Conservation Plans for Biotic Regions in Florida Containing Multiple Rare or Declining Wildlife Taxa

FINAL REPORT

July 1992–June 2002

Kevin M. Enge
Brian A. Millsap
Terry J. Doonan
Jeffery A. Gore
Nancy J. Douglass
Gary L. Sprandel

December 2003

Florida Fish and Wildlife Conservation Commission
Bureau of Wildlife Diversity Conservation
620 South Meridian Street
Tallahassee, FL 32399-1600

Conservation Plans for Biotic Regions in Florida Containing Multiple Rare or Declining Wildlife Taxa

Kevin M. Enge[1]
Brian A. Millsap[2]
Terry J. Doonan[3]
Jeffery A. Gore[4]
Nancy J. Douglass[5]
Gary L. Sprandel[2]

[1]Florida Fish and Wildlife Conservation Commission, 5300 High Bridge Road, Quincy, Florida 32351
[2]Florida Fish and Wildlife Conservation Commission, 620 South Meridian Street, Tallahassee, Florida 32399-1600
[3]Florida Fish and Wildlife Conservation Commission, P.O. Box 177, Olustee, Florida 32072
[4]Florida Fish and Wildlife Conservation Commission, 3911 Highway 2321, Panama City, Florida 32409
[5]Florida Fish and Wildlife Conservation Commission, 3200 Drane Field Road, Lakeland, Florida 33811-1299

Final Report
July 1992–June 2002

December 2003

Suggested citation:

Enge, K. M., B. A. Millsap, T. J. Doonan, J. A. Gore, N. J. Douglass, and G. L. Sprandel. 2003. Conservation plans for biotic regions in Florida containing multiple rare or declining wildlife taxa. Final Report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Conservation Plans for Biotic Regions in Florida Containing Multiple Rare or Declining Wildlife Taxa

Kevin M. Enge[1]
Brian A. Millsap[2]
Terry J. Doonan[3]
Jeffery A. Gore[4]
Nancy J. Douglass[5]
Gary L. Sprandel[2]

[1]Florida Fish and Wildlife Conservation Commission, 5300 High Bridge Road, Quincy, Florida 32351
[2]Florida Fish and Wildlife Conservation Commission, 620 South Meridian Street, Tallahassee, Florida 32399-1600
[3]Florida Fish and Wildlife Conservation Commission, P.O. Box 177, Olustee, Florida 32072
[4]Florida Fish and Wildlife Conservation Commission, 3911 Highway 2321, Panama City, Florida 32409
[5]Florida Fish and Wildlife Conservation Commission, 3200 Drane Field Road, Lakeland, Florida 33811-1299

Abstract: In 1990, the Florida Game and Fresh Water Fish Commission's Nongame Wildlife Program initiated a long-term planning effort to identify and prioritize taxonomic, survey, population monitoring, research, management, habitat protection, and education projects needed to conserve vertebrate wildlife taxa that might be vulnerable to extirpation. Ranking of 668 vertebrate taxa according to biological vulnerability indicated that many imperiled taxa occurred in 5 geographic regions or discrete habitat types: interior scrub and sandhill habitats, interior dry prairie region, South Florida pine rocklands and rockland hammocks, Northwest Florida streams and wetlands, and coastal communities. One hundred and fifteen taxa currently have biological scores (indicating vulnerability to extirpation) ≥24, the median score for state-listed species of special concern. Some of these high-ranking taxa are targeted for specific projects, which we call conservation tasks. Conservation tasks pertaining to wildlife communities in general may include taxa that are considered somewhat vulnerable to extirpation (biological score ≥17), of which there are an additional 149 taxa. Twenty-one taxa with biological scores <17 but for which information and management are needed (action score ≥35) can also be included in conservation tasks, along with the 117 low-ranking taxa, primarily neotropical migrant birds, with declining population trends in Florida. This report lists 13 systematic studies, 3 survey technique development projects, 52 survey projects, 25 monitoring projects, 56 research studies, 16 educational projects, 15 habitat protection projects, and 33 management projects that have been identified for target taxa (excluding bats) or habitats. The list of conservation tasks is incomplete and will be broadened as input is received from Commission staff, other agencies, and private conservation groups. Twenty-six projects have been identified for interior scrub and sandhill taxa, primarily sand-swimming reptiles, the Florida scrub-jay (*Aphelocoma coerulescens*), and several mammals. The interior prairie region has 40 projects, primarily the Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), sandhill crane (*Grus canadensis* subsp.), whooping crane (*G. americana*), crested caracara (*Caracara plancus audubonii*), and short-tailed hawk (*Buteo brachyurus fuliginosus*). Nineteen projects apply mostly to the Key deer (*Odocoileus virginianus clavium*) and endemic rodents of South Florida rockland habitats. Fifty-two projects are identified for amphibians, reptiles, and fishes inhabiting Northwest Florida streams and wetlands. Florida's complex coastal community— beaches, dunes, coastal strands and grasslands, maritime hammocks, tidal marshes, and tidal swamps—contains a diverse array of targeted taxa: seaside sparrows (*Ammodramus maritimus* subsp.), marsh wrens (*Cistothorus palustris* subsp.), declining neotropical migrants, mangrove-nesting songbirds, larids, shorebirds, rails, wading birds, rodents of coastal uplands and tidal marshes, salt marsh snakes (*Nerodia clarkii* subsp.), diamondback terrapins (*Malaclemys terrapin* subsp.), American crocodiles (*Crocodylus acutus*), and nesting sea turtles. Seventy-two tasks have been identified for coastal taxa, which does not include any for the Florida manatee (*Trichechus manatus latirostris*). Additional conservation tasks need to be developed for high-ranking taxa that do not occur primarily in the 5 identified geographic regions or habitats, such as the red-cockaded woodpecker (*Picoides borealis*), Florida black bear (*Ursus americanus floridanus*), and Florida panther (*Puma concolor coryi*). Twenty-one conservation tasks have been identified for the relatively large number of imperiled bat species, which were not covered under the 5 regions/habitats. A section of this report is devoted to each of the 5 regions/habitats with sympatric imperiled taxa. Each section contains habitat descriptions, a summary of the wildlife community present, threats to habitat or wildlife, conservation and management strategies, and a summary of the identified conservation tasks. Because of the complexity of the coastal community section, it is subdivided into coastal uplands and beaches, tidal marshes, and tidal swamps. Appendices provide pertinent scores for all imperiled taxa and details for each conservation task. Each task has a number that identifies the type of project and its priority. Tasks and their priorities will change as research is conducted and management or conservation actions are implemented for target taxa.

ACKNOWLEDGMENTS

We would like to thank all the persons who diligently scored taxa and reviewed scores. D. G. Bass and P. D. Southall scored fish. Besides the authors, fishes were scored by D. G. Bass and P. Ellis; amphibians and reptiles were scored by D. G. Cook and P. E. Moler; mammals were scored by D. T. Cobb, D. S. Maehr, J. M. Priest, and J. D. Ruhl; and birds were scored by S. I. Cerulean, J. Cox, M. F. Delany, D. R. Eggeman, F. A. Johnson, T. E. O'Meara, K. E. Miller, J. A. Rodgers, Jr., D. E. Runde, R. E. Turnbull, and G. E. Wallace. We would like to thank M. J. Allen, G. L. Bass, M. S. Belson, M. F. Delany, K. Dryden, N. C. Dwyer, S. L. Glass, P. Gray, T. Hoehn, M. McMillan, P. E. Moler, J. L. Morrison, S. A. Nesbitt, M. S. Robson, J. A. Rodgers, D. E. Runde, C. L. Tucker, and G. E. Wallace for contributing conservation tasks. R. S. Kautz, J. A. Cox, P. A. Frank, T. Hoehn, E. D. Stys, and A. F. Johnson provided comments on a draft of this document, and S. Cumberbatch and T. H. Eason helped get this report published.

TABLE OF CONTENTS

INTRODUCTION

One of the most pressing tasks facing state wildlife diversity programs is allocating limited funds across a seemingly endless list of poorly known taxa to effectively address information needs and conservation requirements. Nowhere is this problem more pervasive than in Florida. The high wildlife species richness, combined with the rapid growth in human population and the rising demand for agricultural products, place unparalleled pressures on the wildlife resources of the Sunshine State. It should be no surprise, then, that a recent national assessment of endangered ecosystems ranked Florida as having the greatest overall risk of ecosystem loss of any of the 50 states (Noss and Peters 1995). In the last 60 years, Florida has lost 22% of its forests and 51% of its herbaceous wetlands while agricultural lands have increased 60% and urban lands 632% (Kautz 1998). Seventeen vertebrates have gone extinct or been extirpated in Florida over the last 150 years (Kautz and Cox 2001), and 110 vertebrate taxa or populations are currently listed by Florida as endangered, threatened, or species of special concern (Florida Fish and Wildlife Conservation Commission 1999). However, Florida is still a global hot spot of diversity, even after decades of intense development and at least 12,000 years of human occupancy. Florida's location and humid subtropical climate (tropical at the southern tip) have led to the survival of a mixture of plant and animal species from more temperate areas to the north and tropical Caribbean areas to the south (Fernald and Purdum 1992).

The Fish and Wildlife Conservation Commission (FWC; formerly the Game and Fresh Water Fish Commission [GFC]) is the state agency charged with maintaining and enhancing Florida's wildlife diversity. In 1984, the Florida Legislature created in the GFC a Nongame Wildlife Program (NGWP) with the specific mission of maintaining and, where necessary, enhancing the state's nongame wildlife resources. From the outset, NGWP staff and advisors recognized that the key to successfully conserving biodiversity in the face of the challenges posed by Florida's expanding population and resource demands would be to direct efforts where they would be most effective at either conserving a variety of wildlife species or the most vulnerable species. Accordingly, in 1987, NGWP staff began a priority-setting exercise to identify and rank needed wildlife diversity conservation activities for Florida. This process began with a complete assessment of the biological status and knowledge base for each of the state's 668 regularly occurring vertebrate taxa (Millsap et al. 1990), followed by efforts to identify "hot spots" where clusters of highly vulnerable wildlife occurred sympatrically and likely shared some conservation needs (Millsap 1995). Finally, NGWP staff, in consultation with other scientists and wildlife educators both within and outside the GFC, developed lists of needed systematic, survey, monitoring, research, management, education, and habitat protection projects targeting these hot spots and their resident taxa. The NGWP later became the Bureau of Nongame Wildlife, which then combined with the Bureau of Wildlife Research in 1997 to form the Bureau of Wildlife Diversity Conservation (BWDC). Staff in the BWDC formulated the following mission statement in 2000: "to conserve wildlife diversity for the benefit of current and future Floridians by (1) conducting and facilitating baseline inventories, monitoring, research and management focusing on freshwater and terrestrial nongame amphibians, reptiles, birds, and mammals; (2) ensuring effective dissemination of the results of our work; and (3) applying our findings in our interactions with public and private entities whose activities impact Florida's wildlife and its habitats."

Many taxa in need of conservation attention in Florida occur sympatrically in discrete habitats and geographic regions. Sympatric imperiled taxa share many of the same information needs and may benefit from many of the same management practices. One focus of our long-range planning process was to identify regions of the state that support concentrations of imperiled vertebrate taxa, and to develop lists of needed projects that address multi-species and ecosystem-wide conservation needs within these areas. The purpose of this report is to describe the priority-setting process in more detail, to outline what we believe are the key problems that these co-occurring taxa face, and to list and rank activities that could be undertaken to address those problems. The list of needed activities, which we will call conservation tasks, should be considered as examples, and the list is not intended to be all-inclusive. The ultimate aim of conservation tasks is the welfare of a subspecies, species, or group of species. This report only provides a one-time snapshot of the current state of research, management, and education needs regarding select taxa. A database containing these conservation tasks exists and will be continuously updated as tasks are completed and new tasks are proposed.

METHODS

FWC'S APPROACH TO NONGAME CONSERVATION PLANNING

From 1987 to 1990, NGWP staff effected a peer-reviewed numerical ranking of all of Florida's vertebrate nongame taxa with manageable populations (Millsap et al. 1990). The goal was to provide an objective scale by which to compare the relative need for conservation attention of wildlife taxa in Florida. As might be expected, the list of worthy candidates for attention was a long one. A total of 294 (44%) taxa was identified as probably declining in Florida, and 113 taxa had biological vulnerability scores that equaled or exceeded the median for taxa included on the GFC's 1990 list of species of special concern. Following completion of that ranking project, NGWP staff initiated a long-range planning effort to identify and prioritize taxonomic, survey, monitoring, research, management, habitat protection, and education projects needed to help conserve taxa identified by the ranking system as most vulnerable to extirpation or extinction. Identifying needed conservation tasks is an ongoing process, and we do not presume that the current list is complete for any taxon, geographic area, or ecological community.

The ranking project produced biological scores, action scores, and 5 supplemental variables for each taxon (Millsap et al. 1990). The biological score is the sum of 7 variables that reflect different facets of distribution, abundance, and life history. High biological scores indicate greater vulnerability to extirpation. Because of their high potential fecundity, amphibian and fish taxa tend to have low biological scores compared to reptiles, birds, and mammals. This bias against amphibians and fishes is probably unwarranted, however, because only a small proportion of amphibian and fish offspring typically survive to reproduce. The action score is the sum of 4 variables that reflect the current state of knowledge of the taxon's distribution, population trend, limiting factors, and the extent of conservation efforts. High action scores denote poorly known, unmanaged taxa.

