringtail	*Erpetogomphus designatus*
Sandhill clubtail	*Gomphus cavillaris*
Selys' skimmer	*Helocordulia selysii*
Common rubywing	*Hetaerina americana*
Elegant dryad	*Lestes inaequalis*
Purple chaser	*Libellula jesseana*
Apalachicola twilight skimmer	*Neurocordulia clara*
Tawny sand clubtail	*Progomphus alachuensis*
Highlands tiger beetle	*Cicindela highlandensis*
Peninsular tiger beetle	*Cicindela hirtilabris*
Scrub tiger beetle	*Cicindela scabrosa*
Florida intertidal firefly	*Micronaspis floridana*
Everglades brownwing firefly	*Photuris brunnipennis floridana*
Turtle Mound firefly	*Photuris* sp.
Florida leafwing	*Anaea floridalis*
Maesites hairstreak	*Chlorostrymon maesites maesites*
Florida atala	*Eumaeus atala florida*
Florida purplewing	*Eunica tatila tatilista*
Miami blue butterfly	*Hemiargus thomasi bethunebakeri*
Bahama swallowtail	*Heraclides andraemon bonhotei*
Schaus' swallowtail	*Heraclides artistodemus ponceanus*
Hessel's hairstreak	*Mitoura hesseli*
Gaura sphinx	*Proserpinus gaurae*
Ceromatic noctuid moth	*Pyreferra ceromatica*
Bartram's hairstreak	*Strymon acis bartrami*
Florida asaphomyian tabanid fly	*Asaphomyia floridensis*
Brown merycomyian tabanid fly	*Merycomyia brunnea*

Delong's mixogaster flower fly	*Mixogaster delongi*
Sugarfoot fly	*Nemopalpus nearcticus*

PLANTS AND LICHENS

Tamarindillo	*Acacia choriophylla*
Red maple	*Acer rubrum*
Golden leather fern	*Acrostichum aureum*
White baneberry	*Actaea pachypoda*
Ray fern	*Actinostachys pennula*
Southern maidenhair fern	*Adiantum capillus-veneris*
Fragrant maidenhair fern	*Adiantum melanoleucum*
Brittle maidenhair fern	*Adiantum tenerum*
Four-leaved maidenhair fern	*Adiantum tetraphyllum*
Incised groove-bur	*Agrimonia incisa*
Everglades leaf lace	*Alvaradoa amorphoides*
Crenulate lead-plant	*Amorpha crenulata*
Balsam torchwood	*Amyris balsamifera*
Pine-woods bluestem	*Andropogon arctatus*
Broomsedge	*Andropogon* sp.
Wright's anemia	*Anemia wrightii*
Texas anemone	*Anemone berlandieri*
Rue-anemone	*Anemonella thalictroides*
Marianna columbine	*Aquilegia canadensis* var. *australis*
Sicklepod	*Arabis canadensis*
Blodgett's wild-mercury	*Argythamnia blodgettii*
Florida threeawn	*Aristida rhizomophora*
Southern three-awned grass	*Aristida simpliciflora*
Wiregrass	*Aristida stricta*
Dutchman's pipe	*Aristolochia pentandra*
Variable-leaved Indian-plantain	*Arnoglossum diversifolium*
Curtiss' milkweed	*Asclepias curtissii*
Southern milkweed	*Asclepias viridula*
Four-petal pawpaw	*Asimina tetramera*
Auricled spleenwort	*Asplenium auritum*
Single-sorus spleenwort	*Asplenium monanthes*
Dwarf spleenwort	*Asplenium pumilum*
Bird's nest spleenwort	*Asplenium serratum*
Slender spleenwort	*Asplenium trichomanes-dentatum*
Eaton's spleenwort	*Asplenium* x *biscayneanum*
Curtiss' spleenwort	*Asplenium* x *curtissii*
Wagner's spleenwort	*Asplenium* x *heteroresiliens*
Aster	*Aster hemisphericus*
Pine-woods aster	*Aster spinulosus*
Apalachicola River aster	*Aster vimineus* var. *vimineus*
Black mangrove	*Avicennia germinans*
Saltbush	*Baccharis halimifolia*
Purple balduina	*Balduina atropurpurea*
Canby's wild indigo	*Baptisia calycosa* var. *calycosa*
Hairy wild indigo	*Baptisia calycosa* var. *villosa*
Apalachicola wild indigo	*Baptisia megacarpa*
Scare-weed	*Baptisia simplicifolia*
Rockland orchid	*Basiphyllaea corallicola*
Saltwort	*Batis maritima*
Tar flower	*Befaria racemosa*
River birch	*Betula nigra*
Beggar ticks	*Bidens* sp.
Nuttall's rayless goldenrod	*Bigelowia nuttallii*
Sinkhole fern	*Blechnum occidentale*
Haitian bletia	*Bletia patula*
Florida bonamia	*Bonamia grandiflora*
Sea oxeye daisy	*Borrichia frutescens*
Winter grape-fern	*Botrychium lunarioides*
Little strongbark	*Bourreria cassinifolia*
Rough strongbark	*Bourreria radula*
Water shield	*Brasenia schreberi*
Spider orchid	*Brassia caudata*
Flyr's brickell-bush	*Brickellia cordifolia*

Florida thoroughwort brickell-bush	*Brickellia mosieri*
Rat-tail orchid	*Bulbophyllum pachyrrachi*s
Buckthorn	*Bumelia lycioides*
Buckthorn	*Bumelia thornei*
Fakahatchee burmannia	*Burmannia flava*
Gumbo-limbo	*Bursera simaruba*
Locustberry	*Byrsonima lucida*
Ashe's savory	*Calamintha ashei*
Toothed savory	*Calamintha dentata*
Curtiss' sandgrass	*Calamovilfa curtissii*
Woods poppy-mallow	*Callirhoe papaver*
Sweet shrub	*Calycanthus floridus* var. *floridus*
Myrtle-of-the-river	*Calyptranthes zuzygium*
Trailing bindweed	*Calystegia catesbiana*
Brooksville bellflower	*Campanula robinsiae*
Leafless orchid	*Campylocentrum pachyrrhizum*
Narrow-leaved strap fern	*Campyloneurum angustifolium*
Tailed strap fern	*Campyloneurum costatum*
Wild cinnamon	*Canella winteriana*
Baltzell's sedge	*Carex baltzellii*
Chapman's sedge	*Carex chapmanii*
Sandhill sedge	*Carex tenax*
Blue beech	*Carpinus caroliniana*
Water hickory	*Carya aquatica*
Scrub hickory	*Carya floridana*
Pignut hickory	*Carya glabra*
Mockernut hickory	*Carya tomentosa*
Big Pine partridge pea	*Cassia keyensis*
Australian pine	*Casuarina* sp.
Small-flowered lily-thorn	*Catesbaea parviflora*
Powdery catopsis	*Catopsis berteroniana*
Many-flowered catopsis	*Catopsis floribunda*
Nodding catopsis	*Catopsis nutans*
Perforate reindeer lichen	*Cladonia perforata*
Iguana hackberry	*Celtis iguanaea*
Spiny hackberry	*Celtis pallida*
Buttonbush	*Cephalanthus occidentalis*
Spurred neottia	*Centrogenium setaceum*
Sand butterfly pea	*Centrosema arenicola*
Rosemary	*Ceratiola ericoides*
Fragrant prickly-apple	*Cereus eriophorus* var. *fragrans*
Aboriginal prickly-apple	*Cereus gracilis* var. *aboriginum*
Simpson's prickly-apple	*Cereus gracilis* var. *simpsonii*
Key tree-cactus	*Cereus robinii* var. *deeringii*
Big Pine tree-cactus	*Cereus robinii* var. *robinii*
Atlantic white cedar	*Chamaecyparis thyoides*
Sand-dune spurge	*Chamaesyce cumulicola*
Pinelands spurge	*Chamaesyce deltoidea* ssp. 1
Deltoid spurge	*Chamaesyce deltoidea* ssp. *deltoidea*
Wedge spurge	*Chamaesyce deltoidea* ssp. *serpyllum*
Garber's spurge	*Chamaesyce garberi*
Porter's hairy-podded spurge	*Chamaesyce porteriana* var. *keyensis*
Porter's broad-leaved spurge	*Chamaesyce porteriana* var. *porteriana*
Porter's broom spurge	*Chamaesyce porteriana* var. *scoparia*
Southern lip fern	*Cheilanthes microphylla*
Pygmy fringe-tree	*Chionanthus pygmaeus*
Cocoplum	*Chrysobalanus icaco*
Florida golden aster	*Chrysopsis floridana*
Godfrey's golden aster	*Chrysopsis godfreyi*
Cruise's golden aster	*Chrysopsis gossypina* ssp. *cruiseana*
Mexican hibiscus	*Cienfuegosia yucatanensis*
Sawgrass	*Cladium jamaicense*
Pond rush	*Cladium mariscoides*
A virgin's bower	*Clematis catesbyana*
Sweet pepper bush	*Clethra alnifolia*
Black titi	*Cliftonia monophylla*
Pigeon-wing	*Clitoria fragrans*
Pigeon plum	*Coccoloba diversifolia*

Sea grape	*Coccoloba uvifera*
Silver palm	*Coccothrinax argentata*
Piedmont jointgrass	*Coelorachis tuberculosa*
Cuban snake-bark	*Colubrina cubensis* var. *floridana*
Short-leaved rosemary	*Conradina brevifolia*
Etonia rosemary	*Conradina etonia*
Apalachicola rosemary	*Conradina glabra*
Large-flowered rosemary	*Conradina grandiflora*
Autumn coral-root	*Corallorhiza odontorhiza*
Geiger tree	*Cordia sebestena*
Dye-flower	*Coreopsis integrifolia*
Alternate-leaf dogwood	*Cornus alternifolia*
American dogwood	*Cornus florida*
Cranefly orchid	*Cranichis muscosa*
Washington thorn	*Crataegus phaenopyrum*
Calabash tree	*Crescentia cujete*
Croomia	*Croomia pauciflora*
Christmas berry	*Crossopetalum ilicifolium*
Rhacoma	*Crossopetalum rhacoma*
Avon Park rabbit-bells	*Crotalaria avonensis*
Elliott's croton	*Croton elliottii*
Canada honewort	*Cryptotaenia canadensis*
Florida tree fern	*Ctenitis sloanei*
Florida toothache grass	*Ctenium floridanum*
Okeechobee gourd	*Cucurbita okeechobeensis* ssp. *okeechobeensis*
Cupania	*Cupania glabra*
Tropical waxweed	*Cuphea aspera*
Wild comphrey	*Cynoglossum virginianum*
Scrub leatherwood	*Cyrilla arida*
Swamp cyrilla	*Cyrilla racemiflora*
Cow-horned orchid	*Cyrtopodium punctatum*
Beautiful pawpaw	*Deeringothamnus pulchellus*
Rugel's pawpaw	*Deeringothamnus rugelii*
Carolina larkspur	*Delphinium carolinianum*
Hay scented fern	*Dennstaedtia bipinnata*
Garrett's scrub balm	*Dicerandra christmanii*
Longspurred mint	*Dicerandra cornutissima*
Scrub mint	*Dicerandra frutescens*
Lakela's mint	*Dicerandra immaculata*
Florida white-top sedge	*Dichromena floridensis*
Florida crabgrass	*Digitaria floridana*
Longleaf crabgrass	*Digitaria gracillima*
Few-flowered crabgrass	*Digitaria pauciflora*
Bustic	*Dipholis salicifolia*
Eastern leatherwood	*Dirca palustris*
Saltgrass	*Distichlis spicata*
Shootingstar	*Dodecatheon meadia*
Spoon-leaved sundew	*Drosera intermedia*
Milk bark	*Drypetes diversifolia*
Eastern purple coneflower	*Echinacea purpurea*
Water hyacinth	*Eichhornia crassipes*
Beaked spikerush	*Eleocharis rostellata*
Spike rush	*Eleocharis* sp.
Narrow-leaved Carolina scalystem	*Elytraria caroliniensis* var. *angustifolia*
Dollar orchid	*Encyclia boothiana* var. *erythronioides*
Clamshell orchid	*Encyclia cochleata* var. *triandra*
Dwarf encyclia	*Encyclia pygmaea*
Acuna's epidendrum	*Epidendrum acunae*
Night-scented orchid	*Epidendrum nocturnum*
Pendant epidendrum	*Epidendrum strobiliferum*
Trailing arbutus	*Epigaea repens*
Sanibel lovegrass	*Eragrostis tracyi*
A cupgrass	*Eriochloa michauxii* var. *simpsonii*
Scrub buckwheat	*Eriogonum longifolium* var. *gnaphalifolium*
Wedge-leaved button-snakeroot	*Eryngium cuneifolium*
Trout lily	*Erythronium umbilicatum*
Eucalyptus	*Eucalyptis robusta*
Tropical ironwood	*Eugenia confusa*

Red stopper	*Eugenia rhombea*
Dogfennel	*Eupatorium capillifolium*
Villose fennel	*Eupatorium villosum*
Wood spurge	*Euphorbia commutata*
Telephus spurge	*Euphorbia telephioides*
Burningbush	*Evonymus atropurpurea*
American beech	*Fagus grandifolia*
Strangler fig	*Ficus aurea*
White ash	*Fraxinus americana*
Swamp ash	*Fraxinus caroliniana*
Florida pinewood privet	*Forestiera segregata* var. *pinetorum*
Pineland milk-pea	*Galactia pinetorum*
Small's milkpea	*Galactia smallii*
Milk peas	*Galactia* sp.
Galeandra	*Galeandra beyrichii*
Wiregrass gentian	*Gentiana pennelliana*
Coastal vervain	*Glandularia maritima*
Tampa vervain	*Glandularia tampensis*
Downy rattlesnake plantain	*Goodyera pubescens*
Loblolly bay	*Gordonia lasianthus*
Wild cotton	*Gossypium hirsutum*
Sheathing govenia	*Govenia utriculata*
Lignum-vitae	*Guaiacum sanctum*
Fuch's bromeliad	*Guzmania monostachia*
False boxwood	*Gyminda latifolia*
Chapman's skeletongrass	*Gymnopogon chapmanianus*
Johnson's seagrass	*Halophila johnsonii*
Harper's beauty	*Harperocallis flava*
Hartwrightia	*Hartwrightia floridana*
Mock pennyroyal	*Hedeoma graveolens*
Narrow-leaved bluets	*Hedyotis nigricans* var. *pulvinata*
Gulf rockrose	*Helianthemum arenicola*
Lake-side sunflower	*Helianthus carnosus*
Hairy beach sunflower	*Helianthus debilis* ssp. *vestitus*
Liverleaf	*Hepatica nobilis*
Heartleaf	*Hexastylis arifolia*
Manchineel	*Hippomane mancinella*
Hanging clubmoss	*Huperzia dichotoma*
Green violet	*Hybanthus concolor*
Wild hydrangea	*Hydrangea arborescens*
Panhandle spiderlily	*Hymenocallis henryae*
Broad-leaved spiderlily	*Hymenocallis latifolia*
Inkwood	*Hypelate trifoliata*
Highlands scrub hypericum	*Hypericum cumulicola*
Edison's ascyrum	*Hypericum edisonianum*
Smooth-barked St. John's-wort	*Hypericum lissophloeus*
Serviceberry holly	*Ilex amelanchier*
Dahoon holly	*Ilex cassine*
Large gallberry	*Ilex coriacea*
Gallberry	*Ilex glabra*
Myrtle-leaf holly	*Ilex myrtifolia*
American holly	*Ilex opaca*
Scrub holly	*Ilex opaca* var. *arenicola*
Yaupon holly	*Ilex vomitoria*
Florida anise	*Illicium floridanum*
Star anise	*Illicium parviflorum*
Decumbent indigo	*Indigofera keyensis*
Delicate ionopsis	*Ionopsis utricularioides*
Wild potato morning-glory	*Ipomoea microdactyla*
Railroad vine	*Ipomoea pes-caprae*
Beach morning glory	*Ipomoea stolonifera*
Rocklands morning-glory	*Ipomoea tenuissima*
False rue-anemone	*Isopyrum biternatum*
Large whorled pogonia	*Isotria verticillata*
Marsh elder	*Iva frutescens*
Pineland jacquemontia	*Jacquemontia curtissii*
Cuban jacquemontia	*Jacquemontia havanensis*
Beach jacquemontia	*Jacquemontia reclinata*

Joewood	*Jacquinia keyensis*
Coville's rush	*Juncus gymnocarpus*
Southern red cedar	*Juniperus virginiana*
Everglades water willow	*Justicia angusta*
Cooley's water-willow	*Justicia cooleyi*
Thick-leaved water-willow	*Justicia crassifolia*
Mountain laurel	*Kalmia latifolia*
Bog-button	*Lachnocaulon digynum*
White mangrove	*Laguncularia racemosa*
Florida lantana	*Lantana depressa* var. *depressa*
Small-headed lantana	*Lantana microcephala*
Nodding pinweed	*Lechea cernua*
Pine pinweed	*Lechea divaricata*
Lakela's pinweed	*Lechea lakelae*
Ghost plant	*Leiphaimos parasitica*
Corkwood	*Leitneria floridana*
Smooth-lipped leochilus	*Leochilus labiatus*
Duckweed	*Lemna* sp.
Tiny orchid	*Lepanthopsis melanantha*
Little-people	*Lepuropetalon spathulatum*
Dog-hobble	*Leucothoe axillaris*
Florida gay-feather	*Liatris ohlingerae*
Godfrey's blazing star	*Liatris provincialis*
Gulf licaria	*Licaria triandra*
Carolina lilaeopsis	*Lilaeopsis carolinensis*
Southern red lily	*Lilium catesbaei*
Panhandle lily	*Lilium iridollae*
Carolina lily	*Lilium michauxii*
Turk's cap lily	*Lilium superbum*
Pondberry	*Lindera melissifolia*
Bog spicebush	*Lindera subcoriacea*
Sand flax	*Linum arenicola*
Carter's small-flowered flax	*Linum carteri* var. *carteri*
Carter's large-flowered flax	*Linum carteri* var. *smallii*
Harper's grooved-yellow flax	*Linum sulcatum* var. *harperi*
West's flax	*Linum westii*
Sweetgum	*Liquidambar styraciflua*
Pondspice	*Litsea aestivalis*
Holly vine fern	*Lomariopsis kunzeana*
Primrose willow	*Ludwigia peruviana*
Scrub lupine	*Lupinus aridorum*
Gulf Coast lupine	*Lupinus westianus*
Rusty lyonia	*Lyonia ferruginea*
Fetterbush	*Lyonia lucida*
Staggerbush	*Lyonia* sp.
Bahama lysil	*Lysiloma latisiliquum*
Curtiss' loosestrife	*Lythrum curtissii*
Lowland loosestrife	*Lythrum flagellare*
White birds-in-a-nest	*Macbridea alba*
Trinidad macradenia	*Macradenia lutescens*
Hummingbird flower	*Macranthera flammea*
Cucumber magnolia	*Magnolia acuminata*
Ashe's magnolia	*Magnolia ashei*
Southern magnolia	*Magnolia grandiflora*
Pyramid magnolia	*Magnolia pyramidata*
Umbrella magnolia	*Magnolia tripetala*
Sweetbay	*Magnolia virginiana*
Green adder's-mouth	*Malaxis unifolia*
Wild dilly	*Manilkara bahamensis*
Barbara's buttons	*Marshallia obovata*
Southern marshallia	*Marshallia ramosa*
Mastic	*Mastichodendron foetidissimum*
Alabama anglepod	*Matelea alabamensis*
Baldwyn's spiny-pod	*Matelea baldwyniana*
Carolina milkvine	*Matelea flavidula*
Florida spiny-pod	*Matelea floridana*
Hidden orchid	*Maxillaria crassifolia*
Indian cucumber-root	*Medeola virginiana*

Melaleuca	*Melaleuca quinquenervia*
Small-leaved melanthera	*Melanthera parvifolia*
Poisonwood	*Metopium toxiferum*
Climbing vine fern	*Microgramma heterophylla*
Godfrey's sandwort	*Minuartia godfreyi*
Pinesap	*Monotropa hypopithys*
Pigmy-pipes	*Monotropsis reynoldsiae*
Mulberry	*Morus rubra*
Twinberry	*Myrcianthes fragrans* var. *simpsonii*
Wax myrtle	*Myrica cerifera*
Piedmont water-milfoil	*Myriophyllum laxum*
Lotus	*Nelumbo lutea*
Fall-flowering ixia	*Nemastylis floridana*
Ribbon fern	*Nevrodium lanceolatum*
Florida bear-grass	*Nolina atopocarpa*
Britton's bear-grass	*Nolina brittoniana*
West Florida cowlily	*Nuphar luteum* ssp. *ulvaceum*
Spatterdock	*Nuphar* sp.
Sleeping-beauty water-lily	*Nymphaea jamesoniana*
Water tupelo	*Nyssa aquatica*
Blackgum	*Nyssa sylvatica* var. *sylvatica*
Bog tupelo	*Nyssa ursina*
Lancewood	*Ocotea coriacea*
Burrowing four-o'clock	*Okenia hypogaea*
Dancing-lady orchid	*Oncidium bahamense*
Florida oncidium	*Oncidium floridanum*
Mule ear orchid	*Oncidium luridum*
Hand fern	*Ophioglossum palmatum*
Florida semaphore cactus	*Opuntia spinosissima*
Three-spined prickly-pear	*Opuntia triacantha*
Cinnamon fern	*Osmunda cinnamomea*
Royal fern	*Osmunda regalis*
Hop hornbeam	*Ostrya virginiana*
Sourgum	*Oxydendron arboreum*
Giant water-dropwort	*Oxypolis greenmanii*
Allegheny-spurge	*Pachysandra procumbens*
Cutthroat grass	*Panicum abscissum*
Maidencane	*Panicum hemitomon*
Naked-stemmed panic grass	*Panicum nudicaule*
Carolina grass-of-parnassus	*Parnassia caroliniana*
Large-flowered grass-of-parnassus	*Parnassia grandifolia*
Paper-like nailwort	*Paronychia chartacea* ssp. *chartacea*
Crystal lake nailwort	*Paronychia chartacea* ssp. *minima*
Whitish passionflower	*Passiflora multiflora*
Yellow hibiscus	*Pavonia spinifex*
Purple cliff brake	*Pellaea atropurpurea*
Spoon-flower	*Peltandra sagittifolia*
Cypress peperomia	*Peperomia glabella*
Terrestrial peperomia	*Peperomia humilis*
Blunt-leaved peperomia	*Peperomia obtusifolia*
Scrub bay	*Persea humilis*
Swamp bay	*Persea palustris*
Creeping-leaf stalkgrass	*Pharus parvifolius*
Mahogony mistletoe	*Phoradendron rubrum*
Pine-wood dainties	*Phyllanthus leibmannianus* ssp. *platylepis*
Florida five-petaled leaf-flower	*Phyllanthus pentaphyllus* ssp. *floridanus*
Ninebark	*Physocarpus opulifolius*
Apalachicola dragon-head	*Physostegia godfreyi*
Slender-leaved dragon-head	*Physostegia leptophylla*
Bitter bush	*Picramnia pentandra*
Violet-flowered butterwort	*Pinguicula ionantha*
Chapman's butterwort	*Pinguicula planifolia*
Shortleaf pine	*Pinus echinata*
Slash pine	*Pinus elliottii*
Longleaf Pine	*Pinus palustris*
Sand Pine	*Pinus clausa*
Spruce pine	*Pinus glabra*
Pond pine	*Pinus serotina*