For the purposes of this conservation plan, a taxon is considered to be high ranking and warranting taxon-specific projects (tasks) if its rounded-off biological score is ≥24 (Appendix A), the median score for Species of Special Concern (Millsap et al. 1990). However, taxa with biological scores ≥17 are included in projects targeting ecological communities or pertaining to multiple taxa. Consideration is also given to taxa with biological scores <17 whose populations are known or suspected to be decreasing in Florida (i.e., Supplemental Variable 3 is ≥5; Appendix A). Taxa also may be targeted for research or conservation projects if existing information and management efforts are limited (i.e., action score is ≥35; Appendix A).

All taxa were re-scored by FWC personnel from 1997 to 2000 based on the most recent taxonomic information, biological research, and conservation efforts. These revised scores are used in this document (Appendix A). Four taxa were deleted from the original list (Millsap et al. 1990) because of recent revisions in taxonomy or geographic distribution: Florida bark anole (*Anolis distichus floridana),* peninsula green snake (formerly *Opheodrys aestivus carinatus*), northern redbelly snake (*Storeria o. occipitomaculata*), and Scott's seaside sparrow (formerly *Ammodramus maritimus peninsulae*). We also decided to delete extinct taxa from the list: dusky seaside sparrow (*Ammodramus maritimus nigrescens*) (Kale 1996*a*), Goff's pocket gopher (*Geomys pinetis goffi*) (Humphrey 1981, 1992*d*), pallid beach mouse (*Peromyscus polionotus decoloratus*) (Humphrey 1992*h*), Anastasia Island cotton mouse (*Peromyscus gossypinus anastasae*) (Humphrey 1992*b*), and Chadwick Beach cotton mouse (*P. g. restrictus*) (Humphrey 1992*c*). Many taxa were added to the list: southern dwarf siren (*Pseudobranchus axanthus* subsp.), 2 currently undescribed sirens (*Siren* sp. nov. cf. *intermedia* and *Siren* sp. nov. cf. *lacertina*), Escambia map turtle (*Graptemys ernsti*; formerly *G. pulchra*), mimic glass lizard (*Ophisaurus mimicus*), South Florida mole kingsnake (*Lampropeltis calligaster occipitolineata*), western mud snake (*Farancia abacura reinwardtii*), Mississippi green water snake (*Nerodia cyclopion*), greater Canada goose (*Branta canadensis maxima*), whooping crane (*Grus americana*), lesser black-backed gull (*Larus fuscus* subsp.), greater black-backed gull (*L. marinus*), bridled tern (*Sterna anaethetus*), short-eared owl (*Asio flammeus*), West Indian cave swallow (*Petrochelidon f. fulva*), Bicknell's thrush (*Catharus bicknelli*), painted bunting (western population; *Passerina ciris pallidor*), Henslow's sparrow (*Ammodramus henslowii*), Nelson's sharp-tailed sparrow (*A. caudacutus* subsp.), bobolink (*Dolichonyx oryzivorus*), Brewer's blackbird (*Euphagus cyanocephalus*), shiny cowbird (*Molothrus bonariensis*), Bullock's oriole (*Icterus bullockii*), house finch (*Carpodacus mexicanus* subsp.), Pallas's mastiff bat (*Molossus m. tropidorhynchus*), Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*), and Gulf Coast mink (*Mustela vison halilimnetes*).

When biological scores were revised, several taxa for which conservation tasks had been developed no longer had sufficiently high biological scores (i.e., ≥17) to warrant inclusion, including the seal salamander (*Desmognathus monticola*), eastern brown pelican (*Pelecanus occidentalis carolinensis*), southeastern American kestrel (*Falco sparverius paulus*), and Florida burrowing owl (*Athene cunicularia floridana*). Reductions in biological scores for these taxa mostly resulted from additional research, much of which was conducted or funded by the FWC.

In this document, we attempt to identify the most important taxonomic, survey, population monitoring, research, education, habitat protection, or population management needs for each imperiled taxon (Appendix B). Task numbers convey information about each task (see Gore et al. 1991). The first digit represents the type of study involved, where 1 = systematic or taxonomic; 2 = survey technique development; 3 = distributional survey; 4 = population monitoring; 5 = research (i.e., ecology and population biology); 6 = education; 7 = habitat protection; 8 = law enforcement; and 9 = species management. Currently, no law enforcement tasks have been identified. The second digit indicates the relative importance of the task, where 1 = a vital initial step to meeting the objective; 2 = necessary, but not necessarily the most important initial step to meeting the objective; and 3 = useful, but not absolutely necessary to meet the objective. The final 2 digits uniquely number each project; the ordering of the tasks using the final 2 digits does not indicate priority.

In identifying and prioritizing the tasks needed for a particular taxon, we found it helpful to ask the following questions:

1. Are there unresolved questions about the degree of differentiation the taxon has undergone from nearest relatives that might have a bearing on its conservation priority? If so, this should be identified as a problem and systematic work may be warranted to resolve it.
2. Do we know enough about the distribution of the taxon to predict (either from direct knowledge or based on known habitat associations) where it occurs? If not, then this should be identified as a problem, and distributional surveys and studies to describe habitat associations might be warranted to resolve it.
3. Do we confidently know trends in population size of the taxon? If the taxon is biologically vulnerable, then this should be identified as a problem and a monitoring project might be warranted to resolve it.
4. If the taxon is known or thought to be declining, do we know why? If not, this should be identified as a problem and research into causes of the population decline may be warranted to resolve it.
5. If the taxon is declining and we know why, do we know enough to develop management recommendations to reverse population trends? If not, then this should be identified as a problem, and research to identify viable solutions might be warranted.
6. Do we know enough about the biology of the taxon to establish meaningful population objectives? If not, and if the taxon is imperiled (e.g., is on the state or federal list or has a biological score $\geq$24), then this should be identified as a problem and research into population demographics of the taxon might be warranted.
7. If we know limiting factors, and particularly if we have established but not met population objectives, have we initiated management to achieve those objectives? If not, design and implementation of species or habitat management activities (e.g., restocking, building nest boxes, establishing harvest seasons, enforcing critical wildlife area closures) might be warranted to address the specific problems.
8. If we have implemented management activities, are monitoring programs in place that can document progress toward objectives? If not, this should be identified as a problem that might warrant design and implementation of a monitoring program.

This list of questions should only be viewed as a guide, but it helped lead us sequentially through a useful thought process to consistently frame our approach to each taxon. To help organize the results of the exercise, we developed a Conservation Project Nomination form (Appendix C). This form should be used to submit new project ideas from within or outside of the FWC.

A database contains the tasks identified for all the conservation plans and provides more details than appear in this report. This database is intended to facilitate adding, deleting, sorting, prioritizing, and retrieving tasks for future planning purposes, and to enable the FWC to track positive progress towards conservation objectives for priority species by documenting completions of necessary tasks. Conservation tasks will be periodically reviewed to delete those that have been completed by FWC employees or outside researchers, and to re-prioritize remaining tasks using the most current information available. When additional tasks are identified, they will be added to the database and assigned an appropriate task number. This database has enabled the FWC to respond quickly to requests for information on program personnel and funding needs from the Legislature, Governor, and Congress. The biological and action scores of taxa will need to be revised as tasks are completed and our knowledge of various taxa increases. Revisions of scores will be conducted annually because changes in scores partially reflect the performance of the FWC and are being used by the Legislature in performance-based planning and budgeting for the agency.

GEOGRAPHIC DISTRIBUTION OF HIGH-RANKING TAXA IN FLORIDA

To identify the habitats and geographic areas where imperiled taxa co-occur, NGWP staff overlaid maps of ranges of the 113 taxa with biological vulnerability scores equal to or greater than the median score for state-listed species of special concern, and then identified regions with large cumulative biological vulnerability scores. This effort highlighted 5 discrete regions of the state as focal regions for wildlife diversity conservation efforts (Fig. 1). Since then, a conservation plan specific to bats has been developed and included in this document, because 6 bat species in Florida have biological scores $\geq$17, 4 other bat species have action scores $\geq$35, and 2 other bat

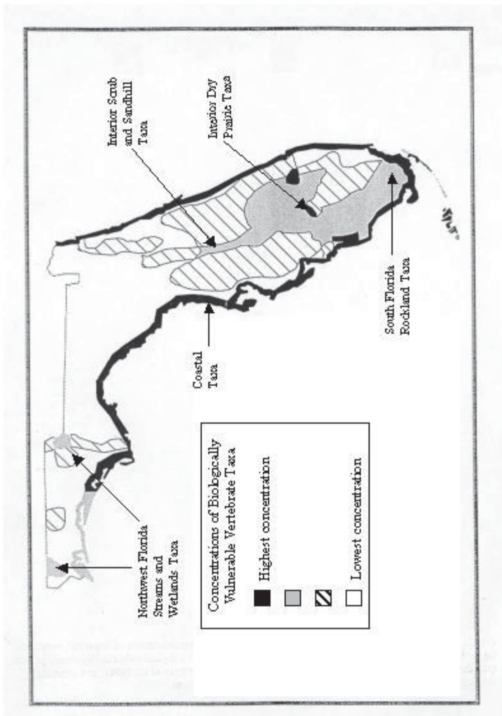

Fig. 1. Map of Florida showing regions of the state with high concentrations of imperiled vertebrate taxa. The map was prepared by overlaying ranges of 113 taxa with biological scores ≥24 (as of 1990), and summing overlapping scores (from Millsap 1995).

species have declining population trends (Appendix A). Although inadequate information exists on the distribution and occurrence of many bat species, bat populations are generally believed to have declined in the United States in recent decades (Kunz and Pierson 1994), partly due to disturbance of roost sites, vandalism, habitat change, and contaminants (Gillette and Kimbrough 1970, Clark 1981). Bats are susceptible to increased mortality or decreased recruitment because of their low reproductive rates and long generation times, and their tendency to aggregate in large, vulnerable colonies (Bogan et al. 1996). Most bat species that warrant conservation consideration in Florida do not fall neatly into 1 of the 5 high-priority regions. Twenty-one conservation tasks for bats have been identified, with most of the tasks related to research, distributional surveys, or population monitoring (Appendix B).

The 5 targeted regions of the state were (1) Florida's coastline, including primary dunes and beaches, tidal marshes, tidal (mangrove) swamps, and maritime hammocks; (2) interior peninsular ridges and associated scrub and sandhill ecological communities, particularly scrubs on the Lake Wales Ridge; (3) rockland (tropical) hammocks and pine rocklands on the Miami Rock Ridge and in the Florida Keys; (4) dry prairies of the peninsula's interior; and (5) wetlands, streams, and rivers of the northwestern peninsula and panhandle. Collectively, these 5 regions include large proportions of the geographic range of 69% of vertebrate taxa included on the state list of endangered and potentially endangered wildlife (Florida Fish and Wildlife Conservation Commission 1999). Names and descriptions of habitat types used in this paper are in accordance with the classification scheme developed by the Florida Natural Areas Inventory (1990). The relative need for conservation attention in each of these regions was assessed by plotting Gausian bivariate 95% confidence ellipses (Wilkinson 1990) about centroids of the sample means for action (knowledge for management) scores and biological (vulnerability) scores of included taxa (Fig. 2; scores are presented in the appendix in Millsap et al. 1990). The greatest mean biological vulnerability exists for taxa in the Florida Keys/Miami Rocklands group, followed by taxa in the peninsular ridge scrub/sandhill group and taxa in the coastal group. The greatest knowledge deficit exists for taxa in the Panhandle wetland group and taxa in the peninsular ridge scrub/sandhill group. Because of the combined high biological vulnerability and high knowledge deficit of included taxa, the peninsular ridge scrub/sandhill group stands out as the group most in need of conservation attention. The Everglades/Big Cypress region did not make the cut, despite this region being critical to the survival of the endangered Florida panther (*Puma concolor coryi*), Big Cypress fox squirrel (*Sciurus niger avicennia*), Everglades mink (*Mustela vison evergladensis*), and South Florida's wading bird populations, whose numbers of nesting colonies have declined drastically (e.g., Ogden 1994).

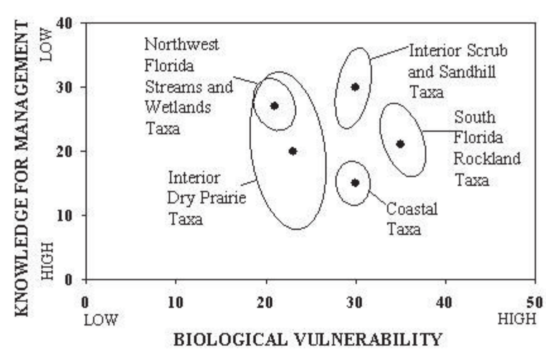

Fig. 2. Centroids and Gausian bivariate 95% confidence ellipses around intersection points for mean biological (vulnerability) scores and mean action (knowledge for management) scores of imperiled and declining taxa that occur in the priority regions of Florida identified in Fig. 1 (from Millsap 1995).

RESULTS AND DISCUSSION

RELATIONSHIP BETWEEN HOT SPOTS AND STRATEGIC HABITAT CONSERVATION AREAS

The FWC's Office of Environmental Services (OES) used the Geographic Information System (GIS) to identify important habitat areas for rare species that were not currently protected (Cox et al. 1994). The OES's Strategic Habitat Conservation Areas (SHCAs) encompass ≈13% (1.95 million ha) of Florida's land area and often coincide with the areas identified by Millsap et al. (1990) as containing a high percentage of biologically vulnerable taxa.