Loblolly pine	*Pinus taeda*
Jamaica dogwood	*Piscidia piscipula*
Rock Key devil's-claws	*Pisonia floridana*
Bent golden aster	*Pityopsis flexuosa*
Little club-spur orchid	*Platanthera clavellata*
Yellow fringeless orchid	*Platanthera integra*
American sycamore	*Platanus occidentalis*
Star-scale fern	*Pleopeltis revoluta*
Frost-flower orchid	*Pleurothallis gelida*
May apple	*Podophyllum peltatum*
Rockland painted-leaf	*Poinsettia pinetorum*
Boykin's few-leaved milkwort	*Polygala boykinii* var. *sparsifolia*
Lewton's polygala	*Polygala lewtonii*
Tiny polygala	*Polygala smallii*
Hairy jointweed	*Polygonella basiramia*
Large-leaved jointweed	*Polygonella macrophylla*
Small's jointweed	*Polygonella myriophylla*
Mexican tear-thumb	*Polygonum meisnerianum*
Tennessee leafcup	*Polymnia laevigata*
Ghost orchid	*Polyrrhiza lindenii*
Pickerel weed	*Pontederia cordata*
Bahama shadow-witch	*Ponthieva brittoniae* var. *brittoniae*
Florida pondweed	*Potamogeton floridanus*
Small-flowered prescotia	*Prescotia oligantha*
Scrub plum	*Prunus geniculata*
West-Indian cherry	*Prunus myrtifolia*
Florida cherry-palm	*Pseudophoenix sargentii*
Bahama brake	*Pteris bahamensis*
A wild coco	*Pteroglossaspis ecristata*
Florida mountain-mint	*Pycnanthemum floridanum*
Bluejack oak	*Quercus incana*
Chapman's oak	*Quercus chapmanii*
Sand live oak	*Quercus geminata*
Laurel oak	*Quercus hemisphaerica*
Overcup oak	*Quercus lyrata*
Sand post oak	*Quercus margaretta*
Blackjack oak	*Quercus marilandica*
Myrtle oak	*Quercus myrtifolia*
Live oak	*Quercus virginiana*
Buttercup	*Ranunculus marginatus*
Beach-star	*Remirea maritima*
Snake orchid	*Restrepiella ophiocephala*
A meadowbeauty	*Rhexia parviflora*
Panhandle meadowbeauty	*Rhexia salicifolia*
Mistletoe cactus	*Rhipsalis baccifera*
Red mangrove	*Rhizophora mangle*
Orange azalea	*Rhododendron austrinum*
Chapman's rhododendron	*Rhododendron chapmanii*
Brown-haired snoutbean	*Rhynchosia cinerea*
Hairy-peduncled beak-rush	*Rhynchospora crinipes*
Georgia beak-rush	*Rhynchospora culixa*
Decurrent beak-rush	*Rhynchospora decurrens*
Pineland beak-rush	*Rhynchospora punctata*
Narrow-leaved beakrush	*Rhynchospora stenophylla*
Miccosukee gooseberry	*Ribes echinellum*
Florida royal palm	*Roystonea elata*
Blackberry	*Rubus* sp.
St. John's-susan	*Rudbeckia nitida* var. *nitida*
Pinnate-lobed coneflower	*Rudbeckia triloba* var. *pinnatiloba*
White-flowered wild petunia	*Ruellia noctiflora*
Cabbage palm	*Sabal palmetto*
Bahama sachsia	*Sachsia polycephala*
Glasswort	*Salicornia* sp.
Arrowhead	*Sagittaria* sp.
Heart-leaved willow	*Salix eriocephala*
Florida willow	*Salix floridana*
Bartram's ixia	*Salpingostylis coelestina*
Blodgett's sage	*Salvia blodgettii*

Chapman's sage	*Salvia chapmanii*
Nettle-leaved sage	*Salvia urticifolia*
Elderberry	*Sambucus canadensis*
White-top pitcher-plant	*Sarracenia leucophylla*
Sweet pitcher-plant	*Sarracenia rubra*
Lizards-tail	*Saururus cernuus*
Maiden bush	*Savia bahamensis*
Yellowwood	*Schaefferia frutescens*
Brazilian pepper	*Schinus terebinthifolius*
Schisandra	*Schisandra coccinea*
Scrub bluestem	*Schizachyrium niveum*
Chaffseed	*Schwalbea americana*
Bulrush	*Scirpus* sp.
Florida skullcap	*Scutellaria floridana*
Meadow spikemoss	*Selaginella apoda*
Eaton's spikemoss	*Selaginella eatonii*
Gulf spikemoss	*Selaginella ludoviciana*
Saw palmetto	*Serenoa repens*
Fringed campion	*Silene polypetala*
Virginia campion	*Silene virginica*
Florida water-parsnip	*Sium floridanum*
Greenbriar	*Smilax* sp.
Rugel's Key West horse-nettle	*Solanum bahamense* var. *rugelii*
Necklace pod	*Sophora tomentosa*
Wedgelet fern	*Sphenomeris clavata*
Gentian pinkroot	*Spigelia gentianoides*
A pinkroot	*Spigelia loganioides*
Reichenbach's orchid	*Spiranthes costaricensis*
Tall neottia	*Spiranthes elata*
A ladies'-tresses	*Spiranthes lanceolata* var. *paludicola*
Green ladies'-tresses	*Spiranthes polyantha*
Southern ladies'-tresses	*Spiranthes tortilis*
Shade betony	*Stachys crenata*
Tallahassee hedge-nettle	*Stachys hyssopifolia* var. *lythroides*
American bladdernut	*Staphylea trifolia*
Silky camellia	*Stewartia malacodendron*
A queen's delight	*Stillingia sylvatica* ssp. *tenuis*
Pride-of-Big-Pine	*Strumpfia maritima*
Scrub stylisma	*Stylisma abdita*
Pineland pencil flowers	*Stylosanthes calcicola*
Bay cedar	*Suriana maritima*
West Indies mahogany (mahogany)	*Swietenia mahagoni*
Florida yew	*Taxus floridana*
Bald cypress	*Taxodium distichum*
Hattie Bauer halberd fern	*Tectaria coriandrifolia*
Incised halberd	*Tectaria incisa*
Lobed halberd	*Tectaria lobata*
Ames halberd fern	T*ectaria x amesiana*
Coastal hoary-pea	*Tephrosia angustissima*
Everglades Key hoary-pea	*Tephrosia corallicola*
Pineland hoary-pea	*Tephrosia mohrii*
Grooved tetramicra	*Tetramicra canaliculata*
Tetrazygia	*Tetrazygia bicolor*
Fire flag	*Thalia geniculata*
Cooley's meadowrue	*Thalictrum cooleyi*
Creeping fern	*Thelypteris reptans*
Hard-leaved shield fern	*Thelypteris sclerophylla*
Brittle thatch palm	*Thrinax morrisii*
Florida thatch palm	*Thrinax radiata*
Thatch palms	*Thrinax* sp.
Basswood	*Tilia americana*
Banded wild-pine	*Tillandsia flexuosa*
Fuzzy-wuzzy air-plant	*Tillandsia pruinosa*
Florida torreya	*Torreya taxifolia*
Sea lavender	*Tournefortia gnaphalodes*
Pineland noseburn	*Tragia saxicola*
Entire-winged bristle fern	*Trichomanes holopterum*
Kraus' bristle fern	*Trichomanes krausii*

Plateau bristle fern	*Trichomanes petersii*
Florida bristle fern	*Trichomanes punctatum*
Narrow-leaved trillium	*Trillium lancifolium*
Craighead's nodding-caps	*Triphora craigheadii*
Broad-leaved nodding-caps	*Triphora latifolia*
Rickett's nodding-caps	*Triphora rickettii*
Florida gama grass	*Tripsacum floridanum*
Young-palm orchid	*Tropidia polystachya*
Cattail	*Typha* sp.
Florida elm	*Ulmus americana*
Cedar elm	*Ulmus crassifolia*
Sea oats	*Uniola paniculata*
Florida merrybells	*Uvularia floridana*
Pearl berry	*Vallesia antillana*
Worm-vine orchid	*Vanilla barbellata*
Scentless vanilla	*Vanilla mexicana*
Brown-flowered vanilla	*Vanilla phaeantha*
False hellebore	*Veratrum woodii*
Chapman's crownbeard	*Verbesina chapmanii*
Variable-leaf crownbeard	*Verbesina heterophylla*
Blodgett's ironweed	*Vernonia blodgettii*
Ocala vetch	*Vicia ocalensis*
Halberd-leaved yellow violet	*Viola tripartita* var. *glaberrima*
Clasping warea	*Warea amplexifolia*
Carter's warea	*Warea carteri*
Blunt-lobed cliff fern	*Woodsia obtusa*
Yellow-root	*Xanthorhiza simplicissima*
Chapman's yellow-eyed grass	*Xyris chapmanii*
Drummond's yellow-eyed grass	*Xyris drummondii*
Quillwort yellow-eyed grass	*Xyris isoetifolia*
Karst pond xyris	*Xyris longisepala*
Kral's yellow-eyed grass	*Xyris louisianica*
Harper's yellow-eyed grass	*Xyris scabrifolia*
Spanish bayonet	*Yucca aloifolia*
Northern prickley ash	*Zanthoxylum americanum*
Biscayne prickly ash	*Zanthoxylum coriaceum*
Yellowheart	*Zanthoxylum flavum*
Rain lily	*Zephyranthes simpsonii*
Scrub ziziphus	*Ziziphus celata*

APPENDIX 2. Description of land-cover classification developed for the landsat habitat mapping project.

The Landsat classifications were grouped into general categories that corresponded to classifications presented by Davis (1967), Hartman (1978), and Soil Conservation Service (undated). The specific types of plant communities mapped in this project were based on: (1) the ability to map the communities accurately using satellite data and image classification techniques; (2) the importance of various land-cover types to different wildlife species; and (3) the need to complete the statewide vegetation mapping effort within a three-year time period.

A. UPLAND PLANT COMMUNITIES

Coastal Strand. Coastal strand occurs on well drained sandy soils and includes the typical zoned vegetation of the upper beach, nearby dunes, and coastal rock formations. Coastal strand generally occurs in a narrow band parallel to open waters of the Atlantic Ocean or Gulf of Mexico, and along the shores of some saline bays or sounds in both north and south Florida. This community occupies areas formed along high energy shorelines, and is influenced by wind, waves, and salt spray. Vegetation within this community typically consists of low growing vines, grasses, and herbaceous plants with very few small trees or large shrubs. Pioneer or early successional herbaceous vegetation characterizes the foredune and upper beach, while a gradual change to woody plant species occurs in more protected areas landward. Typical plant species include beach morning glory, railroad vine, sea oats, saw palmetto, spanish bayonet, yaupon holly, and wax myrtle. Sea grape, cocoplum, and other tropical species are also found in this land-cover type in southern Florida. The coastal strand community only includes the zone of early successional vegetation that lies between the upper beach, and more highly developed communities landward. Adjacent or contiguous community types such as xeric oak scrubs, pinelands, or hardwood forests were classified and mapped respectively.

Dry Prairie. Dry prairies are large native grass and shrub lands that occur on flat terrain interspersed with scattered cypress domes and strands, bayheads, isolated freshwater marshes, and hardwood hammocks. This community is characterized by many species of grasses, sedges, herbs, and shrubs, including saw palmetto, fetterbush, staggerbush, tar flower, gallberry, wiregrass, carpet grasses, and various types of bluestem grasses. The largest areas of these treeless plains historically occurred just north of Lake Okeechobee, and they were subject to frequent fires. Many of these areas have been converted to improved pasture. In central and south Florida, palmetto prairies, which consist of former pine flatwoods where the overstory trees have been thinned or removed, are also included in this category. These sites contain scattered pines that cover less than 15% of an area.

Pinelands. The pinelands category includes several more specific groups of north and south Florida pine flatwoods, south Florida pine rocklands, and, reluctantly, commercial pine plantations. Pine flatwoods occur on flat sandy terrain where the overstory is characterized by longleaf pine, slash pine, or pond pine. Generally, flatwoods dominated by longleaf pine occur on well drained sites, pond pine is found in poorly drained areas, and slash pine occupies intermediate or moderately moist areas. The understory and ground cover within these 3 communities are somewhat similar and include several common species such as saw palmetto, gallberry, wax myrtle, and a wide variety of grasses and herbs. Wiregrass and runner oak dominate longleaf pine sites, fetterbush and bay trees are found in pond pine areas, while saw palmetto, gallberry, and rusty lyonia occupy slash pine flatwoods sites. Cypress domes, bayheads, titi swamps, and freshwater marshes are commonly interspersed in isolated depressions throughout this community type, and fire is a major source of natural disturbance. An additional pine flatwoods forest type occurs in extreme south Florida on rocklands where the overstory is the south Florida variety of slash pine, and tropical hardwood species occur in the understory. Scrubby flatwoods are another pineland type that occur on drier ridges, and on or near old coastal dunes. Longleaf pine or slash pine dominate the overstory, while the ground cover is similar to the xeric oak scrub community.

Commercial pine plantations are also reluctantly included in the pinelands association. This class includes predominately planted slash pine, although longleaf pine and loblolly pine tracts also may fall under this classification. Sand pine plantations, which have been planted on prepared sandhill sites in the north Florida panhandle, may also be included in this category. An acceptably accurate separation of areas consisting of densely stocked native flatwoods and areas consisting of less densely stocked pine stands with a closed canopy was not consistently possible.

Sand Pine Scrub. Sand pine scrub occurs on well-drained, sorted, sterile sands deposited along former shorelines and islands of ancient seas. This xeric plant community is dominated by an overstory of sand pine and has an understory of myrtle oak, Chapman's oak, sand-live oak, and scrub holly. Ground cover is usually sparse to absent, especially in mature stands, and rosemary and lichens occur in some open areas. Sites within the Ocala National Forest which have an overstory of direct seeded sand pine, and an intact understory of characteristic xeric scrub oaks, are also included in this category. Fire is an important ecological management tool, and commonly results in even-aged stands within regenerated sites. The distribution of this community type is almost entirely restricted to within the state of Florida.

Sandhill. Sandhill communities occur in areas of rolling terrain on deep, well-drained, white to yellow, sterile sands. This xeric community is dominated by an overstory of scattered longleaf pine, along with an understory of turkey oak and bluejack oak. The parklike ground cover consists of various grasses and herbs, including wiregrass, partridge pea, beggars tick, milk pea, queen's delight, and others. Fire is an important factor in controlling hardwood competition and other aspects of sandhill ecology. Although many of these sites throughout the state have been modified through the selective or severe cutting of longleaf pine, these areas are still included in the sandhill category.

Xeric Oak Scrub. Oak scrub is a hardwood community typically consisting of clumped patches of low growing oaks interspersed with bare areas of white sand. This community occurs on areas of deep, well-washed, sterile sands, and it is the same understory complex of scrubby oaks and other ground cover species that occurs in the sand pine scrub community. This condition frequently occurs when the short time periods between severe fires results in the complete removal of sand pine as an overstory species. Also included in this category are sites within the Ocala National Forest which have been clearcut, and are sometimes dominated during the first one to five years by the xeric oak scrub association. The xeric oak scrub community is dominated by myrtle oak, Chapman's oak, sand-live oak, scrub holly, scrub plum, scrub hickory, rosemary, and saw palmetto. Fire is important in setting back plant succession and maintaining viable oak scrubs.

Mixed Hardwood-Pine Forest. This community is the southern extension of the Piedmont southern mixed hardwoods, and occurs mainly on the clay soils on the northern panhandle. Younger stands

may be predominantly pines, while a complex of various hardwoods become co-dominant as the system matures over time through plant succession. The overstory consists of shortleaf and loblolly pine, American beech, mockernut hickory, southern red oak, water oak, American holly, and dogwood. Also included in this category are less specific upland forests that occur statewide and contain a mixture of conifers and hardwoods as the co-dominant overstory component. These communities may contain longleaf pine, slash pine, and loblolly pine in mixed association with live oak, laurel oak, and water oak, together with other hardwood species

Hardwood Hammocks and Forests. This class includes the major upland hardwood associations that occur statewide on fairly rich sandy soils. Variations in species composition, and the local or spatial distributions of these communities are due in part to differences in soil moisture regimes, soil types, and geographic location within the state. The major variations within this association are mesic hammocks, xeric hammocks, coastal and hydric hammocks, and live oak or cabbage palm hammocks.

The mesic hammock community represents the climax vegetation type within many areas of northern and central Florida. Characteristic species in the extreme north include American beech, southern magnolia, Shumard oak, white oak, mockernut hickory, pignut hickory, sourgum, basswood, whiteash, mulberry, and spruce pine. Mesic hammocks of the peninsula are less diverse due to the absence of hardwood species which are adapted to more northerly climates, and are characterized by laurel oak, hop hornbeam, blue-beech, sweetgum, cabbage palm, American holly, and southern magnolia. Xeric hammocks occur on deep, well-drained, sandy soils where fire has been absent for long periods of time. These open, dry hammocks contain live oak, sand-live oak, bluejack oak, blackjack oak, southern red oak, sand-post oak, and pignut hickory.

Coastal and hydric hammocks are relatively wet hardwood forests that are found between uplands and true wetlands. These sometimes seasonally wet forests are associated with some non-alluvial peninsula streams, scattered broad lowlands, and are also found in a narrow band along parts of the Gulf and Atlantic coasts where they often extend to the edge of coastal salt marshes. These communities contain water oak, red maple, Florida elm, cabbage palm, red cedar, blue-beech, and sweetgum. Live oak and cabbage palm hammocks are often found bordering large lakes and rivers, and are distributed throughout the prairie region of south central Florida and extend northward in the St. John's River basin. These communities may occur as mixed stands of oak and palm, or one of these species can completely dominate an area.

Tropical Hardwood Hammock. These upland hardwood forests occur in extreme south Florida and are characterized by tree and shrub species on the northern edge of a range which extends southward into the Caribbean. These communities are sparsely distributed along coastal uplands south of a line from about Vero Beach on the Atlantic coast to Sarasota on the Gulf coast. They occur on many tree islands in the Everglades and on uplands throughout the Florida Keys. This cold-sensitive tropical community has very high plant species diversity, sometimes containing over 35 species of trees and about 65 species of shrubs. Characteristic tropical plants include strangler fig, gumbo-limbo, mastic, bustic, lancewood, ironwoods, poisonwood, pigeon plum, Jamaica dogwood, and Bahama lysiloma. Live oak and cabbage palm are also sometimes found within this community. Tropical hammocks in the Florida Keys may also contain several plants, including lignum vitae, mahogany, thatch palms, and manchineel, which are extremely rare within the United States.

B. WETLAND PLANT COMMUNITIES

Coastal Salt Marshes. These herbaceous and shrubby wetland communities occur statewide in brackish waters along protected low energy estuarine shorelines of the Atlantic and Gulf coasts. The largest continuous areas of salt marsh occur north of the range of mangroves, and border tidal creeks, bays, and sounds. Salt marshes are sometimes interspersed within mangrove areas, and also occur as a transition zone between freshwater marshes and mangrove forests such as in the Ten Thousand Islands area along the southwest Florida coast. Plant distribution within salt marshes is largely dependent on the degree of tidal inundation, and many large areas are completely dominated by one species. Generally, smooth cordgrass typically occupies the lowest elevations immediately adjacent to tidal creeks and pools, while black needlerush dominates less frequently inundated zones. The highest elevations form transitional areas characterized by glasswort, saltwort, saltgrass, sea oxeye daisy, marsh elder, and saltbush. For the purposes of this project, cordgrass, needlerush, and transitional or high salt marshes are collectively mapped as this single category.

Freshwater Marsh and Wet Prairie. These wetland communities are dominated by a wide assortment of herbaceous plant species growing on sand, clay, marl, and organic soils in areas of variable water depths and inundation regimes. Generally, freshwater marshes occur in deeper, more strongly inundated situations and are characterized by tall emergent and floating-leaved species. Freshwater marshes occur within depressions, along broad, shallow lake and river shorelines, and are scattered in open areas within hardwood and cypress swamps. Also, other portions of freshwater lakes, rivers, and canals which are dominated by floating-leaved plants such as lotus, spatterdock, duck weed, and water hyacinths are included in this category. Wet prairies commonly occur in shallow, periodically inundated areas and are usually dominated by aquatic grasses, sedges, and their associates. Wet prairies occur as scattered, shallow depressions within dry prairie areas and on marl prairie areas in south Florida. Also included in this category are areas in southwest Florida with scattered dwarf cypress having less than 20% canopy coverage, and a dense ground cover of freshwater marsh plants. Marshes and wet prairies are dominated by various combinations of pickerel weed, sawgrass, maidencane, arrowhead, fire flag, cattail, spike rush, bulrush, white water lily, water shield, and various sedges. Many marsh or wet prairie types, such as sawgrass marsh or maidencane prairie, have been described and so-named based on their dominant plant species.

Cypress Swamp. These regularly inundated wetlands form a forested border along large rivers, creeks, and lakes, or occur in depressions as circular domes or linear strands. These communities are strongly dominated by either bald cypress or pond cypress, with very low numbers of scattered black gum, red maple, and sweetbay. Understory and ground cover are usually sparse due to frequent flooding but sometimes include such species as buttonbush, lizard's-tail, and various ferns.

Mixed Hardwood Swamp. These wooded wetland communities are composed of either pure stands of hardwoods, or occur as a mixture of hardwoods and cypress. This association of wetland-adapted trees occurs throughout the state on organic soils and forms the forested floodplain of non-alluvial rivers, creeks, and broad lake basins. Tree species include a mixed overstory containing black gum, water tupelo, bald cypress, dahoon holly, red maple, swamp ash, cabbage palm, and sweetbay.

Bottomland Hardwood Forest. These wetland forests are composed of a diverse assortment of hydric hardwoods which occur on the rich alluvial soils of silt and clay deposited along several panhandle rivers including the Apalachicola. These communities are

characterized by an overstory that includes water hickory, overcup oak, swamp chestnut oak, river birch, American sycamore, red maple, Florida elm, bald cypress, blue beech, and swamp ash.

Bay Swamp. These hardwood swamps contain broadleaf evergreen trees that occur in shallow, stagnant drainages or depressions often found within pine flatwoods, or at the base of sandy ridges where seepage maintains constantly wet soils. The soils, which are usually covered by an abundant layer of leaf litter, are mostly acidic peat or muck which remain saturated for long periods but over which little water level fluctuation occurs. Overstory trees within bayheads are dominated by sweetbay, swamp bay, and loblolly bay. Depending on the location within the state, other species including pond pine, slash pine, blackgum, cypress, and Atlantic white cedar can occur as scattered individuals, but bay trees dominate the canopy and characterize the community. Understory and ground cover species may include dahoon holly, wax myrtle, fetterbush, greenbriar, royal fern, cinnamon fern, and sphagnum moss.

Shrub Swamp. Shrub swamps are wetland communities dominated by dense, low-growing, woody shrubs or small trees. Shrub swamps are usually characteristic of wetland areas that are experiencing environmental change, and are early to mid-successional in species complement and structure. These changes are a result of natural or man-induced perturbations due to increased or decreased hydroperiod, fire, clear cutting or land clearing, and siltation. Shrub swamps statewide may be dominated by one species, such as willow, or an array of opportunistic plants may form a dense, low canopy. Common species include willow, wax myrtle, primrose willow, buttonbush, and saplings of red maple, sweetbay, black gum, and other hydric tree species indicative of wooded wetlands.

In northern Florida, some shrub swamps are a fire-maintained subclimax of bay swamps. These dense shrubby areas are dominated by black titi, swamp cyrilla, fetterbush, sweet pepperbush, doghhobble, large gallberry, and myrtle-leaf holly.

Mangrove Swamp. These dense, brackish water swamps occur along low-energy shorelines and in protected, tidally influenced bays of southern Florida. This community is composed of freeze-sensitive tree species that are distributed south of a line from Cedar Key on the Gulf coast to St. Augustine on the Atlantic coast. These swamp communities are usually dominated by red, black, and white mangroves that progress in a sere from seaward to landward areas, respectively, while buttonwood trees occur in areas above high tide. Openings and transitional areas in mangrove swamps sometimes contain glasswort, saltwort, and other salt marsh species. All three major species of mangroves are mapped as a single class with no effort made to differentiate these species into separate zones.

C. OPEN WATER

Open Water. This community is comprised of the open water areas of inland freshwater lakes, ponds, rivers, and creeks, and the brackish and saline waters of estuaries, bays, tidal creeks, the Gulf of Mexico, and the Atlantic Ocean.

D. DISTURBED COMMUNITIES

Grassland and Agriculture. These areas are dominated by low-growing herbaceous vegetative cover on intensively managed sites such as row crops, improved pastures, lawns, golf courses, road shoulders, cemeteries, or weedy, fallow agricultural fields, etc. This very early successional category includes all sites with herbaceous vegetation during the time period between bare ground and the shrub and brush stage, as well as agricultural fiends of all types.

Shrub and Brushland. This association includes a variety of situations where natural upland community types have been recently disturbed through clear-cutting commercial pinelands, land clearing, or fire, and are recovering through natural successional processes. This type could be characterized as an early condition of old field succession, and the community is dominated by various shrubs, tree saplings, and lesser amounts of grasses and herbs. Common species include wax myrtle, saltbush, sumac, elderberry, saw palmetto, blackberry, gallberry, fetterbush, staggerbush, broomsedge, and dog fennel, together with oak, pine, and other tree seedlings or saplings.

Exotic Plant Communities. Upland and wetland areas dominated by non-native trees that were planted or have escaped and invaded native plant communities. These exotics include melaleuca, Australian pine, Brazilian pepper, and eucalyptus.

Barren and Urban Land. This class includes highly reflective unvegetated areas such as roads, beaches, active strip mines, tilled agricultural sites, and cleared land on sandy soils. Unvegetated sites in urban areas, which include rooftops of buildings, athletic fields, landfills, and parking lots, etc., are also included in this category. Vegetated tracts within urban areas are classified and mapped according to their predominate vegetation cover or plant community type.

APPENDIX 3. Tabulation of land cover types by county and conservation lands within counties. Area figures are in square kilometers. There are approximately 247 acres per square kilometer. The figures are divided into three tables for (1) "natural" upland cover types, (2) "natural" wetland cover types, and (3) "disturbed" cover types.

Appendix 3, Table 1. Natural upland cover types.