The SHCAs depict, in part, lands needed to meet minimum conservation goals for high-quality sandhill, scrub, pine rocklands, and rockland hammock sites; these habitats were also targeted for conservation plans by Millsap et al. (1990). The SHCAs also identified lands needed by 30 species of wildlife inadequately protected by the current system of conservation lands; some of these species are addressed here under conservation plans for interior dry prairie communities and Northwest Florida streams and wetlands. Relatively few coastal areas were identified as SHCAs, whereas coastal habitats were identified as important areas for many vulnerable species by Millsap et al. (1990), and the first conservation plan developed was for coastal communities (Gore et al. 1991). Since 1994, OES has identified another 24,213 ha of strategic habitats that should be conserved to ensure the long-term persistence of 16 additional vertebrates and to protect known congregations of nesting and wintering shorebirds (Kautz and Cox 2001). Between 1994 and 1998, government land-acquisition programs purchased 0.32 million ha of the strategic habitats identified by Cox et al. (1994), leaving 1.65 million ha still in private ownership (Kautz and Cox 2001). This conservation plan document is not intended to identify parcels of land that should be protected or purchased by state agencies.

PROBLEMS INHERENT TO OUR CONSERVATION PLANNING APPROACH

As we developed the lists of conservation tasks, it became apparent that despite our interest in approaching species conservation at a community level, much of what we identified as needing to be done was species-specific. Genetic studies, surveys, monitoring projects, habitat assessments, and even many management activities simply cannot be designed to effectively and efficiently target diverse groups of species, even if they do occur in the same place at the same time. Also, many vulnerable taxa do not readily fall into one or more of the targeted geographic hot spots. Our conservation planning effort needed to be broadened to incorporate (1) species not readily associated with priority biological communities, and (2) the needs of species that are associated with priority communities but have wider distributions and might require conservation attention in other parts of their range.

Conservation tasks need to be developed for at least some of the following taxa ignored by existing conservation plans: Florida panther, Florida black bear (*Ursus americanus floridanus*), river otter (*Lutra canadensis lataxina*), Sherman's short-tailed shrew (*Blarina carolinensis shermani*), ivory-billed woodpecker (*Campephilus p. principalis*), Stoddard's yellow-throated warbler (*Dendroica dominica stoddardi*), swallow-tailed kite (*Elanoides f. forficatus*), broad-winged hawk (*Buteo p. platypterus*), American bittern (*Botaurus lentiginosus*), northern flicker (*Colaptes a. auratus*), rusty blackbird (*Euphagus carolinus*), and blueback herring (*Alosa aestivalis*) (Appendix A). These taxa may utilize some of the habitats covered in the following conservation plans, but we have not included any tasks specific to these taxa. Tasks will be developed for these taxa and added to the database, as has been done recently for the red-cockaded woodpecker (*Picoides borealis*) (Appendix B). If the freshwater wetlands of the Everglades and Big Cypress regions, which contain mostly high-ranking mammalian taxa (Millsap et al. 1990), were incorporated into the South Florida rocklands conservation plan, as was suggested by Millsap (1995), additional high-ranking taxa would be covered by this conservation plan.

Development of conservation tasks and ranking of taxa would be facilitated if all important recent literature on high-ranking taxa were available in a bibliographic database. Some of the most important citations are already contained in the species-ranking database. Such a bibliographic database should also contain important references pertaining to the management, conservation, and ecological processes of habitats that have been targeted as containing a high proportion of imperiled taxa. A comprehensive bibliography has already been compiled for those taxa included in the interior scrub and sandhill conservation plan, and an indexed bibliography on Florida herpetofauna compiled by Enge and Dodd (1992) has been kept current (>6,400 citations in 2002) and can be found on the FWC's web site.

INTERIOR SCRUB AND SANDHILL COMMUNITIES

Habitat Descriptions

Xeric upland communities are present on hills of dry, deep, well-drained sand and include sandhill, scrub, and xeric hammock habitats. The first evidence of xeric uplands in Florida appeared nearly 20 million years ago, but in the last 10,000 years, rising water tables have created habitat islands of scrub and sandhill by replacing formerly xeric habitat with wetlands (Webb 1990). Even without man's influence, scrubs appear to be shrinking and becoming more isolated. During the last glacial maximum about 20,000 years ago, Florida was twice its present size, and scrub was probably the most abundant habitat type (Christman 1988). During the past 10,000 years, both climatic factors and anthropogenic practices, such as setting fires, may have favored the expansion of sandhill vegetation at the expense of scrub (Myers 1985). Long-term wildfire activity in Florida is related to the presence of the El Niño Southern Oscillation (Brenner 1991).

Sandhill, or high pine, habitat occurs on rolling hills, and the vegetation typically consists of widely spaced longleaf pines (*Pinus palustris*) with a sparse understory of deciduous oaks, primarily turkey (*Quercus laevis*), bluejack (*Q. incana*), or sand post (*Q. margaretta*) oaks. These longleaf pine-turkey oak sandhills can have a fairly dense and diverse ground cover of wiregrass (*Aristida stricta*), other grasses, and forbs. Fire occurs naturally in sandhill habitat every 2–5 years, partly because of the fire-carrying capacity of combustible longleaf pine needles, wiregrass, and other herbaceous species. Pine trees are generally unaffected by such frequent, low-intensity fires, and the ground cover recovers rapidly. On the southern Lake Wales ridge, sandhills typically have an overstory dominated by South Florida slash pine (*Pinus elliottii* var. *densa*) with scattered longleaf pine. Stunted, gnarled turkey oaks, abundant scrub hickory (*Carya floridana*), and evergreen scrub oaks, especially in unburned areas, characterize these southern ridge, or slash pine-turkey oak, sandhills (Abrahamson et al. 1984, Myers and White 1987).

Turkey oak barrens is a plant community intermediate between sandhill and scrub, and it is characterized by elements of both, as well as several distinctive plant species (Christman 1988). Natural turkey oak barrens are present along the eastern flank of the Lake Wales Ridge from Catfish Creek in Polk County south to Bear Hollow in Highlands County, where the irregular pattern of hills, valleys, and ponds affects fire behavior such that neither community is favored for very long periods of time (Christman 1988). Turkey oak barrens is characterized by scattered longleaf pines, abundant turkey or bluejack oaks, and sparse wiregrass. Elsewhere in Florida, man has created turkey oak barrens by suppressing fire, removing longleaf pines, and disturbing the wiregrass ground cover (Campbell and Christman 1982). These altered turkey oak-dominated sandhills typically have extensive areas of bare sand interspersed with drifts of oak leaves and scattered herbaceous vegetation (Campbell and Christman 1982).

Scrub habitat occurs on sand ridges that originated as wave-washed sandbars or wind-deposited dunes (Laessle 1968). In these areas, the deep, fine, well-drained sand often supports sand pines (*Pinus clausa*) that form an open to dense canopy. The understory typically consists of dense clumps or thickets of evergreen scrub oaks: sand live (*Quercus geminata*), myrtle (*Q. myrtifolia*), Chapman's (*Q. chapmanii*), and scrub (*Q. inopina*) oaks. Other common understory shrubs are saw palmetto (*Serenoa repens*), scrub rosemary (*Ceratiola ericoides*), and rusty lyonia (*Lyonia ferruginea*). Ground cover is sparse and interspersed with patches of barren sand and ground lichens (*Cladonia* spp.). Although a fire-adapted community, scrub habitat typically burns catastrophically only once every 20–80 years, with high-intensity crown fires often occurring in dense stands of sand pines because of high fuel loads due to the accumulation of resinous needles and the retention of lower branches (Florida Natural Areas Inventory 1990). Fires often destroy most aboveground vegetation, but oaks and other shrubs vigorously resprout from roots, and sand pine and rosemary reseed (Myers 1990). Scrubs that burn too frequently may lose sand pine and rosemary as seedbanks become depleted (Richardson 1977, Johnson 1982).

On the most excessively well-drained sands, where the water table is too deep for most plant roots, scrub plants are widely spaced and dwarfed. These scrub patches are frequently dominated by rosemary and are called rosemary scrubs or balds; they probably burn every 10–40 years (Johnson 1982). Oak scrubs are dominated by scrub oaks and lack a sand pine overstory, and they typically occur on isolated sandy rises or low dune ridges within a mosaic of other vegetation types that burn frequently (Myers 1990).

Scrubs on the Lake Wales, Winter Haven, and Lake Henry ridges of central peninsular Florida are on remnants of beach and sand dune systems associated with Miocene, Pliocene, or Early Pleistocene shorelines (Laessle 1968, White 1970, Christman and Judd 1990), and they are sometimes referred to as "ancient" scrubs (Christman 1988). These ancient scrubs have a longer history of emergence above sea level than other areas of peninsular Florida, and all are >25 m above mean sea level (Christman and Judd 1990). Most of the approximately 200 ancient scrubs in Highlands, Polk, Orange, and Osceola counties (Christman 1988) are <80 ha in size and located on private lands (Christman and Judd 1990). Ancient scrubs on these 3 sand ridges are biogeographically similar, and ≈40–60% of their taxa may be endemic (Christman 1988). About 17 plant taxa are endemic to ancient scrubs, and 40 vascular plant taxa are restricted to scrubs, natural turkey oak barrens, or scrub/sandhill ecotones (Christman and Judd 1990). The biologically diverse ancient scrubs on the Central Florida ridges are disjunct and scattered in a matrix of sandhills, turkey oak barrens, and flatwoods.

Ancient scrubs should not be confused with coastal scrubs or scrubs that developed following human disturbance. Coastal scrubs are probably not remnants of once-continuous scrub but have instead independently evolved where they now occur. Coastal scrubs contain some of the more vagile scrub endemics (Fernald 1989). During lower sea levels, many xeric-adapted species spread off their interglacial refuge on the Central Florida ridges to colonize "pioneer" and coastal scrubs. More recent scrubs in the interior of the peninsula are on dry, sandy soils in areas where topography results in wildfires that are too infrequent to maintain a sandhill community and too frequent to allow the development of xeric hammock vegetation (Myers 1985, Noss 1988). These "fire shadows" are often near wetlands, on peninsulas, or on steep slopes.

Pioneer interior scrubs are now being created by human activities, such as logging of pines and fire suppression in sandhill habitat. Logged and over-grazed pine flatwoods, old strip or sand mines, and even abandoned agricultural land may become pioneer scrubs. Pioneer scrubs and manmade turkey oak barrens usually have low species richness, little herbaceous vegetation, and infrequent fire. They are typically predominated by sand live oak, laurel oak (*Quercus hemisphaerica*), or turkey oak. On the Lake Wales Ridge, scrub hickory is locally abundant in young or pioneer scrubs, which often have yellow instead of white sand (Christman 1988).

Sand pine forests and scrubs in Ocala National Forest (ONF) are the largest pioneer scrubs and must have developed on former sandhills prior to European settlement (Christman 1988). Ocala National Forest contains ≈85,020 ha of sand pine scrub and 18,219 ha of sandhill habitat (Stout et al. 1988). Soil properties of Ocala's sandhill and sand pine forests are identical (Kalisz and Stone 1984*a*). Ocala's sand pine forests are naturally perpetuated by high-intensity fires every 30–50 years and become oak scrub for 5–10 years following each fire (Christman 1988). Sand pine forests commonly develop on logged and unburned sandhill sites adjacent to scrub, and some scrubs will develop into sand pine forests in the absence of fire, although this is rare on the Central Florida ridges (Christman 1988).

Extensive ecotones between scrub and mesic flatwoods are called scrubby flatwoods (Laessle 1942, Abrahamson et al. 1984), which are not xeric uplands but often contain xeric-adapted species. Scrubby flatwoods are usually on slightly elevated relictual sandbars and dunes, and they are characterized by widely scattered slash (*Pinus elliottii*) and longleaf pines with a sparse, shrubby understory of scrub oaks and saw palmetto, and numerous areas of barren white sand. The water table is much shallower than in scrub, but scrubby flatwoods do not normally flood because the white, sandy soil drains rapidly (Abrahamson et al. 1984, Florida Natural Areas Inventory 1990). Fires occur naturally in scrubby flatwoods every 8–25 years and tend to burn in a mosaic pattern because of the sparse ground cover and high proportion of relatively incombustible leaf litter from scrub oaks (Abrahamson et al. 1984, Florida Natural Areas Inventory 1990). The term scrubby flatwoods has also been applied to scrubs lacking a pine overstory (i.e., oak scrub) or to unburned flatwoods that have a scrubby appearance (Myers 1990).

In the absence of fire, sandhill habitat (and sometimes scrub) may be invaded by xeric or even mesic hardwood species, depending on available seed sources (Laessle 1958, Snedaker 1963, Monk 1968, Veno 1976, Myers 1985). Hardwood invasion into sandhills may be prevented by competition with the overlapping roots of wiregrass plants, which grow extremely dense where fires are frequent (Clewell 1989). The intermediate community of mixed pines and xeric hardwoods resulting from hardwood invasion into sandhills may succeed to xeric hammock in the continued absence of fire, or it may become scrub if a high-intensity fire occurs (Myers 1985). Frequent, high-intensity fires may revert this intermediate community, or sometimes even scrub habitat, to sandhill vegetation. The canopy of xeric hammocks is variable in density and height, but it usually contains live oak (*Quercus virginiana*), sand live oak, laurel oak, or pignut hickory (*Carya glabra*). The sparse understory typically consists of shrubs such as saw palmetto and sparkleberry (*Vaccinium arboreum*). Scrubby flatwoods and sand pine and rosemary scrubs often remain relatively stable during the prolonged absence of fire (Peroni and Abrahamson 1986, Christman 1988).