	Coastal Strand	Dry Prairie	Pinelands	Sand pine Scrub	Sandhill	Xeric Oak Scrub	Mixed HW Pines	Hardwood Hammocks	Tropical Hammocks
NASSAU	4	0	811	0	1	3	7	82	0
Conservation Lands	1	0	9	0	0	0	0	3	0
MADISON	0	0	622	0	0	0	0	150	0
Conservation Lands	0	0	21	0	0	0	0	4	0
HAMILTON	0	0	596	0	0	0	0	127	0
Conservation Lands	0	0	14	0	0	0	0	6	0
COLUMBIA	0	0	823	0	9	0	0	110	0
Conservation Lands	0	0	245	0	3	0	0	16	0
BAKER	0	0	746	0	0	0	0	0	0
Conservation Lands	0	0	243	0	0	0	0	0	0
DUVAL	1	7	738	0	17	8	26	62	0
Conservation Lands	1	1	76	0	0	7	1	15	0
SUWANNEE	0	0	467	0	54	0	0	210	0
Conservation Lands	0	0	3	0	5	0	0	10	0
TAYLOR	0	0	1245	0	0	0	0	254	0
Conservation Lands	0	0	39	0	0	0	0	120	0
LAFAYETTE	0	0	738	0	2	0	0	65	0
Conservation Lands	0	0	0	0	1	0	0	4	0
ST. JOHNS	1	3	621	0	12	3	50	127	0
Conservation Lands	0	0	3	0	0	0	7	16	0
CLAY	0	0	675	3	175	9	14	70	0
Conservation Lands	0	0	124	2	68	2	4	9	0
UNION	0	0	278	0	0	0	0	15	0
Conservation Lands	0	0	17	0	0	0	0	0	0
BRADFORD	0	0	289	0	6	0	0	23	0
Conservation Lands	0	0	24	0	0	0	0	1	0
ALACHUA	0	0	671	0	33	0	2	254	0
Conservation Lands	0	0	21	0	0	0	2	26	0
GILCHRIST	0	0	224	0	62	0	0	61	0
Conservation Lands	0	0	0	0	0	0	0	4	0
DIXIE	0	0	715	0	0	0	0	119	0
Conservation Lands	0	0	18	0	0	0	0	18	0
PUTNAM	0	1	623	29	250	8	12	179	0
Conservation Lands	0	0	55	27	30	5	1	13	0
FLAGLER	0	2	578	1	0	3	3	48	0
Conservation Lands	0	0	1	0	0	0	0	1	0
LEVY	0	0	1062	0	246	10	128	212	0
Conservation Lands	0	0	39	0	0	5	7	42	0
MARION	0	0	531	683	421	160	195	149	0
Conservation Lands	0	0	67	655	136	151	39	42	0
VOLUSIA	1	124	835	46	8	26	71	197	0
Conservation Lands	1	15	33	3	0	4	3	21	0
LAKE	0	30	156	68	73	19	9	143	0
Conservation Lands	0	22	64	63	60	14	2	16	0
CITRUS	0	0	75	12	485	9	30	194	0
Conservation Lands	0	0	7	1	126	5	6	32	0
SUMTER	0	2	104	12	39	1	44	111	0
Conservation Lands	0	2	73	0	5	1	12	28	0
SEMINOLE	0	24	73	7	2	17	1	93	0
Conservation Lands	0	0	6	0	0	2	0	1	0
BREVARD	2	203	298	4	0	49	0	136	0
Conservation Lands	1	80	12	0	0	35	0	57	0
ORANGE	0	315	278	18	16	14	6	94	0
Conservation Lands	0	16	58	4	10	1	1	25	0
HERNANDO	0	0	90	12	304	2	110	137	0
Conservation Lands	0	0	28	0	62	0	19	32	0

Appendix 3, Table 1. Natural upland cover types (continued).

	Coastal Strand	Dry Prairie	Pinelands	Sand pine Scrub	Sandhill	Xeric Oak Scrub	Mixed HW Pines	Hardwood Hammocks	Tropical Hammocks
PASCO	0	80	154	13	137	15	14	121	0
Conservation Lands	0	18	45	2	3	4	3	21	0
POLK	0	435	278	6	53	54	27	172	0
Conservation Lands	0	134	95	1	4	9	1	21	0
OSCEOLA	0	833	177	1	0	25	1	38	0
Conservation Lands	0	194	30	0	0	1	0	4	0
PINELLAS	0	2	61	1	0	0	1	14	0
Conservation Lands	0	0	0	0	0	0	0	1	0
HILLSBOROUGH	0	83	43	7	7	12	34	134	0
Conservation Lands	0	8	2	0	0	0	0	13	0
INDIAN RIVER	0	119	64	7	0	7	2	24	0
Conservation Lands	0	5	1	0	0	0	1	3	0
HARDEE	0	170	55	0	0	7	16	135	0
Conservation Lands	0	1	0	0	0	0	0	0	0
HIGHLANDS	0	427	167	14	0	112	4	46	0
Conservation Lands	0	112	41	3	0	12	0	5	0
ST. LUCIE	0	100	81	16	0	3	4	23	0
Conservation Lands	0	9	1	2	0	1	0	0	0
SARASOTA	0	314	239	0	0	1	12	81	0
Conservation Lands	0	104	23	0	0	0	0	27	0
DESOTO	0	319	35	0	0	4	10	43	0
Conservation Lands	0	0	0	0	0	0	0	0	0
MARTIN	0	213	140	12	0	16	3	31	0
Conservation Lands	0	30	13	5	0	6	0	0	0
GLADES	0	496	248	0	0	0	9	123	0
Conservation Lands	0	0	0	0	0	0	0	0	0
CHARLOTTE	0	369	392	0	0	0	2	18	0
Conservation Lands	0	144	56	0	0	0	0	0	0
PALM BEACH	0	139	301	0	0	1	0	58	0
Conservation Lands	0	35	186	0	0	0	0	20	0
HENDRY	0	300	106	0	0	0	16	100	0
Conservation Lands	0	1	0	0	0	0	0	0	0
LEE	3	65	348	0	0	1	8	74	8
Conservation Lands	0	4	2	0	0	0	2	2	2
COLLIER	0	96	323	0	0	2	28	359	1
Conservation Lands	0	1	27	0	0	0	2	282	1
BROWARD	0	0	3	0	0	0	0	42	0
Conservation Lands	0	0	0	0	0	0	0	10	0
DADE	0	49	49	0	0	0	0	165	7
Conservation Lands	0	5	37	0	0	0	0	107	7
MANATEE	0	269	17	18	1	41	15	114	0
Conservation Lands	0	37	0	1	1	5	1	3	0
OKEECHOBEE	0	412	26	0	0	3	22	33	0
Conservation Lands	0	19	0	0	0	0	0	2	0
MONROE	3	1	33	0	0	0	0	66	38
Conservation Lands	3	1	29	0	0	0	0	64	17
JACKSON	0	0	374	0	0	0	190	179	0
Conservation Lands	0	0	8	0	0	0	1	19	0
HOLMES	0	0	452	0	0	0	0	121	0
Conservation Lands	0	0	8	0	0	0	0	0	0
ESCAMBIA	1	0	1106	13	218	3	10	121	0
Conservation Lands	1	0	393	3	171	0	8	7	0
SANTA ROSA	5	0	721	4	0	0	0	172	0
Conservation Lands	3	0	5	1	0	0	0	1	0
OKALOOSA	5	0	617	29	673	1	0	83	0
Conservation Lands	5	0	258	18	574	0	0	20	0
WALTON	1	0	941	27	402	8	30	157	0
Conservation Lands	0	0	213	11	262	0	22	24	0
WASHINGTON	0	0	526	0	170	0	2	79	0
Conservation Lands	0	0	10	0	0	0	0	1	0

Appendix 3, Table 1. Natural upland cover types (continued).

	Coastal Strand	Dry Prairie	Pinelands	Sand pine Scrub	Sandhill	Xeric Oak Scrub	Mixed HW Pines	Hardwood Hammocks	Tropical Hammocks
GADSDEN	0	0	552	0	4	0	6	220	0
Conservation Lands	0	0	26	0	1	0	0	10	0
LEON	0	0	865	0	4	0	59	150	0
Conservation Lands	0	0	342	0	2	0	1	15	0
JEFFERSON	0	0	421	0	0	0	13	301	0
Conservation Lands	0	0	12	0	0	0	0	43	0
LIBERTY	0	0	1065	0	0	0	7	103	0
Conservation Lands	0	0	746	0	0	0	3	22	0
CALHOUN	0	0	630	0	30	0	2	53	0
Conservation Lands	0	0	0	0	0	0	0	0	0
BAY	1	0	1184	17	71	4	0	2	0
Conservation Lands	1	0	71	11	0	1	0	1	0
WAKULLA	0	0	915	0	0	1	0	129	0
Conservation Lands	0	0	651	0	0	1	0	92	0
GULF	4	0	442	2	0	3	0	39	0
Conservation Lands	3	0	5	1	0	2	0	1	0
FRANKLIN	9	0	841	5	1	3	0	38	0
Conservation Lands	1	0	113	0	0	2	0	4	0

Appendix 3, Table 2. Cross-tabulation of wetland cover types mapped by FGFWFC by county and conservation lands within counties. Area figures are in square kilometers. There are approximately 247 acres per square kilometer.

	Salt Marsh	F.-Water Marsh	Cypress Swamp	Hardwood Swamp	Bay Swamp	Shrub Swamp	Mangrove Swamp	Bottom H.-Woods
NASSAU	128	3	5	189	0	0	0	0
Conservation Lands	7	0	0	0	0	0	0	0
MADISON	0	25	142	98	7	15	0	0
Conservation Lands	0	0	0	1	0	0	0	0
HAMILTON	0	10	22	79	6	1	0	0
Conservation Lands	0	0	1	1	0	0	0	0
COLUMBIA	0	2	134	59	30	64	0	0
Conservation Lands	0	0	26	14	2	11	0	0
BAKER	0	0	361	37	8	50	0	0
Conservation Lands	0	0	97	11	1	35	0	0
DUVAL	164	4	6	121	0	0	0	0
Conservation Lands	110	0	0	3	0	0	0	0
SUWANNEE	0	1	2	4	0	0	0	0
Conservation Lands	0	0	0	1	0	0	0	0
TAYLOR	100	19	70	263	1	5	0	0
Conservation Lands	70	0	0	14	0	0	0	0
LAFAYETTE	0	2	83	164	0	9	0	0
Conservation Lands	0	0	0	1	0	0	0	0
ST. JOHNS	94	9	10	147	0	2	0	0
Conservation Lands	20	3	0	1	0	0	0	0
CLAY	0	2	6	113	0	1	0	0
Conservation Lands	0	0	0	13	0	0	0	0
UNION	0	0	11	47	3	2	0	0
Conservation Lands	0	0	0	2	1	0	0	0
BRADFORD	0	3	13	57	23	0	0	0
Conservation Lands	0	0	3	4	16	0	0	0
ALACHUA	0	110	63	23	4	23	0	0
Conservation Lands	0	40	4	6	0	7	0	0
GILCHRIST	0	3	12	21	0	0	0	0
Conservation Lands	0	0	0	0	0	0	0	0
DIXIE	93	10	99	428	0	2	0	0
Conservation Lands	80	0	3	36	0	0	0	0
PUTNAM	0	36	8	177	0	2	0	0
Conservation Lands	0	10	1	21	0	0	0	0
FLAGLER	15	27	67	76	0	4	0	0
Conservation Lands	0	1	0	3	0	0	0	0
LEVY	179	35	48	244	0	5	0	0
Conservation Lands	152	7	2	42	0	2	0	0
MARION	0	91	38	131	0	13	0	0
Conservation Lands	0	35	6	65	0	4	0	0
VOLUSIA	31	72	264	168	61	50	46	0
Conservation Lands	10	30	15	37	5	33	12	0
LAKE	0	121	202	295	15	42	0	0
Conservation Lands	0	2	36	101	6	1	0	0
CITRUS	157	96	6	55	0	11	0	0
Conservation Lands	40	32	2	15	0	6	0	0
SUMTER	0	63	131	155	0	18	0	0
Conservation Lands	0	5	104	58	0	13	0	0
SEMINOLE	0	51	13	80	7	11	0	0
Conservation Lands	0	2	1	12	0	2	0	0
BREVARD	98	449	25	46	0	152	4	0
Conservation Lands	82	167	3	4	0	99	3	0
ORANGE	0	78	132	133	50	14	0	0
Conservation Lands	0	57	8	66	2	10	0	0
HERNANDO	46	11	16	86	0	2	0	0
Conservation Lands	23	2	11	60	0	0	0	0
PASCO	32	42	128	78	0	2	1	0
Conservation Lands	0	3	31	34	0	1	0	0
POLK	0	213	274	220	22	58	0	0
Conservation Lands	0	31	21	21	5	4	0	0
OSCEOLA	0	313	251	154	59	28	0	0
Conservation Lands	0	14	21	23	4	6	0	0
PINELLAS	4	2	18	9	0	0	15	0
Conservation Lands	0	0	0	0	0	0	2	0
HILLSBOROUGH	9	29	46	136	0	1	13	0
Conservation Lands	1	3	5	34	0	0	1	0
INDIAN RIVER	5	92	23	32	1	107	8	0
Conservation Lands	0	65	10	14	0	94	0	0

Appendix 3, Table 2. Cross-tabulation of wetland cover types mapped by FGFWFC by county and conservation lands within counties (continued).