Scrub and sandhill habitats occur on similar droughty, infertile soils, but their vegetative structure and composition are different. These habitats are considered pyrogenic, which means that they are fire-maintained and fire-dependent, and their flora and fauna have developed adaptations to fire (Myers 1990). Fire frequency is important in managing these habitats in order to provide suitable conditions for taxa or groups of taxa. In pre-settlement times, single fires sometimes burned for weeks and covered areas the size of several counties (Means and Grow 1985). The high frequency of lightning strikes in Florida accounts for the dominance of pyrophytic vegetation (Komarek 1968, Abrahamson et al. 1984), although Native Americans may have increased fire frequencies in some areas during the past 12,000 years (Myers and Peroni 1983). Decreased fire frequency has resulted in the conversion of longleaf pine-turkey oak sandhills to turkey oak barrens. Fire suppression in southern ridge sandhills has resulted in the growth and expansion of turkey oak, scrub oaks, and scrub hickory, and a decrease in wiregrass and herbs (Peroni and Abrahamson 1986).

Seasonality of fire may also be important. Natural fires are caused by lightning strikes, which are most frequent during summer thunderstorms. Man, however, traditionally burned southeastern pine forests during the winter when fires were easier to control. Growing-season burns are more natural and result in minimal mortality of longleaf pine seedlings and saplings, a decline in understory hardwoods, and increased flowering and presumably seed production by dominant grasses and some forbs (Streng et al. 1993). The sharp discontinuity (i.e., edge) between scrub and sandhill was once thought to reflect soil differences (Laessle 1958) but is now thought to largely result from fire history, which is partially controlled by the vegetation itself (Myers 1985). Scrub has been called a "fire-fighting association" (Webber 1935, Laessle 1968) because fires spread into scrubs from surrounding habitats only under severe burning conditions: high wind, low humidity, and low fuel moisture. Scrub is not very flammable and has a high ignition temperature because of the scarcity of fine-textured, flashy fuels like grasses, pine straw, and dead woody material (Doren et al. 1987).

Wildlife Communities

Ten vertebrate taxa commonly found in the xeric uplands of peninsular Florida are state-listed as special concern or threatened (Appendix A). Other biologically vulnerable taxa (biological score $\geq$24) are the peninsula crowned snake (*Tantilla r. relicta*), Central Florida crowned snake (*T. r. relicta*), Florida scrub lizard (*Sceloporus woodi*), eastern diamondback rattlesnake (*Crotalus adamanteus*), peninsula mole skink (*Eumeces egregius peninsularis*), and striped newt (*Notophthalmus perstriatus*). Additional taxa of peninsular xeric uplands are suspected of having declining populations: southeastern pocket gopher (*Geomys p. pinetis*), Florida worm lizard (*Rhineura floridana*), Florida scarlet snake (*Cemophora c. coccinea*), southern hognose snake (*Heterodon simus*), ornate chorus frog (*Pseudacris ornata*), eastern tiger salamander (*Ambystoma t. tigrinum*), and barking treefrog (*Hyla gratiosa*) (Appendix A).

Xeric uplands are especially important because of their high degree of endemism, particularly along sand ridges in Central Florida. Vertebrate taxa endemic to Florida whose ranges encompass peninsular interior scrub and sandhill habitats include 3 subspecies of mole skink (*Eumeces egregius*), the sand skink (*Neoseps reynoldsi*), the Florida scrub lizard, the short-tailed snake (*Stilosoma extenuatum*), 2 subspecies of Florida crowned snake (*Tantilla relicta*), the Florida scarlet snake, the Florida scrub-jay (*Aphelocoma coerulescens*), and the Florida mouse (*Podomys floridanus*). Xeric-adapted species—Florida scrub-jay, Florida pine snake (*Pituophis melanoleucus mugitus*), Florida scrub lizard, and gopher tortoise (*Gopherus polyphemus*)—arrived in Florida along a Gulf coastal corridor that linked the savannas of Florida with semiarid western North America during low sea levels in the late Pliocene and early Pleistocene (Neill 1957, Auffenberg and Milstead 1965, Meylan 1982).

Historically, "Florida sand pine scrub was characterized by a temporally shifting age-class mosaic of variable patch sizes, frequently on the scales of hundreds to thousands of hectares as a result of large-scale, high-intensity wildfire" (Greenberg 1993). Characteristic xeric-adapted reptile species are uncommon in mature sand pine forest, suggesting that these species evolved in an environment where young, open scrub conditions created by high-intensity disturbances were abundantly available and close enough together in time and space to permit populations to shift among available habitat patches to avoid local extirpation (Campbell and Christman 1982, Greenberg 1993).

Ancient scrubs on the Central Ridges have ≈40 endemic arthropod taxa (Deyrup 1989) and 2 endemic lizard taxa, the sand skink and bluetail mole skink (*Eumeces egregius lividus*). Based on plant and animal species' distributions, the nearby Bombing Range Ridge, Lakeland Ridge, and Orlando Ridge are biogeographically different from the Central Florida ridges (Christman 1988). For example, sand and bluetail mole skinks are absent from the Bombing Range Ridge, although Florida scrub lizards are present (Branch and Hokit 2000).

The gopher tortoise is considered the "keystone" species for sandhill communities (Eisenberg 1983). Gopher tortoises require well-drained loose soil for burrowing, adequate low-growing herbs for food, and open sunny sites for nesting (Diemer 1992). The open canopy and dense ground cover of wiregrass and herbaceous species in frequently burned sandhills provide ideal conditions for gopher tortoises, which often attain their highest population densities here (McRae et al. 1981, Auffenberg and Franz 1982, Diemer 1986, Cox et al. 1987). Gopher tortoises are also commonly found in scrub, xeric hammock, and scrubby flatwoods. Scrub habitat typically does not provide ideal conditions for gopher tortoises because the sparse ground cover provides little food, and the loose sand often results in collapsed burrow mouths. In scrub habitat, gopher tortoises are often found along the ecotone between scrub and adjacent habitats, or along roads (Christman 1988). Gopher tortoises are more common in scrubby flatwoods and turkey oak barrens than in most scrubs and xeric hammocks, which have too much canopy closure and too little ground cover.

Species reported from tortoise burrows in Florida include at least 36 amphibians and reptiles, 19 mammals, and 7 birds (Jackson and Milstrey 1989, Brandt et al. 1993, Kent and Snell 1994). Over 300 species of invertebrates have also been found in gopher tortoise burrows (Diemer 1992), and many are strictly obligate commensals (Hubbard 1894, Woodruff 1982). Tortoise burrows are especially important to eastern indigo snakes (*Drymarchon corais couperi*) in North Florida, Florida gopher frogs (*Rana capito aesopus*), and Florida mice. Burrows provide sites for nesting and feeding, and they also provide refugia from fire, predators, extreme temperatures, or desiccation (Bogert and Cowles 1947, Landers and Speake 1980). The aprons in front of tortoise burrows provide germination sites for some plant species and microhabitats for sand-swimming reptiles—sand skink, mole skink, crowned snake—and other fossorial herpetofauna.

Drift-fence studies in peninsular Florida have provided information on the herpetofaunal communities of sandhill (e.g., Florida Game and Fresh Water Fish Commission 1976*b*, U.S. Fish and Wildlife Service 1978; Campbell and Christman 1982; Mushinsky 1985; Dodd and Charest 1988; Stout et al. 1988; Dodd 1992*a*; Joiner and Godwin 1992*a*,*b*; Franz et al. 1995; Stout and Corey 1995; Enge and Wood 1998, 1999–2000, 2001; Meshaka and Layne 2002) and scrub habitats (e.g., Florida Game and Fresh Water Fish Commission 1976*b*, Christman et al. 1979, Campbell and Christman 1982, Christman 1988, Greenberg et al. 1994, Timmerman et al. 1994, Mushinsky and McCoy 1995, Branch and Hokit 2000). Drift-fence studies have also been conducted on the impacts on herpetofaunal communities of logging in sand pine scrub in ONF (Christman et al. 1979, Greenberg et al. 1994) and in sandhills in the Panhandle (U.S. Fish and Wildlife Service 1980). Drift-fence studies have also provided information on the effects of fire frequency or lack of fire on sandhill herpetofauna (Mushinsky 1985, Meshaka and Layne 2002).

Many xeric-adapted wildlife species are present in both sandhill and scrub habitats, but some species are primarily restricted to only one habitat (Campbell and Christman 1982). Many xeric-adapted vertebrate species are semifossorial or fossorial, either burrowing or using the burrows of other animals to find more favorable temperature and moisture conditions in these harsh environments (Bogert and Cowles 1947, Neill 1952, Telford 1962, Lee 1969, Ashton and Ashton 1977, Campbell and Christman 1982, Franz 1988, Jones and Franz 1990, Layne 1990, Layne and Jackson 1994). An important component of the vertebrate community of some xeric uplands is fossorial or semifossorial amphibians: eastern spadefoot toad (*Scaphiopus h. holbrookii*), gopher frog, barking treefrog, and ornate chorus frog. The occurrence and relative abundance of amphibians in xeric uplands are dependent upon the presence and proximity of suitable wetland breeding sites (Christman et al. 1979, Greenberg et al. 1994, Enge and Wood, 2001). Xeric-adapted reptiles with fossorial tendencies include the gopher tortoise, worm lizard, mole skink, sand skink, pine snake, crowned snake, and short-tailed snake. Fossorial mammals in xeric habitats are the pocket gopher, Florida mouse, and old-field mouse (*Peromyscus polionotus*). As is the case with tortoise burrows, these mammal burrows are often used by other species (Gentry and Smith 1968, Lee 1968, Franz 1995, Franz et al. 1995).

Sandhills often have a diverse lizard and snake herpetofauna, and sand-swimming species are able to exist in loose sand in fire "hot spots," where high fuel loads, such as fallen trees, were present (Stout et al. 1988), or in mounds of geotrupine scarab beetles (*Aephodius*, *Copris*, or *Onthophagus*), gopher tortoises, and pocket gophers (Telford 1962, Mount 1963, Funderburg and Lee 1968). Scarab beetle mounds are most common in sandhills with sparse wiregrass, whereas pocket gopher and gopher tortoise mounds are most common in sandhills with dense wiregrass (Auffenberg and Iverson 1979, Kalisz and Stone 1984*b*).

The reduced wiregrass cover and extensive areas of bare sand present in turkey oak barrens provide suitable conditions for some scrub vertebrates, particularly sand-swimmers, worm lizards, and short-tailed snakes (Florida Game and Fresh Water Fish Commission 1976*a*, Campbell and Christman 1982, Smith 1982, Christman 1988). Sand-swimming reptiles and Florida scrub lizards are less common in xeric hammocks than in scrub and frequently burned sandhills, because they need open patches of bare sand. Historically, sandhill and sand pine scrub must have had a mix of successional stages, or mature communities must have had disturbed areas of open, loose sand suitable for the survival of some of the unique herpetofaunal taxa (Campbell and Christman 1982). Suitable disturbed microhabitats, besides animal mounds, could have resulted from severe fires, blow-downs of canopy trees by tornados or hurricanes, or outbreaks of pine-bark beetles (Campbell and Christman 1982).

The sand skink is most abundant on the Lake Wales and Winter Haven ridges, and it is extremely rare and localized in Lake and Marion counties on the Mount Dora Ridge (Christman 1992*d*). It reaches its northern range limit in ONF (Christman 1970, Smith 1982), where it appears to be very uncommon (Florida Game and Fresh Water Fish Commission 1976*b*, Christman et al. 1979, Telford 1992, Greenberg et al. 1994). Smith (1982) hypothesized that sand skinks were once more common in ONF when extensive wildfires occurred in sand pine scrub, and he claimed that they were still marginally abundant in man-induced turkey oak barrens, which have substrate conditions similar to oak or young sand pine scrub (Campbell and Christman 1982). The primary habitat of the sand skink is rosemary scrub, but it also occurs in sand pine scrub, oak scrub, scrubby flatwoods, and turkey oak barrens (Christman 1992*d*). The sand skink is restricted to microhabitats with loose sand and sunny exposures, and is usually found in moist subsurface sand (Telford 1959). Mushinsky and McCoy (1999) found that the relative abundance of sand skinks was positively related to the amount of loose surface sand, canopy density, and sand composed of relatively large particles. Loose sand and canopy cover seemed to moderate soil temperature, thereby permitting skinks to select favorable thermal microhabitats.

The relative abundances of sand skinks and bluetail mole skinks in 16 rosemary balds on the Lake Wales Ridge were negatively correlated with scrub oaks and the presence of Florida scrub-jays (Mushinsky and McCoy 1995). A drift-fence survey on the Lake Wales Ridge yielded >4 times as many sand skinks as bluetail mole skinks in rosemary balds (Mushinsky and McCoy 1995), and 1.5 times as many sand skinks as bluetail mole skinks in various sand pine, oak, and rosemary scrubs (Christman 1988). These 2 taxa sometimes coexist in the same microhabitat, but they do not compete for food (Myers and Telford 1965, Smith 1982).