	Salt Marsh	F.-Water Marsh	Cypress Swamp	Hardwood Swamp	Bay Swamp	Shrub Swamp	Mangrove Swamp	Bottom H.-Woods
HARDEE	0	23	12	107	0	6	0	0
Conservation Lands	0	0	0	0	0	0	0	0
HIGHLANDS	0	129	21	41	17	21	0	0
Conservation Lands	0	34	8	5	0	5	0	0
ST. LUCIE	2	26	14	12	4	2	16	0
Conservation Lands	0	4	0	0	0	0	0	0
SARASOTA	9	40	0	5	0	0	0	0
Conservation Lands	0	8	0	0	0	0	0	0
DESOTO	0	55	0	117	0	0	0	0
Conservation Lands	0	0	0	0	0	0	0	0
MARTIN	0	68	9	13	2	5	0	0
Conservation Lands	0	1	3	4	0	0	0	0
GLADES	0	358	42	2	0	86	0	0
Conservation Lands	0	2	0	0	0	0	0	0
CHARLOTTE	33	72	51	1	0	1	64	0
Conservation Lands	1	38	0	0	0	0	14	0
PALM BEACH	0	937	24	15	0	204	0	0
Conservation Lands	0	842	14	2	0	160	0	0
HENDRY	0	198	207	10	0	16	0	0
Conservation Lands	0	1	2	0	0	0	0	0
LEE	14	14	169	1	0	0	156	0
Conservation Lands	1	0	1	0	0	0	48	0
COLLIER	98	923	1849	214	0	77	375	0
Conservation Lands	72	650	931	151	0	8	252	0
BROWARD	0	1417	25	1	0	489	4	0
Conservation Lands	0	1388	22	0	0	460	0	0
DADE	252	2458	24	2	0	197	235	0
Conservation Lands	202	1986	24	0	0	147	205	0
MANATEE	9	41	1	65	0	1	16	0
Conservation Lands	0	4	0	6	0	1	0	0
OKEECHOBEE	0	108	13	20	7	26	0	0
Conservation Lands	0	10	0	0	0	4	0	0
MONROE	271	460	210	11	0	8	1292	0
Conservation Lands	244	460	210	11	0	8	1234	0
JACKSON	0	17	27	142	0	0	0	4
Conservation Lands	0	6	0	4	0	0	0	0
HOLMES	0	3	3	52	0	0	0	45
Conservation Lands	0	0	0	8	0	0	0	27
ESCAMBIA	0	62	21	188	79	5	0	32
Conservation Lands	0	9	3	92	28	3	0	9
SANTA ROSA	2	8	13	80	12	6	0	31
Conservation Lands	0	0	1	11	0	0	0	4
OKALOOSA	1	3	4	185	75	30	0	0
Conservation Lands	0	1	4	63	42	28	0	0
WALTON	0	9	6	131	21	25	0	32
Conservation Lands	0	3	3	64	12	7	0	25
WASHINGTON	0	4	11	123	1	17	0	55
Conservation Lands	0	0	0	13	0	0	0	42
GADSDEN	0	1	6	90	0	0	0	5
Conservation Lands	0	0	0	1	0	0	0	0
LEON	0	39	36	132	0	13	0	0
Conservation Lands	0	1	12	15	0	13	0	0
JEFFERSON	16	24	77	219	0	9	0	0
Conservation Lands	13	0	4	33	0	4	0	0
LIBERTY	0	2	74	258	0	97	0	104
Conservation Lands	0	1	51	135	0	85	0	61
CALHOUN	0	2	23	167	0	11	0	65
Conservation Lands	0	0	0	0	0	0	0	0
BAY	14	4	3	40	18	96	0	2
Conservation Lands	1	0	1	3	0	6	0	2
WAKULLA	88	5	26	79	0	40	0	0
Conservation Lands	56	5	23	56	0	40	0	0
GULF	3	26	55	233	1	14	0	49
Conservation Lands	0	3	6	66	0	0	0	36
FRANKLIN	22	71	56	150	0	38	0	4
Conservation Lands	8	40	12	82	0	4	0	4

Appendix 3, Table 3. Tabulation of other cover types mapped by FGFWFC by county and conservation lands within counties. Area figures are in square kilometers. There are approximately 247 acres per square kilometer.

	Water	Grass & Ag. Lands	Shrub Brush	Exotic	Barren Lands	Total Land Cover
NASSAU	67	148	259	0	36	1742
Conservation Lands	4	0	0	0	0	24.6
MADISON	5	300	423	0	45	1832
Conservation Lands	0	0	4	0	0	30.3
HAMILTON	12	118	305	0	65	1341
Conservation Lands	0	1	1	0	0	23.5
COLUMBIA	8	193	608	0	34	2074
Conservation Lands	0	1	27	0	1	345.0
BAKER	8	43	203	0	52	1509
Conservation Lands	8	3	21	0	5	423.4
DUVAL	236	87	277	0	479	2235
Conservation Lands	40	4	22	0	19	298.8
SUWANNEE	4	482	470	0	99	1793
Conservation Lands	0	0	3	0	0	21.7
TAYLOR	130	32	647	0	84	2850
Conservation Lands	60	0	5	0	2	311.3
LAFAYETTE	4	48	213	0	87	1416
Conservation Lands	0	0	0	0	0	6.6
ST. JOHNS	224	143	288	0	77	1812
Conservation Lands	15	0	1	0	2	68.2
CLAY	117	79	289	0	112	1665
Conservation Lands	18	9	32	0	24	306.5
UNION	9	41	220	0	21	646
Conservation Lands	0	3	10	0	2	34.1
BRADFORD	18	55	254	0	38	777
Conservation Lands	0	3	13	0	2	65.1
ALACHUA	116	442	564	0	204	2507
Conservation Lands	8	15	7	0	1	134.7
GILCHRIST	6	119	380	0	33	921
Conservation Lands	0	0	2	0	0	5.7
DIXIE	117	3	323	0	46	1956
Conservation Lands	74	0	9	0	3	241.0
PUTNAM	247	147	362	0	59	2140
Conservation Lands	9	1	9	0	1	183.8
FLAGLER	81	62	262	0	110	1338
Conservation Lands	0	0	0	0	1	7.7
LEVY	234	446	62	0	246	3155
Conservation Lands	67	2	1	0	5	371.5
MARION	117	1251	187	0	334	4302
Conservation Lands	34	33	26	0	19	1311.0
VOLUSIA	481	199	425	0	255	3361
Conservation Lands	100	5	24	0	6	355.4
LAKE	364	297	935	0	218	2988
Conservation Lands	20	4	47	0	4	460.0
CITRUS	216	237	37	0	189	1810
Conservation Lands	56	15	3	0	15	359.4
SUMTER	25	629	75	0	75	1485
Conservation Lands	1	13	7	0	3	324.0
SEMINOLE	98	193	57	0	169	895
Conservation Lands	1	0	1	0	1	30.0
BREVARD	854	515	193	0	451	3478
Conservation Lands	235	83	27	0	51	939.4
ORANGE	246	337	398	0	459	2591
Conservation Lands	4	11	9	0	9	289.4
HERNANDO	98	201	4	0	228	1347
Conservation Lands	38	15	1	0	4	294.7
PASCO	159	747	93	0	268	2085
Conservation Lands	7	37	3	0	3	216.3
POLK	445	1478	339	0	1122	5197
Conservation Lands	8	28	19	0	24	424.7

Appendix 3, Table 3. Tabulation of other cover types mapped by FGFWFC by county and conservation lands within counties (continued).

	Water	Grass & Ag. Lands	Shrub Brush	Exotic	Barren Lands	Total Land Cover
OSCEOLA	341	1427	135	0	123	3905
Conservation Lands	5	19	18	0	4	344.4
PINELLAS	558	64	11	0	511	1271
Conservation Lands	15	0	0	0	4	23.7
HILLSBOROUGH	548	1295	130	0	717	3244
Conservation Lands	12	17	4	0	13	114.6
INDIAN RIVER	113	479	164	1	139	1386
Conservation Lands	26	42	5	0	1	267.3
HARDEE	5	979	56	0	80	1651
Conservation Lands	0	0	0	0	0	1.5
HIGHLANDS	202	1086	271	0	307	2866
Conservation Lands	1	15	18	0	11	270.8
ST. LUCIE	118	819	47	2	279	1570
Conservation Lands	2	0	0	0	2	21.6
SARASOTA	136	369	42	0	387	1634
Conservation Lands	9	15	0	0	3	189.7
DESOTO	16	845	84	0	126	1653
Conservation Lands	0	0	0	0	0	0
MARTIN	347	584	88	1	209	1741
Conservation Lands	1	5	0	0	6	74.1
GLADES	252	752	125	0	57	2551
Conservation Lands	0	1	1	0	0	5.0
CHARLOTTE	327	411	48	0	348	2138
Conservation Lands	231	13	4	0	3	504.2
PALM BEACH	705	2170	24	14	1056	5647
Conservation Lands	16	28	0	4	13	1321.6
HENDRY	70	1665	164	0	228	3080
Conservation Lands	0	0	0	0	0	5.0
LEE	739	446	94	11	664	2815
Conservation Lands	408	1	1	4	4	480.2
COLLIER	318	396	174	2	326	5561
Conservation Lands	168	3	2	1	15	2565.3
BROWARD	156	295	64	34	656	3188
Conservation Lands	74	33	3	7	14	2010.9
DADE	562	419	98	75	980	5581
Conservation Lands	326	22	0	4	64	3135.1
MANATEE	311	776	204	0	313	2211
Conservation Lands	2	10	10	0	5	82.9
OKEECHOBEE	290	1223	16	0	109	2306
Conservation Lands	5	16	0	0	4	60.4
MONROE	3505	4	1	0	190	6094
Conservation Lands	2459	0	0	0	80	4820.0
JACKSON	41	1120	253	0	103	2452
Conservation Lands	25	8	0	0	0	72
HOLMES	8	245	175	0	159	1264
Conservation Lands	0	0	0	0	0	44
ESCAMBIA	334	295	280	0	199	2965
Conservation Lands	2	6	41	0	20	796
SANTA ROSA	307	216	135	0	303	2016
Conservation Lands	9	4	0	0	26	66
OKALOOSA	207	271	172	0	265	2621
Conservation Lands	9	30	102	0	123	1276
WALTON	274	148	562	0	243	3021
Conservation Lands	4	4	64	0	27	746
WASHINGTON	38	83	402	0	86	1595
Conservation Lands	0	1	4	0	1	73
GADSDEN	25	62	299	0	85	1354
Conservation Lands	2	0	11	0	1	52
LEON	38	82	261	0	132	1811
Conservation Lands	6	1	112	0	23	543

Appendix 3, Table 3. Tabulation of other cover types mapped by FGFWFC by county and conservation lands within counties (continued).

	Water	Grass & Ag. Lands	Shrub Brush	Exotic	Barren Lands	Total Land Cover
JEFFERSON	17	127	335	0	28	1588
Conservation Lands	1	0	8	0	1	120
LIBERTY	15	89	310	0	60	2185
Conservation Lands	5	16	135	0	31	1289
CALHOUN	9	136	307	0	52	1487
Conservation Lands	0	0	0	0	0	0
BAY	415	17	415	0	90	2391
Conservation Lands	26	2	18	0	11	154
WAKULLA	104	15	268	0	31	1701
Conservation Lands	12	6	160	0	13	1115
GULF	286	138	319	0	109	1722
Conservation Lands	13	0	2	0	5	144
FRANKLIN	752	3	113	0	82	2186
Conservation Lands	32	1	16	0	6	325