The Florida scrub lizard is an abundant and conspicuous inhabitant of rosemary, oak, and sand pine scrubs, and it may even occur in turkey oak barrens and frequently disked young citrus groves (Lee 1974). In xeric hammocks and sand pine forests, scrub lizards are mostly restricted to habitat edges, canopy openings, and disturbed areas such as road shoulders (Enge et al. 1986).

Ideal habitat consists of clumps of shrubs for escape cover separated by areas of bare sand with high insolation. The disjunct distribution of the scrub lizard includes the extensive sand pine forests of ONF and adjacent areas in Marion, Putnam, and Lake counties. It also inhabits scattered scrubs in Polk, Osceola, Orange, and Highlands counties, and Atlantic Coastal Ridge scrubs from Brevard to Broward counties (Enge et al. 1986, Christman 1988). It probably no longer exists along the southwestern Gulf Coast in Lee and Collier counties (Clark et al. 1999). Poor dispersal abilities have apparently prevented it from occupying large tracts of seemingly suitable habitat, although local population extinctions have likely occurred in some areas (Jackson 1973). In ONF, scrub lizards apparently colonize stands 1–2 years after logging and abandon them 7–9 years after replanting of sand pines (Tiebout and Anderson 1997). In a study of 16 rosemary balds on the Lake Wales Ridge, the relative abundance of the scrub lizard was positively correlated with scrub size (Mushinsky and McCoy 1995). The distribution of the scrub lizard in scrub patches on Avon Park Air Force Range (AFR) and Arbuckle State Forest was strongly influenced by the amount of open sandy habitat, patch size, and patch isolation; patches lacked scrub lizards if they were >750 m from an occupied patch (Hokit et al. 1999).

The short-tailed snake occurs primarily in sandhill habitat, but occasionally in sand pine scrub and xeric hammock, from Suwannee and Columbia counties south to Hillsborough, Orange, and Highlands counties (Campbell 1992). Early successional sand pine scrub is probably more suitable than mature scrub (Campbell and Christman 1982). The short-tailed snake apparently preys primarily upon small snakes, especially the crowned snake (Mushinsky 1984, Rossi and Rossi 1993). Drift-fence surveys indicate that crowned snakes are the most abundant snake species in most xeric upland communities (Florida Game and Fresh Water Fish Commission 1976*b*, Mushinsky 1985, Christman 1988, Franz et al. 1995, Mushinsky and McCoy 1995, Joiner and Godwin 1992*b*, Greenberg et al. 1994, Timmerman et al. 1994). The fossorial peninsula crowned snake occurs in both scrub and sandhill habitats, although it appears to be absent from sandhills in areas of syntopy with the semifossorial Central Florida crowned snake (Telford 1966). In sand pine scrub in ONF, the peninsula crowned snake is most abundant in early successional stages but is also present in mature sand pine forests (Christman et al. 1979, Telford 1992, Greenberg et al. 1994). The Central Florida crowned snake apparently prefers areas with at least partial shade and a thin to moderate litter layer of leaves or pine needles in sandhills and xeric and mesic hammocks (Telford 1966, Franz et al. 1995).

The pine snake prefers sandhill and oldfield habitats but also uses sand pine scrubs, scrubby flatwoods, and xeric hammocks. In north-central Florida sandhills, pine snakes had a mean home range size of 53 ha, and males used up to 100 ha (Franz 1988). The pine snake is an accomplished burrower and spends 85% of its time underground, especially in burrows of the pocket gopher, which is an important prey item (Franz 1988).

Ephemeral wetlands (e.g., grassy ponds, dome swamps), especially fish-free ones, in xeric upland communities are important breeding sites for the gopher frog, barking treefrog, ornate chorus frog, striped newt, mole salamander (*Ambystoma talpoideum*), and tiger salamander (Dodd 1991; Christman and Means 1992; Dodd 1992*a*, 1993; Telford 1993; Franz and Smith 1999; Enge and Wood 1999–2000, 2001; Greenberg *in press*). The striped newt, tiger salamander, mole salamander, and ornate chorus frog occur in xeric uplands in only the northern part of the peninsula. The gopher frog is apparently declining due to destruction and alteration of sandhill habitat and upland breeding sites, and the decline in gopher tortoise populations (Godley 1992). The gopher frog is most common in sandhill habitat but is also found in sand pine scrub, xeric hammock, and scrubby flatwoods, provided that gopher tortoises are present and suitable breeding ponds are ≤1.6 km away (Franz et al. 1988, Godley 1992). Some terrestrial amphibians in xeric uplands have been trapped 900–5,000 m from the nearest known water source (Greenberg 1993, Dodd 1996). Wetlands also provide foraging sites for the indigo snake (Moler 1985*b*), pine snake, rat snakes (*Elaphe* spp.) (Franz 1995), and diamondback rattlesnake (Timmerman 1995). Temporary sinkhole ponds in sandhills are important centers of herpetofaunal diversity, and their lack of predatory fish and certain invertebrates provides favorable conditions for larval amphibian development (Dodd 1992*a*).

The Florida mouse, Florida's only endemic mammal species, occurs primarily in sand pine scrub, oak scrub, scrubby flatwoods, and turkey oak barrens (Layne 1992). Highest population densities are attained in early successional scrub and turkey oak barrens, or in sandhills that have been recently burned and lack dense wiregrass (Layne 1992, Newman 1997).

Mature sandhills provide optimum habitat for Sherman's fox squirrel (*Sciurus niger shermani*), although xeric hammock, open flatwoods, dry prairie, and scrub may also be used. The lower slopes of sandhills may provide the best habitat because of the large mast crop provided by longleaf pines and turkey oaks interspersed with sand post, live, laurel, and bluejack oaks (Kantola and Humphrey 1990). The low diversity and abundance of food resources, along with their variability in time and space, may explain the large home ranges and relatively low population densities of fox squirrels in Florida (Humphrey et al. 1985, Kantola 1986, Kantola and Humphrey 1990).

Optimal Florida scrub-jay habitat consists of clumps of 1–3 m tall scrub oaks interspersed with numerous patches of bare sand (Cox 1984). The scrub-jay is the most distinctive indicator species for oak scrub habitat, but other potentially suitable habitats include open sand pine scrub, open scrubby flatwoods with slash pines, rosemary scrub, southern ridge sandhill, and the edges of sand pine forest, mature sand pine scrub, and xeric hammock (Fitzpatrick et al. 1991). The scrub-jay may also use both natural and manmade habitats adjacent to scrub: dry prairies, turkey oak barrens, citrus groves, pastures, and lawns. The scrub-jay exhibits permanent monogamy, year-round territoriality, delayed dispersal, and cooperative breeding, which have evolved in response to the scattered, isolated nature of its oak scrub habitat. Virtually all habitat suitable for scrub-jay survival and reproduction is already occupied, so new territories can only be established at the expense of neighboring breeders (Fitzpatrick et al. 1991).

Threats to Habitat or Wildlife

Populations of xeric-adapted species have declined in Florida because of substantial habitat loss due to human activity. Sandhill habitat in 1987 covered only 2.4% of Florida, which represented an 88% loss of habitat since European settlement (Kautz et al. 1993). Prior to European settlement, sandhill vegetation covered 2.78 million ha or 20% of Florida, mostly in the Panhandle and northern two-thirds of the peninsula (Davis 1967). Only 344,530 ha of sandhill habitat remain (Kautz et al. 1993), and sandhill vegetation occurs in disparate patches covering <10% of its former area (Cox et al. 1994). Only 38.2% of remaining sandhill habitat is found on public lands (Cox et al. 1994). The largest remaining sandhill habitat in the peninsula occurs along the sand ridge extending from Levy to Pasco County and on sand ridges in Putnam and Clay counties, where the Ordway Preserve, Jennings Forest Wildlife Management Area (WMA), and Camp Blanding WMA are located (Cox et al. 1994).

Only ≈1.2% of Florida is now covered by scrub habitat, which has declined 59% since European settlement (Kautz et al. 1993). Prior to European settlement, Florida had ≈417,000 ha of scrub (Davis 1967), but only 170,850 ha remained in 1987 on the 3 Central Florida ridges (Kautz et al. 1993). Ancient scrubs along these central ridges have experienced an 82% decline (J. W. Fitzpatrick, cited by Cox et al. 1994). Between 1936 and 1959, an average of 700 ha of sand pine scrub was annually converted to citrus groves and urban areas, but increased commercial planting of sand pine on sandhill sites has masked subsequent losses (Kautz 1993). About 75% of sand pine scrubs (primarily in ONF) and 41.3% of xeric oak scrubs are in public ownership, but the quality of the habitat varies. The Lake Wales Ridge Ecosystem Project protects an additional 4,940 ha of scrub.

Severe freezes in the 1890s caused the citrus industry to move southward from north-central Florida to Lake, Orange, and Polk counties. "Rough lemon rootstock" came into extensive use in orange horticulture between 1905 and 1910, and this rootstock was found to grow well on the higher sandhill ridges, which also provided protection against severe freezes (Hoffman and Collopy 1988). Human settlement on the southern Lake Wales Ridge increased during the 1920s and resulted in more fires but less area burned per fire (Peroni and Abrahamson 1986). Fires became less frequent on any given parcel of undeveloped land due to direct fire suppression and manmade barriers to fire: roads, citrus groves, and housing projects (Peroni and Abrahamson 1986).

By 1981, ≈64% of xeric upland habitat on the southern Lake Wales Ridge had been converted to citrus groves or residential developments, and another 10% of the habitat was subdivided and platted with roads (Peroni and Abrahamson 1985). Conversion of scrubs to citrus groves on the southern Lake Wales Ridge accelerated following the devastating freezes of 1983 and 1985 (J. N. Layne, pers. commun. to Christman and Judd 1990). Currently, citrus groves constitute almost one-half of the agricultural acreage in Florida (Florida Department of Agriculture and Consumer Services 1994). Scrub that was formerly ignored by agricultural interests is presently considered prime residential and citrus land, and low agricultural tax rates encourage its destruction (Christman 1988). Private landowners sometimes clear and root-rake scrubs to destroy the vegetation and avoid possible governmental land-use restrictions (Christman 1988, Fergus 1993).

Some sandhills are threatened by invasion of the nonnative cogongrass (*Imperata* sp.), which forms dense stands that are probably unsuitable for many native plant and animal species (Simons 1990). Cogongrass is difficult to eradicate by mechanical means, herbicides, and fire; the highly flammable fuel loads of cogongrass may eventually eliminate most of the fire-adapted woody plant species (Simons 1990).

Landscape development and fragmentation potentially pose demographic, genetic, and environmental stochasticity threats to xeric-adapted taxa. Land clearing has fragmented and isolated sandhill habitat, reducing the size and increasing the distance between remaining patches of habitat until they no longer can support viable populations of some species, especially ones with large home ranges, such as the indigo snake and fox squirrel. Even species with smaller home ranges, such as the southern hognose snake and short-tailed snake, may be experiencing population declines due to habitat destruction or degradation and road mortality (Tuberville et al. 2000). Sandhill vertebrates are impacted by logging of longleaf pine and subsequent timber management practices, and by destruction and fragmentation of sandhill habitat in Central Florida by phosphate mining and conversion to citrus groves and subdivisions. The remnant sandhills of south-central Florida are small, isolated, and faunally depauperate (Humphrey et al. 1985).

In 1998, Florida had over 184,000 km of public highways that were used by almost 40 million motor vehicles, including ones registered in Florida and automobiles driven by ≈44% of almost 49 million visitors (Bureau of Economic and Business Research 1999). The network of roads threatens wildlife populations via highway mortality, fragmenting individual home ranges and regional populations, altering the physical or chemical environment, increasing the use of remote areas by humans, and promoting the spread of exotic species (Lodé 2000, Trombulak and Frissell 2000). In eastern Texas, populations of large snakes were 50% less abundant up to 450 m from roads than they were 850 m from roads, apparently due to road-related mortality (Rudolph et al. 1999).

The indigo snake is a large, active, diurnal species that is vulnerable to mortality caused by vehicles, dogs, and insensitive landowners (Mount 1975, Steiner et al. 1983, Moler 1985*b*). This taxon was once heavily collected for the pet trade, but it was protected by the state in 1971 and by the federal government as a threatened species in 1978 (Moler 1987), and populations have since recovered in many areas. Although large-scale commercial trade in indigo snakes has ceased, some illegal trade persists. The illegal practice of pouring gasoline into tortoise burrows to drive out diamondback rattlesnakes poses a threat to indigo snakes, pine snakes, and gopher frogs in some areas (Speake and Mount 1973, Speake and McGlincy 1981). Habitat fragmentation particularly affects this species because of its large home range requirements.

The existence of the red imported fire ant (*Solenopsis invicta*) in the Coastal Plain of the southeastern United States has been blamed for apparent declines in populations of some herpetofaunal species (Mount 1981, Tuberville et al. 2000). Fire ants can indirectly affect wildlife populations by altering their food supply or habitat, but they have also been documented killing amphibians, reptile eggs and hatchlings, nestling birds, rodents, young rabbits (*Sylvilagus* spp.), and even white-tailed deer (*Odocoileus virginianus*) fawns (e.g., Freed and Neitman 1988; Dickinson 1995; Allen et al. 1997*a*,*b*,*c*, 1998; Ferris et al. 1998; Mueller et al. 1999, Reagan et al. 2000; Allen et al. 2001; Legare and Eddleman 2001).

Based on the amount of known habitat loss, Sherman's fox squirrel populations have undoubtedly declined ≥85% from pre-settlement levels (Kantola 1992). Habitat destruction and fire suppression have eliminated populations in many areas, and small isolated populations on remnant fragments may suffer genetic and demographic problems (Noss 1988). The optimal mature sandhill habitat has been greatly altered through extensive logging; turpentining; fire suppression; clearing for pastureland; conversion to short-rotation pine plantations; and agricultural, commercial, and residential development (Bechtold and Knight 1982, Kantola and Humphrey 1990). Annual winter burns to manage for northern bobwhite quail (*Colinus virginianus*) have damaged the habitat for fox squirrels by reducing longleaf pine regeneration. Longleaf pine seeds dropped in October–November require bare mineral soil without shade for germination; seedlings <1 year old are usually killed by fire (Wahlenberg 1946).

The Florida scrub-jay once occurred in 39 of the 40 counties south of, and including, Levy, Gilchrist, Alachua, Clay, and Duval (Cox 1987). The scrub-jay has been extirpated from 7 of these counties, and habitat loss or degradation along the Lake Wales Ridge since human settlement has resulted in an estimated loss of ≥80% of the scrub-jay population (Fitzpatrick et al. 1991). The statewide population is estimated at about 7,000–11,000 birds (Breininger 1989), with >50% occurring on and around ONF (2,600–3,400; Cox 1987) and Merritt Island National Wildlife Refuge (NWR) (1,400–3,600; Breininger 1989). Fragmented habitat on the Lake Wales Ridge in Highlands and Polk counties, particularly Archbold Biological Station, supports the third highest concentration of birds (Fitzpatrick et al. 1991).

Gopher tortoise populations in North Florida have been impacted by the lack of prescribed burning and the conversion of sandhill habitat to dense pine monocultures or subdivisions. Extensive research has been conducted on this species, including population demographics and responses to habitat management. A new threat to some populations is the presence of upper respiratory tract disease (URTD), a highly contagious and potentially fatal disease caused by *Mycoplasma* spp. transmitted by direct contact between tortoises. A widespread outbreak of URTD occurred on Sanibel Island in 1989, where 86% of the population carried URTD, although only 24% were clinically symptomatic (Diemer Berish et al. 2000). Seropositive wild gopher tortoises have since been found in 23 Florida counties and several locations in Georgia and Mississippi (Smith et al. 1998, Diemer Berish et al. 2000). The presence of URTD in tortoise populations has important implications for tortoise relocation efforts (Anon. 1993, Jacobson 1994, McLaughlin 1997), and the effects of the disease on tortoise population dynamics and viability are unknown and need to be assessed. Large dieoffs have recently occurred in the Perry Oldenburg Mitigation Park and the Citrus Tract of Withlacoochee State Forest in Central Florida.

Scrub habitat occurs naturally in patches, and populations of many herpetofaunal species endemic to scrub—scrub lizard, sand skink, mole skink, crowned snake—can persist in relatively small areas; however, extensive habitat destruction has increasingly isolated scrubs so they cannot be recolonized if populations become extinct through some catastrophic event. If a patch of scrub later becomes suitable for the survival of an extirpated taxon through succession or restoration, most taxa have limited vagility and are unable to recolonize it. Populations that appear to exist as stable metapopulations (i.e., a network of local populations linked by dispersal) in a patchy landscape may actually be on their way to extinction because a large population is sustaining smaller populations, and insufficient movements occur between patches for patch recolonization to exceed patch extinction over long periods of time (Harrison 1994).

Improper fire regimes and habitat degradation have decreased the suitability of both sandhill and scrub habitats for many taxa. Present regulation of development in xeric uplands will result in a patchwork of small, isolated nature preserves of limited value to many taxa, particularly those dependent upon sandhill communities. Small, isolated wetlands are important wildlife habitats but are often overlooked for protection during development of xeric uplands (Moler and Franz 1987, LaClaire and Franz 1990). Alteration of these wetlands through the introduction of fish, ditching, deepening, or use as livestock watering holes often makes them unsuitable as breeding sites for many amphibian species (Christman and Means 1992).

Conservation and Management Strategies

The central sand ridges of peninsular Florida contain a high concentration of imperiled taxa, primarily reptiles, that share similar information needs and could benefit from many of the same management strategies. Large-scale studies, such as drift-fence surveys, of wildlife communities in certain habitats are largely observational, and the management needs of individual taxa can only be derived secondarily from this research (Stout et al. 1988). Basic life history information is needed for many xeric-adapted vertebrate taxa to refine habitat management guidelines, such as has been done for the gopher tortoise (Cox et al. 1987) and scrub-jay (Fitzpatrick et al. 1991).

Fragmentation of sandhill habitat has increasingly isolated and diminished the size of populations of many species, which may have profound genetic implications. Xeric upland habitat corridors between sandhill and scrub islands may be necessary to maintain viable populations of some species and facilitate genetic interchange. Habitat island biogeography assumes that larger areas and areas connected by habitat corridors will support greater biotic diversity than small, isolated areas. Corridors between preserves may permit population exchange and recolonization in case of local population declines, but Simberloff et al. (1992) questioned whether wildlife will use narrow corridors, which are expensive to purchase. Corridors should be designed specifically for conservation-priority target species (Soulé 1991), and wide, continuous corridors are probably best (Hobbs and Hopkins 1991, Noss 1991). A large body of theoretical literature exists on the effects of habitat fragmentation on populations (e.g., Simberloff and Abele 1982, Wilcox and Murphy 1985, Boecklen and Simberloff 1986, Zimmerman and Bierregaard 1986, Murcia 1995), but empirical knowledge is based mainly on studies of fragments ≤100 ha in size, which would be strongly influenced by edge effects (Zuidema et al. 1996). Simulations indicate that the effects of habitat loss far outweigh the effects of habitat fragmentation on population extinction, so conservation efforts should be aimed at stopping habitat loss and at habitat restoration instead of worrying about the spatial arrangement of habitat patches (Fahrig 1997). Although preservation of large areas of habitat to conserve biodiversity is undoubtedly best (e.g., Meffe and Carroll 1994), protecting medium-sized areas (10,000–100,000 ha) that are strategically located probably could support viable populations of most species, and this size of a preserve is more manageable and advantageous for financial, social, and logistical reasons (Zuidema et al. 1996).

Although some empirical evidence indicates that communities in longleaf pine forests are affected by fragmentation, the structure and organization of biological diversity in these forests may make them less affected by exploitation and more feasible to restore than other forest types, such as tropical and temperate rain forests (Simberloff 1993). The key attributes of longleaf pine forests that make them different are (1) most of the biological diversity is in the ground cover, not the canopy; (2) second-growth trees can provide some of the same structural aspects of canopy trees; and (3) the sparseness of trees, nature of the soil, and gentle terrain permit economical selective logging (Simberloff 1993). Because scrub habitat typically exists as patches in the landscape, habitat fragmentation may be less critical for some scrub taxa, although the increased isolation and distance between many scrub "islands" preclude their recolonization by most scrub endemics should populations become extinct.

Translocation or re-introduction of a target taxon into suitable habitat may be necessary where a population has been eliminated by catastrophic events—disease, weather events, predation, habitat destruction—or by a reduction in the minimum species area needed to maintain a viable population. Translocation of gopher tortoises into vacant or under-populated sites has been somewhat successful (see Diemer 1989), but translocation of gopher tortoise burrow commensals has been largely ignored. Some evidence indicates that commensal species, especially insects and mammals, will immigrate to relocated burrows if source populations are available (Knizley 1997). Taxa that are probably most suitable for translocation efforts are the scrub lizard, sand skink, mole skink, crowned snake, scrub-jay, and Florida mouse. Translocation efforts have become a prominent strategy to conserve rare species (Griffith et al. 1989), but translocation may compromise the integrity of genetic differences among populations, such as those of the scrub lizard, that have accumulated over thousands to a few million years (Clark et al. 1999).

Approximately one-half of scrub-jays that were translocated to suitable but unoccupied habitat within their historical range remained and eventually established territories (Mumme and Below 1999, 2000). Although translocation is apparently a useful management technique for scrub-jays, it should not be considered as an acceptable substitute for the management of existing populations because (1) properly managed translocation sites are scarce, (2) translocated birds initially had high rates of mortality or emigration, and (3) source populations may potentially be affected by translocation (Mumme and Below 1999). Sand skinks that were translocated to 2 experimental scrubs created by moving top soil and mulch from donor scrub sites. The skinks established reproducing populations, but long-term population survival appeared better at the experimental scrub that was adjacent to a natural scrub (Mushinsky and McCoy 1999, Penney 2001). Scrub habitats that have been created through phosphate mine reclamation (Macdonald 1994) or suppression of fire in sandhills may provide suitable sites to experimentally transplant scrub endemics. Attempts should be made to restore sandhill vegetation (Buchanan 1999) and former wildlife communities (Humphrey et al. 1985) onto abandoned citrus groves and old fields.

Relocation of gopher tortoises from areas being developed has occurred since at least the 1970s, and tortoise relocation guidelines were developed by the GFC in 1985 and modified over the next 3 years until achieving their current form (Florida Game and Fresh Water Fish Commission 1988). The Standard Gopher Tortoise Relocation Permit authorizes relocation of ≤5 tortoises on-site or any number of tortoises off-site from a development project area. Relocation saves individual tortoises, but the habitat and other burrow-dwelling species are destroyed. From 1989 through 1998, the GFC issued permits to relocate >25,000 tortoises. Current gopher tortoise relocation protocol is being reexamined by the FWC and a Stakeholder's Working Group (i.e., interested state agencies, wildlife organizations and societies, university departments, landowner groups, and environmental consultants) in light of the potential for URTD transmission among populations, and a statewide tortoise management plan will be developed. Other concerns regarding relocation are the disruption of locally adapted gene pools, transmission of other diseases and parasites, impacts on population dynamics, and dispersal-related mortality (Diemer 1989). Most relocated tortoises typically do not remain on the designated recipient site, which may partially be explained by the suitability of relocation sites, post-relocation techniques to minimize dispersal, tortoise population demographics, and tortoise behavior (Burke 1989, Diemer et al. 1989). Relocation sites should be unoccupied or have a depleted tortoise population, and the habitat should be evaluated for suitability, security, and carrying capacity (Diemer 1989).

Extensive research has been conducted on the responses of tortoises to different habitat management practices. Summer fires in sandhills do not have to be as frequent as winter fires to maintain suitable gopher tortoise habitat by reducing woody vegetation and stimulating herbaceous growth (Cox et al. 1987). Many tortoises are able to dig out of burrows covered during roller-chopping treatment on deep, sandy soils (Landers and Buckner 1981, Diemer and Moler 1982). Effects of roller chopping on gopher tortoise nests, juveniles, and preferred food plants need to be studied. Chopping small openings in dense oak scrub benefited gopher tortoises (Breininger et al. 1988). A minimum population size of 40–50 gopher tortoises should be protected in areas being developed to ensure population viability (Cox et al. 1987). In properly designed preserves, 10–20 ha of favorable habitat are necessary to sustain such a population, provided that the habitat continues to be suitably managed (Cox et al. 1987). An estimated 83 conservation areas contain sufficient habitat to support gopher tortoise populations of >200 individuals (Cox et al. 1994).

Preservation of populations of Florida scrub lizards in mature sand pine scrub requires periodic major disturbances of the canopy and ground cover (Enge et al. 1986, Richardson et al. 1986). During surveys in ONF, scrub lizards were usually found in young scrubs (Telford 1992, Anderson and Tiebout 1993), but a few immature specimens were found in mature sand pine forests (Greenberg 1993). Burned sand pine forests in ONF may have fewer scrub lizards than clearcut sites (Anderson and Tiebout 1993, Greenberg 1993). The current clearcut rotation in ONF creates a mosaic of even-aged stands 8–25 ha in size, of which only 20% are <10 years old and suitable for scrub lizards (Tiebout and Anderson 1997). Based upon intrinsic connectivity of managed sand pine stands, 26% of extant scrub lizard populations could experience local extinction as their stands age, unless existing sand roads provide suitable dispersal corridors (Tiebout and Anderson 1997).

Small vertebrates species, such as the Florida scrub lizard, short-tailed snake, and crowned snake, may continue to exist in developed areas if zoning requires that home sites ≥0.4 ha in size in critical habitat must retain native vegetation, and if similar restrictions are imposed on agricultural or industrial developments (Campbell 1992). Short-tailed snake populations would be detrimentally affected by land-use practices that impacted populations of crowned snakes, their primary prey. Burned sand pine forests in ONF may have fewer crowned snakes than clearcut sites (Anderson and Tiebout 1993, Greenberg et al. 1994). Different fire regimes in sandhill habitat in Hillsborough County apparently have no effect on populations of the peninsula crowned snake (Mushinsky and Witz 1993); however, frequent burning of sandhill habitat may be expected to favor this taxon over the Central Florida crowned snake in areas of syntopy.

Habitat loss, degradation, and fragmentation threaten large species of snakes that require large tracts of land to maintain viable populations. When indigo snake habitat is to be eliminated by development, mitigation funds should be pooled in "mitigation land banks" in order to accumulate adequate funds to allow acquisition of large preserves. Tracts of land ≥1,000 ha will need to preserved to sustain populations, and even low-density development, such as 8-ha "ranchettes," can seriously affect populations (Moler 1992*b*).