APPENDIX 4. A population simulation model written in BASIC language and used to measure the threat posed to small populations by environmental variability and infrequent catastrophes.

```
1 dim sddrep(200)
2 dim sddsur(200)
3 dim age(200)
4 dim sur(200)
5 dim rep(200)
6 dim n(200)
7 dim cvrep(200)
8 dim cvsur(200)
9 dim sdsur(200)
10dim sdrep(200)
11dim newrep(200)
12dim newn(200)
13dim newsur(200)
14dim temp(200)
15dim trial(500)
16dim yrr(500)
17dim varyr(500)
18dim regsurf(200)
19dim means(200)
20dim prop(200)
27print
28print
29print " ***************************************************"
40print " *This is a population simulation model for *"
50print " *use in estimating extinction probabilities.  *"
57print " *Up to 250 trials may be executed. *"
60print " *  *"
70print " *The information needed to run the model  *"
75print " *includes demographic data from a file *"
80print " *in the same directory as this program. An *"
85print " *example of the structure of this file is  *"
90print " *provide in the READ.ME file on the disk.  *"
130  print " *  *"
210  print " *The output from the model is the pro- *"
220  print " *portion of trials persisting for 200  *"
230  print " *years.  This information is written to a  *"
240  print " *file that can be later read using a word- *"
245  print " *processor or the DOS TYPE command.  This  *"
250  print " *program also allows you to increment  *"
255  print " *population sizes automatically or to conduct  *"
256  print " *a single series of trials.*"
270  print "***************************************************"
280  print
320  print
321  input "What is the name of the demographic input file" ; flnm1$
325  cls 0
335  print
340  print "Here are the first 10 lines of data as read from "flnm1$"."
355  print
360  open flnm1$ for input as #1
371  print
382  print "SURV","REPRO","CV SUR","CV REP","PROPORTION"
399  let tick = 0
400  for i = 1 to 100
410if eof(1) then goto 470
420input #1, age(i),sur(i),rep(i),cvsur(i),cvrep(i),prop(i)
430if age(i) < 10 then print sur(i),rep(i),cvsur(i),cvrep(i),prop(i)
440if sur(i) + rep(i) = 0 then goto 470
455 let tick = tick + 1
460  next i
470  print
473  input "Hit RETURN to continue...."  ,  kklop
480  print
485  let cumsurf = 1
```

```
486  let numf = 0
487  let denf = 0
490  print
500  print “Here are demographic parameters for the data file you have”
510  print “submitted.”
520  for i = 1 to tick
530  let cumsurf = cumsurf*sur(i)
540  let regsurf(i) = cumsurf
550  let numf = (age(i)*cumsurf*rep(i)) + numf
560  let denf = (cumsurf*rep(i)) + denf
570  next i
580  let genf = numf/denf
590  print
595  print “————————————————————————————————”
596  print
600  print “Approx. Gen. Length: “ , genf
610  print
620  print “Intrinsic R: “ , log(denf)/genf
630  print
640  print “Instantaneous r: “ , 2.718^(log(denf)/genf)
650  print
653  if log(denf)/genf > .1 then print “Warning — population may explode.”
655  if log(denf)/genf > .1 then print “Intrinsic r is high.”
657  print
658  print “————————————————————————————————”
659  print
660  input “You may want to write these down.  Hit a key to continue...”  , jk
680  cls 0
2000  print
2030  input “What is the extinction threshold” ; xx
2040  print
2052  input “How many trials do you want” ; zz
2063  print
2074  input “What is the initial population size” ; mike
2085  print
2097  print “Type 1 to have the model increment populations for you.”
2108  input “Type 0 to conduct a single run....”  , kkl
2110  if kkl <> 1 then let zztop = 2
2111  if kkl <> 1 then goto 2215
2112  print
2113  input “What is the name of the file for the summary output” ; flnm3$
2114  open “A”,#3,flnm3$
2210  print
2211  print “How many increments would you like (e.g., entering a 5 will”
2212  input “increment the population size 5 times?”  ;  zztop
2213  print
2214  input “How large should each increment be (e.g., 20 individuals)” , sttp
2215  cls 0
2216  print “You may also prescribe a frequency for a catastrophic year and the”
2217  print “reduction in reproduction and survival associated with such rare”
2218  print “events.”
2220  print
2221  print “What is the frequency of catastrophic events (use fractions,”
2222  input “e.g., 0.05 for 1/20, or 0 for no catastrophe)”  ; incat
2223  if incat = 0 then goto 2240
2224  print
2225  print “The reduction in survival and reproduction is calculated as a”
2226  print “percentage of normal reproduction and survival.  If you want to”
2227  print “model a reduction in one without affecting the other, enter 1.0”
2228  print “for either of the following questions.”
2230  print
2232  print “What is the reduction in survival during a catastrophic year?”
2234  input “If you enter 0.75, it will reduce survival by 25%.”  ;  insur
2235  print
2236  input “And now reproduction (e.g., 0.75 for 25% reduction)”  ; inrep
2240  for value = 1 to zztop
2242  print
2243  open “A”,#2,”temp.dat”
```

```
2244  for i = 0 to tick
2245let sdsur(i) = cvsur(i)*sur(i)
2246let sdrep(i) = cvrep(i)*rep(i)
2247  next i
2248  rem total up the population to provide carrying capacity limits
2249  rem carrying capacity can be disabled by remark statement next 3 lines
2250  rem let totnn = 0
2251  rem for i = 1 to tick
2252  rem let n(i) = mike*prop(i)
2253  let totnn = n(i) + totnn
2256  next i
2260  let limit1 = totnn
2261  let limit2 = 2*totnn
2262  let limit3 = 3*totnn
2263  let limit4 = 4*totnn
2264  let limit5 = 5*totnn
2265  let limit6 = 6*totnn
2266  let limit7 = 7*totnn
2267  let totnnn = totnn
2270  for trial = 1 to zz
2275  print "Simulation underway for population size of "totnn"."
2280  print "Completing trial  "trial
2281  for i = 1 to tick
2282  let n(i) =  mike * prop(i)
2283  next i
2284  let propsur = 0
2285  rem this begins the simulation
2290for yr = 1 to 110
2292  let cat = 1
2293  let catrep = 1
2294  let catsur = 1
2295  if incat = 0 then goto 2308
2296  randomize timer
2297  let cat = rnd
2300  if cat <= incat then let catrep = inrep
2301  if cat <= incat then let catsur = insur
2308  rem  this is the reproduction loop
2309  let totad = 0
2310  let totrep = 0
2315  let totn = 0
2320  for i = 1 to tick
2325  randomize timer
2326  let rnum = nrnd
2327  if rnum = 0 then goto 2325
2335  let sddrep(i) = (rnum*sdrep(i))
2340  let t = rnd
2345  if t < 0.500001 then let sddrep(i) = 0 - sddrep(i)
2350  if t >= 0.500001 then let sddrep(i) = sddrep(i)
2360  let newrep(i) = catrep*(rep(i) + sddrep(i))
2365  if newrep(i) < 0 then let newrep(i) = 0
2380  let newn(i) = n(i)*newrep(i)
2400  let totrep = totrep + newn(i)
2401  let totad = n(i) + totad
2402 next i
2403  rem culling young from the population based on carrying capacity
2404  let totn = totad + totrep
2405  if totn > limit7 then let totrep = (rnd)/7*(totad)
2406  if totn > limit7 then goto 2430
2407  if totn > limit6 then let totrep = (rnd)/6*(totad)
2408  if totn > limit6 then goto 2430
2409  if totn > limit5 then let totrep = (rnd)/5*(totad)
2410  if totn > limit5 then goto 2430
2411  if totn > limit4 then let totrep = (rnd)/4*(totad)
2412  if totn > limit4 then goto 2430
2414  if totn > limit3 then let totrep = (rnd)/3*(totad)
2415  if totn > limit3 then goto 2430
2416  if totn > limit2 then let totrep = (rnd)/2*(totad)
2417  if totn > limit2 then goto 2430
```

```
2418  if totn > limit1 then let totrep = (rnd)*(totad)
2430  let totn = totrep + totad
2435  let n(1) = int(totrep)
2436  if ch <> 1 then goto 2440
2437  rem write#3,trial,yr,totad,n(1)
2440  rem this is the survival loop for this year
2445 for i = 1 to tick
2450  randomize timer
2452  let rnum = nrnd
2453  if rnum = 0 then goto 2450
2470  let sddsur(i) = (rnum*sdsur(i))
2480  let t = rnd
2490  if t < 0.500001 then let sddsur(i) = 0 - sddsur(i)
2500  if t <= 0.500001 then let sddsur(i) = sddsur(i)
2510  let newsur(i) = catsur*(1.2*(sur(i))) + sddsur(i)
2515  if newsur(i) > 1 then let newsur(i) = 1
2516  if i > 1 then let mean = newsur(i) + mean
2520  let newn(i) = int(n(i)*newsur(i))
2540 next i
2550  rem advance all of the age classes by 1
2560 let tick2 = tick - 1
2565 let q = 0
2570 for i = 1 to tick2
2575 let q = i + 1
2580 let n(q) = newn(i)
2590 next i
2650  rem total up the new population to see if extinct
2655 let newtot = 0
2660 for i = 1 to tick
2670  let newtot = newtot + n(i)
2680 next i
2685 let n = newtot
2688 let endyr = yr - 1
2690 if n < xx then goto 2740
2730next yr
2740write#2,trial,endyr
2741  cls 0
2745  close #1
2755  open flnm1$ for input as #1
2760  for i = 1 to 210
2770if eof(1) then goto 2820
2780input #1, age(i),sur(i),rep(i),cvsur(i),cvrep(i),prop(i)
2800if sur(i) + rep(i) = 0 then goto 2820
2810  next i
2820  next trial
2845 close #2
2850 open "temp.dat" for input as #2
2855 let sumyr = 0
2856 let totvar = 0
2860 for i = 1 to zz
2865  if eof(2) then goto 2890
2870  input #2,trial(i),yrr(i)
2871  if yrr(i) >= 100 then propsur = propsur + 1
2875  let sumyr = (yrr(i) - 1) + sumyr
2880 next i
2885 if zz <= 1 then goto 2970
2890 let meanyr = sumyr/zz
2900  for i = 1 to zz
2910  let varyr(i) = ((meanyr - yrr(i))^2)
2920  let totvar = totvar + varyr(i)
2925  next i
2926  print "_____"
2927  print
2928  print "The simulation is complete."
2929  print
2930  print "Mean Extinction times and s.d.'s for this run are:"
2940  print
2950  print "Mean: "meanyr,,"SD: "(totvar/(zz-1))^.5
```

```
2960  print
2961  let vart = 1.96*((totvar/zz-1))^.5
2965  print "Appox. 95% interval: " meanyr+vart,meanyr-vart
2966  print
2967  let prrr = propsur/zz
2968  print "The proportion making it 100 years was "propsur/zz"."
2969  print
2970  print  "The initial population size was "totnn"."
2971  print
2973  print  "-------------------------------------------------------"
2975  close #2
2978  kill "temp.dat"
2979  if kkl <> 1 then goto 2985
2980  write#3,totnn,prrr,meanyr,vart
2981  if prrr > 0.95 then goto 2984
2982  let mike = mike + sttp
2983  next value
2984  close #3
2985  print
2986  if kkl <> 1 then print "Type 1 to run a new initial population size."
2990  input "Hit 0 to exit the program to DOS."  , mkj
3000  if mkj = 1 then goto 470
3010  stop
```

APPENDIX 5. Demographic data compiled for selected species of wildlife

Table 1. Black bear demographic data used in population simulations. Reproduction reflects the number of females born on average to each adult female each year. A catastrophic event that lowered reproduction by 40% occurred (on average) every 25 years.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
0	1.00 ±0.00	1.00 ±0.00	0.00 ±0.00	0.00 ±0.00
1	0.65 ±0.07	0.80 ±0.08	0.00 ±0.00	0.00 ±0.00
2	0.80 ±0.08	0.90 ±0.09	0.00 ±0.00	0.00 ±0.00
3	0.80 ±0.08	0.90 ±0.09	0.30 ±0.10	0.30 ±0.10
4	0.80 ±0.08	0.90 ±0.09	0.45 ±0.12	0.50 ±0.15
5	0.80 ±0.08	0.90 ±0.09	0.45 ±0.12	0.50 ±0.15
40	0.80 ±0.08	0.90 ±0.09	0.45 ±0.12	0.50 ±0.15

Instantaneous r values for these models are: best (Model 1) = 1.10051; medium (Model 2) = 1.0659; worst (Model 3) = 0.98157.

Table 2. Sandhill Crane demographic data used in population simulations. Reproduction reflects the number of females born on average to each adult female each year. A catastrophic event that lowered reproduction in that year by 40% and survival by 25% occurred (on average) every 25 years.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
0	1.00 ±0.00	1.00 ±0.00	0.00 ±0.00	0.00 ±0.00
1	0.60 ±0.30	0.63 ±0.31	0.00 ±0.00	0.00 ±0.00
2	0.88 ±0.18	0.93 ±0.20	0.00 ±0.00	0.00 ±0.00
3	0.93 ±0.16	0.98 ±0.17	0.01 ±0.04	0.01 ±0.04
4	0.93 ±0.13	0.98 ±0.14	0.04 ±0.06	0.04 ±0.06
5	0.92 ±0.07	0.97 ±0.08	0.16 ±0.08	0.17 ±0.08
6	0.92 ±0.05	0.96 ±0.05	0.26 ±0.02	0.27 ±0.02
7	0.91 ±0.02	0.95 ±0.03	0.26 ±0.02	0.27 ±0.02
8	0.90 ±0.04	0.94 ±0.05	0.26 ±0.02	0.27 ±0.02
9	0.89 ±0.06	0.91 ±0.06	0.26 ±0.03	0.27 ±0.03
10	0.86 ±0.09	0.89 ±0.09	0.26 ±0.03	0.27 ±0.03
11	0.84 ±0.08	0.89 ±0.08	0.26 ±0.03	0.27 ±0.03
12	0.84 ±0.08	0.89 ±0.08	0.26 ±0.03	0.27 ±0.03
13	0.84 ±0.08	0.87 ±0.08	0.26 ±0.03	0.27 ±0.03
14	0.77 ±0.08	0.81 ±0.08	0.26 ±0.03	0.27 ±0.03
15	0.72 ±0.07	0.76 ±0.07	0.26 ±0.03	0.27 ±0.03
16	0.65 ±0.06	0.68 ±0.06	0.26 ±0.03	0.27 ±0.03
17	0.48 ±0.05	0.51 ±0.05	0.26 ±0.03	0.27 ±0.03
18	0.47 ±0.05	0.50 ±0.05	0.26 ±0.03	0.27 ±0.03
19	0.47 ±0.05	0.50 ±0.05	0.26 ±0.03	0.27 ±0.03
20	0.47 ±0.05	0.50 ±0.05	0.26 ±0.03	0.27 ±0.03

Instantaneous r values for these models are: best (Model 1) = 1.0196; medium (Model 2) = 0.9681; worst (Model 3) = 0.9625.

Table 3. Bobcat demographic data used in population simulations. Reproduction reflects the number of females born on average to each adult female each year. A catastrophic event that lowered survival and reproduction by 30% occurred every 25 years (on average).

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
0	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00
1	0.32 ±0.18	0.34 ±0.20	0.60 ±0.30	0.63 ±0.31
2	0.68 ±0.07	0.71 ±0.08	0.60 ±0.24	0.63 ±0.25
3	0.68 ±0.07	0.71 ±0.08	1.15 ±0.32	1.20 ±0.34
4	0.68 ±0.07	0.71 ±0.08	1.15 ±0.24	1.20 ±0.26
5	0.68 ±0.07	0.71 ±0.08	1.15 ±0.12	1.20 ±0.14
16	0.68 ±0.07	0.71 ±0.08	1.15 ±0.12	0.27 ±0.13

Instantaneous r values for these models are: best (Model 1) = 1.0169; medium (Model 2) = 1.0055; worst (Model 3) = 0.956.

Table 4. Fox squirrel demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. A catastrophic event that lowered reproduction by 80% occurred every 15 years (see Weigl et al. 1989 for more details).

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
0	1.00 ±0.00	1.00 ±0.00	0.00 ±0.00	0.00 ±0.00
1	0.23 ±0.13	0.28 ±0.15	0.47 ±0.35	0.47 ±0.35
2	0.67 ±0.10	0.73 ±0.10	1.15 ±0.41	1.15 ±0.41
3	0.67 ±0.07	0.73 ±0.08	1.15 ±0.41	1.15 ±0.41
4	0.67 ±0.07	0.73 ±0.08	1.15 ±0.41	1.15 ±0.41
5	0.67 ±0.07	0.73 ±0.08	1.15 ±0.41	1.15 ±0.41
14	0.67 ±0.07	0.73 ±0.08	1.15 ±0.41	1.15 ±0.41

Instantaneous r values for these models are: best (Model 1) = 1.0037; medium (Model 2) = 0.9379; worst (Model 3) = 0.8754.

Table 5. Gopher tortoise demographic data used in population simulations. Reproduction reflects the number of females born on average to each adult female. A catastrophic event that lowered reproduction by 70% occurred every 25 years (on average).

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
0	1.00 ±0.00	1.00 ±0.00	0.00 ±0.00	0.00 ±0.00
1	0.20 ±0.10	0.21 ±0.10	0.00 ±0.00	0.00 ±0.00
2	0.60 ±0.24	0.63 ±0.24	0.00 ±0.00	0.00 ±0.00
3	0.70 ±0.14	0.73 ±0.15	0.00 ±0.00	0.00 ±0.00
4	0.75 ±0.08	0.79 ±0.09	0.00 ±0.00	0.00 ±0.00
5	0.85 ±0.06	0.79 ±0.06	0.00 ±0.00	0.00 ±0.00
6	0.85 ±0.06	0.89 ±0.06	0.00 ±0.00	0.00 ±0.00
7	0.85 ±0.06	0.89 ±0.06	0.00 ±0.00	0.00 ±0.00
8	0.85 ±0.06	0.89 ±0.06	0.00 ±0.00	0.00 ±0.00
9	0.90 ±0.06	0.94 ±0.06	0.00 ±0.03	0.00 ±0.00
10	0.90 ±0.06	0.94 ±0.06	0.28 ±0.14	0.30 ±0.15
11	0.90 ±0.06	0.94 ±0.06	0.28 ±0.14	0.30 ±0.15
12	0.90 ±0.05	0.94 ±0.05	0.28 ±0.10	0.30 ±0.12
13	0.90 ±0.05	0.94 ±0.05	0.28 ±0.07	0.30 ±0.08
14	0.90 ±0.05	0.94 ±0.05	0.30 ±0.07	0.31 ±0.08
15	0.90 ±0.05	0.94 ±0.05	0.30 ±0.06	0.31 ±0.07
16	0.90 ±0.05	0.94 ±0.05	0.30 ±0.03	0.31 ±0.03
17	0.90 ±0.05	0.94 ±0.05	0.30 ±0.03	0.31 ±0.03
18	0.90 ±0.05	0.94 ±0.05	0.30 ±0.03	0.31 ±0.03
19	0.90 ±0.05	0.94 ±0.05	0.30 ±0.03	0.31 ±0.03
20	0.90 ±0.05	0.94 ±0.05	0.30 ±0.03	0.31 ±0.03
21	0.90 ±0.06	0.94 ±0.06	0.40 ±0.14	0.42 ±0.15
22	0.90 ±0.06	0.94 ±0.06	0.40 ±0.14	0.42 ±0.15
23	0.90 ±0.05	0.94 ±0.05	0.40 ±0.10	0.42 ±0.12
24	0.90 ±0.05	0.94 ±0.05	0.40 ±0.07	0.42 ±0.08
25	0.90 ±0.05	0.94 ±0.05	0.40 ±0.07	0.42 ±0.08
26	0.90 ±0.05	0.94 ±0.05	0.40 ±0.06	0.42 ±0.07
27	0.90 ±0.05	0.94 ±0.05	0.40 ±0.03	0.42 ±0.03
28	0.90 ±0.05	0.94 ±0.05	0.40 ±0.03	0.42 ±0.03
29	0.90 ±0.05	0.94 ±0.05	0.40 ±0.03	0.42 ±0.03
30	0.90 ±0.05	0.94 ±0.05	0.50 ±0.04	0.52 ±0.04
60	0.90 ±0.05	0.94 ±0.05	0.50 ±0.04	0.52 ±0.04

Instantaneous r values for these models are: best (Model 1) = 0.9701; medium (Model 2) = 0.9681; worst (Model 3) = 0.9075.

Table 6. Red-cockaded woodpecker demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. A catastrophic event that lowered survival by 50% occurred every 50 years. The frequency and magnitude of the catastrophic event was designed to mimic the threat of hurricanes (see Cely 1990).

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
0	1.00 ±0.00	1.00 ±0.00	0.00 ±0.00	0.00 ±0.00
1	0.32 ±0.11	0.34 ±0.11	0.37 ±0.05	0.39 ±0.05
2	0.71 ±0.07	0.75 ±0.08	0.79 ±0.11	0.82 ±0.11
3	0.78 ±0.08	0.82 ±0.08	0.90 ±0.11	0.94 ±0.11
4	0.70 ±0.07	0.73 ±0.08	0.89 ±0.11	0.94 ±0.11
5	0.70 ±0.07	0.73 ±0.08	0.93 ±0.11	0.94 ±0.11
12	0.70 ±0.07	0.73 ±0.08	0.93 ±0.11	0.94 ±0.11

Instantaneous r values for these models are: best (Model 1) = 0.9549; medium (Model 2) = 0.9457; worst (Model 3) = 0.8963.

Table 7. Southern bald eagle demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. A catastrophic event lowered survival by 25% and reproduction by 40%. A catastrophic event had a 1 in 50 chance of occurring in a given year. The frequency and severity of catastrophic events was based on the effects that a freak winter storm had on eagles nesting in Florida in March 1993.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
1	0.42±0.5	0.47±0.5	0.00±0.00	0.00±0.00
2	0.82±0.11	0.86±0.11	0.00±0.00	0.00±0.00
3	0.82±0.11	0.86±0.11	0.00±0.00	0.00±0.00
4	0.82±0.11	0.86±0.11	0.00±0.00	0.00±0.00
5	0.82±0.11	0.86±0.11	0.35±0.40	0.66±0.40
6	0.82±0.11	0.86±0.11	0.35±0.30	0.66±0.30
7	0.82±0.11	0.86±0.11	0.35±0.30	0.66±0.30
8	0.82±0.11	0.86±0.11	0.35±0.20	0.66±0.20
9	0.82±0.11	0.86±0.11	0.35±0.20	0.66±0.20
10	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
11	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
12	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
13	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
14	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
15	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
16	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
17	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
18	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
19	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
20	0.82±0.11	0.86±0.11	0.40±0.20	0.66±0.20
21	0.82±0.11	0.83±0.11	0.40±0.20	0.66±0.20
22	0.82±0.11	0.83±0.11	0.40±0.20	0.66±0.20
23	0.82±0.11	0.83±0.11	0.40±0.20	0.66±0.20
24	0.80±0.11	0.83±0.11	0.40±0.20	0.66±0.20
25	0.78±0.11	0.83±0.11	0.40±0.20	0.66±0.20
26	0.78±0.11	0.83±0.11	0.40±0.20	0.66±0.20
27	0.78±0.11	0.82±0.11	0.40±0.20	0.66±0.20

Table 8. Florida scrub jay demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. Catastrophic events lowered survival by 25% and reproduction by 70%. Catastrophic events had a 1 in 10 chance of occurring in a given year.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
1	0.300±0.26	0.307±0.26	0.06±0.29	0.06±0.29
2	0.770±0.11	0.809±0.11	0.60±0.29	0.67±0.29
3	0.770±0.11	0.809±0.11	1.00±0.29	1.05±0.29
4	0.770±0.11	0.809±0.11	1.00±0.29	1.05±0.29
5	0.770±0.11	0.809±0.11	1.00±0.29	1.05±0.29
6	0.770±0.11	0.809±0.11	1.00±0.29	1.05±0.29
19	0.770±0.11	0.809±0.11	1.00±0.29	1.05±0.29
20	0.770±0.11	0.809±0.11	1.00±0.29	1.05±0.29

Table 9. Snowy plover demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. Catastrophic events lowered reproduction by 30%. Catastrophic events had a 1 in 10 chance of occurring in a given year. The frequency and severity of catastrophic events was designed to mimic freak summer storm events that caused coastal waters to wash over nesting areas.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
1	0.45±0.85	0.48±0.85	0.35±0.0	0.35±0.0
2	0.69±0.10	0.73±0.10	0.75±0.2	0.70±0.2
3	0.69±0.10	0.73±0.10	0.75±0.2	0.70±0.2
4	0.69±0.10	0.73±0.10	0.75±0.2	0.70±0.2
13	0.69±0.10	0.73±0.10	0.75±0.2	0.70±0.2
14	0.69±0.10	0.73±0.10	0.75±0.2	0.70±0.2

Table 10. Wild turkey demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. Catastrophic events lowered survival by 20%. Catastrophic events had a 1 in 20 chance of occurring in a given year. The frequency and severity of catastrophic events was designed to mimic epizootic diseases.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
1	0.25±0.30	0.25±0.30	0.0±0.0	0.0±0.0
2	0.368±0.12	0.38±0.12	2.8 ±1.2	5.3 ±1.2
3	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
4	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
5	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
6	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
7	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
8	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
9	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2
10	0.54±0.21	0.63±0.21	3.9 ±1.2	5.3 ±1.2

Table 11. Florida panther demographic data used in population simulations. Reproduction reflects the number of females born on average to each breeding female. Catastrophic events lowered survival by 20%. Catastrophic events had a 1 in 20 chance of occurring in a given year. The frequency and severity of catastrophic events was designed to mimic epizootic diseases.

	Survival		Reproduction	
Age Class	Worst	Best	Worst	Best
1	0.600±0.00	0.675±0.00	0.10±0.00	0.00±0.00
2	0.635±0.20	0.675±0.20	1.00±0.50	0.70±0.50
3	0.635±0.15	0.675±0.15	1.00±0.40	1.05±0.40
4	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
5	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
6	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
7	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
8	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
9	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
10	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
11	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
12	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
13	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
14	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
15	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40
16	0.635±0.10	0.675±0.10	1.00±0.40	1.05±0.40