Fires benefit Florida mouse populations in sandhills by maintaining an open canopy and by increasing the diversity of herbaceous species (Jones 1990). These conditions are also the most suitable for gopher tortoises (Cox et al. 1987), whose burrows are used extensively by Florida mice (Layne 1970, Jones and Franz 1990, Layne 1990, Jones 1992, Layne and Jackson 1994). The Florida mouse is apparently an obligate commensal of the gopher tortoise in sandhill habitat, but its use of tortoise burrows is facultative in scrubby flatwoods (Morgan 1998). In the absence of normal fire frequency, mechanical disturbance of the vegetation—logging, partial clearing, disking, chopping, mowing, and vehicular traffic—may favor Florida mice by creating more open cover conditions. The size of a preserve necessary to maintain a long-term population of Florida mice could be smaller in scrub than in sandhill habitat, because mouse population densities are higher in scrub and fluctuate less between years (Newman 1997). Florida mice have similar habitat requirements as Florida scrub-jays in scrub habitats, but mice are able to persist longer in unsuitable, unburned sites (Richardson et al. 1986, Layne 1992). A population has been successfully transplanted from Highlands County to Hillsborough County (Adams 1978).

Sherman's fox squirrel conservation requires the preservation of large areas ($\geq$25 km^2) of heterogeneous, natural sandhill habitat (Kantola 1986). Sandhill preserves should include the vital lower slopes as well as the hilltops, and the habitat should be prescription burned during the summer every 2–5 years to regulate turkey oaks, promote longleaf pine regeneration, and control succession (Means and Grow 1985, Kantola 1992). Secure fox squirrel populations require ≈2,000–4,000 ha of appropriate habitat (Cox et al. 1994). Current conservation areas support at least 10 populations with >200 individuals (Cox et al. 1994).

Management of Florida scrub-jay populations is facilitated by extensive knowledge of its biology and its dependence on a specific and easily identified habitat that naturally occurs in patches or ecological "islands" (Woolfenden and Fitzpatrick 1988). Ideal habitat management for the scrub-jay consists of burning scrub every 5–20 years (Cox 1984, Woolfenden and Fitzpatrick 1988). More frequent burning will decrease acorn production (the primary food item) and increase the proliferation of saw and scrub (*Sabal etonia*) palmettos (Woolfenden and Fitzpatrick 1988). The best management option is to burn 10% of the habitat every 1–2 years in blocks of a few ha each (Cox 1984). If this is not feasible, blocks of habitat 10–20 ha each should be rotationally burned every 5–15 years (Cox 1984). Firebreaks should be used to divide a preserve into blocks of habitat to facilitate prescribed burning and to preserve intact territories in each management unit (Cox 1984). Where prescribed burning is inadvisable, mechanical means can be used to create clearings in oak scrub (Cox 1984, Breininger et al. 1988). Clear cutting mature sand pine scrub and sand pine forests temporarily produces the oak scrub conditions favored by scrub-jays (Cox 1984, Fitzpatrick et al. 1991). Clearing of a patch of occupied scrub will eliminate the resident family of scrub-jays because suitable adjacent habitat is probably already occupied by another family.

Estimates vary concerning the amount of habitat and number of scrub-jays needed to preserve a long-term population. Woolfenden and Fitzpatrick (1988) suggested preserving $\geq$30 contiguous territories, or ≈300 ha of oak scrub, whereas Fitzpatrick et al. (1991) felt that >40 territories were needed. Cox et al. (1994) estimated that 400–800 ha of properly managed habitat were needed to support a long-term population. In undisturbed scrub habitat specifically managed for scrub-jays, densities seldom exceed 1 bird per hectare (Cox 1984). A density of 0.5 birds per hectare would be the best that could be expected on tracts managed for scrub community preservation (Cox 1984). Isolated, unoccupied scrubs are probably unlikely to be naturally repopulated by scrub-jays because of their sedentary nature, so preservation of existing populations and appropriate habitat management are important (Fernald 1989, Fitzpatrick et al. 1991). Thaxton and Hingtgen (1996) found that female scrub-jays in fragmented, suburbanized habitat dispersed longer distances (up to 22 km) and at an earlier age than females in undeveloped habitat, resulting in higher mortality rates. No birds dispersed from undeveloped to suburban habitats, making these isolated suburban territories vulnerable to extirpation. The 5 conservation areas with sufficient habitat to sustain large scrub-jay populations (i.e., 50–100 territories) are ONF, Merritt Island NWR, Arbuckle State Forest/Kicco WMA/Avon Park AFR, Jonathan Dickinson State Park, and Archbold Biological Station (Cox et al. 1994). Nine conservation areas have sufficient habitat to support modest populations (i.e., 5–20 territories), although Camp Blanding Military Reserve mostly consists of densely planted sand pine and needs management to provide suitable scrub-jay habitat (Cox et al. 1994).

Developments of Regional Impact (DRIs) are large-scale development projects that have a substantial effect upon the health, safety, or welfare of citizens of more than 1 county. The Florida Department of Community Affairs administers the DRI program, and the DRI process requires a multi-agency review of large-scale development proposals. Studies of wildlife populations and their associated habitats, with particular emphasis on listed taxa, are required for DRIs. Developers with xeric uplands on their property can either employ conservation set-asides or mitigation. The conservation set-aside option involves dedicating some habitat in perpetuity as a nature preserve on the area. Developers often opt for mitigation rather than on-site preservation for political and economic reasons. Off-site mitigation may involve restoration of degraded land or purchase of land of equivalent natural value for preservation. Mitigation may also involve relocating sensitive species from land being developed to land that is dedicated to purposes consistent with the long-term survival of the relocated species.

An effective system of nature preserves must reflect unified commitment to a comprehensive program of long-term habitat preservation and management; therefore, each preserve should be (1) large enough to support viable communities or populations of target taxa; (2) under public management authority, or under private control that ensures its preservation through conservation easements or management agreements with state, regional, or local government; (3) located in surroundings that facilitate long-term management via prescribed burning or mechanical renovation; and (4) managed through an adequately funded and authorized program (Fernald 1989). Large preserves encompassing a mosaic of xeric uplands, mesic forests, and seasonal and permanent wetlands offer the ideal landscape unit for long-term preservation of a suite of taxa. However, preserves on private lands must be justified and dedicated through the DRI process, so economics dictates that most preserves will be of minimal size and have reduced suites of taxa. In practice, conservation set-asides are small and consist of only 1 habitat type. Taxa that require 2 or more contrasting habitats (e.g., the gopher frog), or have large home range requirements, will not benefit from these preserves.

Instead of creating small, scattered preserves through mitigation, developers of several projects could contribute money to a pooled fund (i.e., mitigation banking) that could be used by an independent group, such as the Trust for Public Lands or the Nature Conservancy, to assist in purchasing larger preserves or in expanding existing conservation lands. For example, Cox et al. (1994) identified 4 top Strategic Habitat Conservation Areas in Polk, Highlands, Hardee, De Soto, and Okeechobee counties that should be purchased. This region of the state has only 5.6% of its area in conservation lands compared to the statewide average of 19.6%, and the areas identified include scrub islands, sandhill tracts, and connecting upland corridors.

Based upon species-area relationships, larger preserves should have higher species richness and, therefore, be preferred over smaller preserves (Connor and McCoy 1979, Frankel and Soulé 1981, McGuinness 1984). However, several small preserves of equivalent total area to a single large preserve may contain more species (Simberloff and Abele 1976, Soulé and Simberloff 1986), particularly in scrub habitat. The question of whether a "single large or several small" (i.e., the SLOSS dilemma) preserves is better probably depends upon the communities involved, the autecologies of the keystone species, and the genetic and population attributes of the species (Soulé and Simberloff 1986). The species composition of preserves may also depend upon the regional setting of preserves (Hooper 1971), their shape and habitat diversity, and the presence of corridors between preserves (Simberloff and Cox 1987).

The species-area relationship and island biogeographic theory suggest that as the size of a tract is reduced by development, the number of species expected to occur will decline. The continued presence of a species in a habitat "island" is determined by the minimum viable population size of that species and whether sufficient area and other resources are available to support a population of that size (Diamond 1975). Minimum viable population size is a function of the calculated rate of loss of genetic variability; which over the long-term (evolutionary time) reduces the ability of a species to adapt to environmental changes (Franklin 1980), and over the short-term (ecologic time) results in inbreeding depression (Senner 1980, Lehmkuhl 1984).

In a study of 16 scrub islands on the Lake Wales Ridge, scrub size was the most important habitat attribute in predicting vertebrate species richness (Mushinsky and McCoy 1995). Large and medium-sized scrubs were more diverse than small scrubs, although relatively high numbers of some taxa were found even in small scrubs. The relative abundance of taxa differed between open-canopied and closed-canopied scrubs of similar size. Distance to water and distance to other scrub habitat influenced species richness of amphibians, reptiles, and mammals, but not birds (Mushinsky and McCoy 1995).

Scrub habitat occurs in small patches, and no known scrub on the Lake Wales Ridge contains all the endemic plants and animals; therefore, scrub preserves should consist of numerous small tracts near the northern, southern, and central portions of the distributions of the various endemic taxa (Christman 1992*a*). Populations of species with low dispersal capabilities, such as the scrub lizard, that occur in isolated scrub patches are demographically independent, and populations need to be protected in all the major scrub archipelagos in order to preserve the genetic diversity of these species (Clark et al. 1999). Christman (1992*a*) suggested that a series of 10 preserves, each only 16–40 ha in size, on the Lake Wales Ridge would provide long-term security for scrub endemics. In 1999, the size of the Lake Wales Ridge NWR totaled ≈730 ha. Scrub preserves in the Lake Wales Ridge Ecosystem Project will potentially provide long-term survival of scrub taxa, provided that proper management strategies are implemented to restore or maintain suitable habitats. Design standards for an urban sand pine scrub preserve have been developed (Richardson et al. 1986, Stout et al. 1987). The FWC's objective for the scrub wildlife community was to provide long-term protection to an additional 16,200 ha of sand pine and oak scrub by 1997–1998 (Florida Game and Fresh Water Fish Commission 1994).

Stout and Corey (1995) recommended that sandhill preserves be ≥10 ha and embedded within a larger habitat mosaic of 25–50 ha comprised of other pinelands in the proximity of small, isolated wetlands. Preserves of this size will not preserve viable populations of some taxa. For example, an indigo snake typically uses 160–240 ha (Moler 1987), and a diamondback rattlesnake usually uses <100 ha but may use up to 200 ha (Means 1985*b*, Timmerman 1995). FWC objectives for the sandhill wildlife community were to provide long-term protection to an additional 40,500 ha by 1997–1998, which would bring approximately one-half of current sandhill habitat into public ownership (Florida Game and Fresh Water Fish Commission 1994). To ensure the long-term viability of all sandhill vertebrate species, tracts <2,025 ha in size should not be acquired, unless they are contiguous with extensive publicly owned lands (Florida Game and Fresh Water Fish Commission 1994).

The success of preserves largely depends on our knowledge of species biology and ecosystem patterns and processes. Management of preserves is needed to maintain their original conservation value, particularly for small preserves. Management activities may differentially impact populations of various taxa. Fire is an important tool for managing scrub and sandhill habitats, but the proliferation of highways and developments in xeric uplands may limit the use of fire to maintain or create desired successional stages and ecosystem diversity. Future burning techniques will need to be more precise and reliable, and alternative management actions that mimic fire may have to be explored where problems exist with smoke or the proximity of human habitations (Doren et al. 1987).

The infrequent, high-intensity crown fires characteristic of sand pine scrub are difficult to control (Hough 1973) and only occur under the most extreme conditions (Cooper 1973), although a successful controlled burn of scrub has been conducted that followed the predicted model (Doren et al. 1987). Strips of roller-chopped vegetation 30–50 m wide encircled the site 3–4 weeks prior to the burn, and the burn was only conducted under certain weather conditions and fuel moisture levels (Doren et al. 1987). A mosaic pattern of different successional stages are naturally created during fire when changing weather conditions—wind speed, temperature, relative humidity—affect the fire, which can sustain itself only under extreme conditions in scrub. Concentrating natural fuels (i.e., piling debris) before conducting a prescribed burn in scrub will create "hot spots," exposing the mineral soil and killing the roots of shrubs.

Chemical or mechanical means of vegetation control may be feasible as an analog of fire in scrub habitat. Clear cutting and even-aged management of sand pines in sand pine forest apparently mimics, at least in the short term, the natural situation of infrequent crown fires to which scrub fauna are adapted (Campbell and Christman 1982, Greenberg 1993). Clear cutting and roller chopping creates early successional stages of scrub that favor many wildlife species, including sand-swimming reptiles and scrub-jays (Christman et al. 1979, Greenberg 1993). To minimize soil disturbance and compaction and wildlife mortality, roller chopping of scrubs should be conducted using a small, empty roller-drum chopper (Greenberg 1993). Mechanical treatment of vegetation with a roller chopper, web plow, or bar cutter may be a short-term alternative to fire, but the long-term effects of mechanical treatments on floral and faunal composition and diversity are unknown. Mechanical treatment is probably more desirable as a precursor to prescribed burning. Both clear cutting and burning sand pine scrub apparently reduce populations of sand skinks, especially the year following treatment, probably because increased surface insolation often heats the sand above the skink's temperature threshold (Mushinsky and McCoy 1999).

The use of heavy equipment or off-road vehicles (ORVs) and the establishment of roads or firelines may inadvertently create bare areas of root-free sand, which are important to sand-swimming reptile species, the Florida scrub lizard, and the scrub-jay. However, areas of bare sand created by ORVs could have lower arthropod densities, and ORVs could kill sand-swimming reptiles and other taxa attracted to these areas. Areas of bare sand may be intentionally created in xeric uplands by scraping the surface or root raking. Shrub-free natural openings, fire lanes, and sand roads in overgrown southern ridge sandhill vegetation that had not burned in 67 years allowed the persistence of populations of the Florida scrub lizard and sand-swimming reptile species (Meshaka and Layne 2002).

If management for timber production of sand pine scrub in ONF continues to be a primary goal, clear cutting (with modifications) large areas of sand pine on a 30–50-year rotation is recommended to maintain both open scrub and forest-specific biotic communities (Greenberg 1993). Presently, sand pine scrub is routinely harvested on ONF on a 50-year rotation in patchy clearcuts 16–24 ha in size (Stout et al. 1988). Understory vegetation is allowed to regenerate naturally, but sand pine is seeded following site preparation by a single roller chopping (Stout et al. 1988). Herpetofauna in ONF appears to respond similarly to 3 different silvicultural treatments of sand pine forests (5–7 years post disturbance): high-intensity burn followed by salvage logging and natural regeneration; clear cutting, roller chopping, and broadcast seeding; and clear cutting and bracke seeding. Clear cutting mimics high-intensity burns followed by salvage logging, and it does not appear to be a short-term threat to reptiles typical of open sand pine scrub (Greenberg 1993). The abundance of peninsula mole skinks, Florida scrub lizards, and (less so) peninsula crowned snakes is positively correlated with open scrub features such as bare ground (Greenberg 1993). Reduction of dense accumulations of coarse woody debris from typical on-site delimbing and chipping practices would benefit Florida scrub lizards and other reptiles preferring bare sand (Tiebout and Anderson 2001). The most favorable method of reducing coarse woody debris might be concentrating it into a few large mounds or rows and burning it (Tiebout and Anderson 2001). Reptile species richness is similar between early successional scrub and mature sand pine forests, but typical scrub species are much less abundant (mostly consisting of immature animals) or even absent in the mature forests, suggesting that mature forest may be used during dispersal or as temporary, suboptimal habitat (Greenberg 1993). Unconditional generalizations should not be made regarding the suitability of clear cutting versus natural disturbances (i.e., wildfire, tornados, hurricanes) until long-term studies are made spanning several rotations and looking at the entire landscape (Greenberg 1993).

Sandhill habitat needs to be burned much more frequently than scrub, but large preserves should be managed to maintain ecotones and transitional communities instead of a single landscape. The season, frequency, and regularity of fire should be varied in sandhill habitat to preserve floral and faunal diversity. In general, sandhills should be burned every 3–8 years during the spring and early summer. The more natural summer fires are necessary to promote flowering and seed production of wiregrass (Parrott 1967, Abrahamson 1984, Platt et al. 1988, Clewell 1989) and to reduce woody vegetation (Boyer 1990, Glitzenstein et al. 1995). Once the native wiregrass ground cover has been eliminated through site disturbance (e.g., site preparation) or long-term fire suppression, community restoration is difficult (Noss 1988). Wiregrass restoration and management must include growing-season burns and opening up dense canopies to permit light penetration (Means 1997). It may be difficult to conduct frequent burns in sandhill habitat with both a sparse wiregrass ground cover and longleaf pine overstory because of inconsistent fuel dispersion. Prior mechanical or chemical treatment may enhance the effectiveness of prescribed burning (Brockway and Outcalt 2000). Mechanical and chemical alternatives to burning are probably ineffective at long-term maintenance of a natural sandhill community, but these artificial treatments could be used to create openings in overgrown habitat that would permit the survival of species adapted to open, early-successional habitats until burning is possible (Meshaka and Layne 2002). Burning of overgrown sandhill habitat during the growing season was apparently more effective at restoring typical vegetation than mechanical girdling and felling of oaks or herbiciding oaks, but herpetofaunal community composition apparently did not differ significantly among the 3 restoration treatments (Litt et al. 2001).

Longleaf pines on sandhill sites should not be harvested on a rotation of <80 years because large pine trees are important to red-cockaded woodpeckers and Sherman's fox squirrels. On public lands, longleaf pines are often harvested on a 60-year rotation, although 80–120 years may be prescribed (Stout et al. 1988). The preferred method of harvesting longleaf pines is shelterwood cutting, which preserves some of the large pines as sources of seed for regeneration and for wildlife food, and as cavity trees and future snags.

The public needs to be educated regarding the value of scrub and its many endemic taxa. Landowners and developers of xeric uplands should be encouraged to xeriscape roadsides and yards with native plants, particularly oaks. Destruction of native flora and planting of ornamental shrubs and trees should be minimized. In refuges, house pets (especially house cats [*Felis*]) and unauthorized motor vehicles should be prohibited because of their deleterious impacts on wildlife populations (Fernald 1989). Local, county and regional comprehensive plans should include provisions for the preservation of xeric uplands in proposed developments.

Conservation Tasks

Some of the 26 taxa with biological scores $\geq$17 (Appendix A) that are included in conservation tasks for scrub and sandhill habitats occupy a wide range of habitats and exhibit a great deal of variation in both their distribution and abundance. Other taxa have specialized habitat requirements, such as sand-swimming reptiles, or may represent relictual populations of formerly more wide-ranging species. Many taxa would benefit from the same conservation or management strategies.

Twenty-six conservation tasks have been identified for taxa inhabiting interior scrub and sandhill communities (Appendix B). These tasks are only examples and are not intended to be all-inclusive. Originally, systematic reviews of mole skinks and crowned snakes in Florida (some of which inhabit scrub and sandhill habitats) were considered high-priority tasks, but mtDNA studies are currently being conducted or have been completed (Branch et al. 1997; P. E. Moler, pers. commun.). Nine tasks are related to research and 8 tasks to management. Six tasks target scrub-jays, but no other taxon has more than 2 taxon-specific tasks identified. The relatively few taxon-specific tasks reflect the considerable research that has already been conducted on the gopher tortoise, sand skink, scrub lizard, gopher frog, Sherman's fox squirrel, and Florida mouse (as indicated by their relatively low action scores). Twelve tasks address multiple species, primarily dealing with the effects of habitat management or land-use practices on terrestrial vertebrates, especially on WMAs and parcels of the Lake Wales Ridge Ecosystem. The isolation and small size of remnant xeric upland fragments may pose serious long-term threats to populations by reducing their genetic diversity and their potential to survive environmental changes. We need to educate the public and land managers regarding the value of scrub endemism and the importance of retaining scrub vegetation in residential communities. Landowners should be encouraged to preserve xeric uplands by developing a program that provides economic incentives. A possible conservation tool is the introduction of xeric-adapted taxa into scrubs created by human disturbances or into restored sandhill habitats.

INTERIOR DRY PRAIRIE AND ASSOCIATED COMMUNITIES

Habitat Descriptions

Dry prairie habitat is "perhaps the least appreciated, most poorly studied, and incompletely documented of Florida's endemic terrestrial systems" (Hilsenbeck 1996). Dry prairie is sometimes referred to as palm savanna, palmetto prairie, or pineland-threeawn range. Dry prairies are open, grassy expanses with scattered shrubs that often merge into open pine flatwoods and wet prairies. The typical undisturbed and undrained dry prairie landscape consists of a mosaic of interdigitating dry and wet prairies, interspersed with ephemeral depression ponds or marshes, hammocks, and slough or swale-like drainages (Anonymous 1999). Dry prairies may be dotted with dome swamps and prairie hammocks, which are clumps of tall cabbage palms and live oaks that typically have a very open understory and a perimeter of saw palmetto (Florida Natural Areas Inventory 1990). Dry prairies resemble mesic flatwoods, but pine trees are sparse or absent (Harper 1927, Davis 1943, Steinberg 1980). Dry prairies occur in south-central Florida on acidic sands on relatively flat terrain that may flood for short periods after heavy summer rains, but the hydroperiod is usually shorter than in mesic flatwoods. The predominant ground cover is various grasses and forbs. Characteristic grasses include wiregrass, bottlebrush threeawn (*Aristida spiciformes*), arrowfeather (*A. purpurascens*), broomsedge (*Andropogon virginicus*), and silver bluestem (*A. ternarius*). Forbs may include blazing star (*Liatris* spp.), rabbit tobacco (*Pterocaulon pycnostachyum*), pine lily (*Lilium catesbaei*), yellow-eyed grass (*Xyris* spp.), marsh pink (*Sabatia* spp.), milkwort (*Polygala* spp.), meadow beauty (*Rhexia* spp.), and goldenrod (*Solidago* spp.). Common shrubs are saw palmetto, fetterbush (*Lyonia lucida*), staggerbush (*L. fruticosa*), gallberry, shiny blueberry (*Vaccinium myrsinites*), runner oak (*Quercus minima* or *pumila*), and wax myrtle (*Myrica cerifera*). Frequently burned dry prairies are usually dominated by wiregrass, low-growing runner oak, and saw palmetto, which is typically sparse, scattered, and stunted (Abrahamson and Hartnett 1990).

The natural fire frequency of dry prairies appears to be every 1–4 years, and frequent fires apparently prevent the invasion of pines (Florida Natural Areas Inventory 1990). Some authorities suggest that frequent fires are an artifact of human intervention and that dry prairies are not a natural biological community, whereas others think that dry prairies are naturally treeless areas that were once more widespread, which is supported by maps of pre-settlement public land surveys (Bridges 1998, Huffman and Judd 1998) and early historical accounts (Harshberger 1914; Harper 1921, 1927). Dry prairies and mesic flatwoods are often found on the same soil series, topographic positions, and moisture regimes. Dry prairie represents the essentially treeless endpoint of a continuum of variation in canopy cover across pine flatwoods landscapes in Central Florida (Anonymous 1999). Trees may be absent from some areas that resemble dry prairies because of too frequent burning of flatwoods or scrub, clear cutting, or continuous livestock grazing (Steinberg 1980, Abrahamson and Harnett 1990, Florida Natural Areas Inventory 1990). Palmetto prairies are usually former pine flatwoods where the overstory trees have been thinned or removed such that pine trees cover <15% of the area (Cox et al. 1994). Most former dry prairies are now improved pastures dominated by bahia grass (*Paspalum notatum*), Bermuda grass (*Digitaria sanguinalis*), carpet grass (*Axoponus affinis*), or clover (*Trifolium* spp.).

The most extensive dry prairies formerly occurred in the Kissimmee Valley in the Osceola Plain, the De Soto Plain in eastern De Soto and Charlotte counties, and areas of Sarasota and southeastern Manatee counties. Dry prairies were present along Fisheating Creek, the Kissimmee River, and the upper St. Johns River (Davis 1967). Based on area calculations from Davis' (1967) map, 0.83 million ha (5.9%) of pre-settlement Florida were covered by dry prairies and depression marshes (Kautz et al. 1993). In 1989, dry prairie vegetation covered 0.56 million ha (4.0%) of Florida (Kautz et al. 1993), but this figure includes prairie habitat outside of the historic distribution defined by Davis (1967).

Wildlife Communities

We consider the interior dry prairie region to encompass all the grassland areas of south-central Florida, including both wet and dry prairies plus the mosaic of other interspersed terrestrial and wetland habitats. Most conservation tasks identified for this region target avian taxa (except for the Florida burrowing owl) that are primarily confined to this area and were originally identified by Millsap et al. (1990): short-tailed hawk (*Buteo brachyurus fuliginosus*), crested caracara (*Caracara plancus audubonii*), Florida sandhill crane (*Grus canadensis pratensis*), and Florida grasshopper sparrow. We also address species that occur within the interior prairie region but are not necessarily dependent upon grassland habitat or restricted to this region: Florida snail kite, Florida mottled duck (*Anas f. fulvigula*), greater sandhill crane (*Grus canadensis tabida*), limpkin (*Aramus guarauna pictus*), South Florida rainbow snake (*Farancia erytrogramma seminola*), and South Florida mole kingsnake. The 1993 reintroduction of whooping cranes to the Kissimmee Prairie (Nesbitt 1996*b*, Stap1998) has necessitated developing conservation tasks for this taxon. We also identified a conservation task for Henslow's sparrow, although its biological score of 23.3 is just below the cutoff level for taxon-specific tasks, because of summer sightings of these sparrows at the Ordway-Whittell Kissimmee Prairie Sanctuary (Pranty and Schuerell 1997).

Much of the wildlife of dry prairies may also live in scrubby and mesic flatwoods, sandhill, or coastal grassland. Dry prairies sometimes provide suitable habitat for the scrub-jay, Sherman's fox squirrel, Florida mouse, gopher frog, gopher tortoise, pine snake, indigo snake, and diamondback rattlesnake, which were addressed in the interior scrub and sandhill section. Other high-ranking taxa that are potentially found in the interior prairie region are Sherman's short-tailed shrew, Florida mastiff bat

(*Eumops glaucinus floridanus*), Florida panther, and peregrine falcon (*Falco peregrinus tundrius*), but these taxa are not discussed here. The southern bald eagle (*Haliaeetus l. leucocephalus*) and various wading bird species forage and nest in or near lakes, streams, and other wetlands in this region; many of these taxa are covered in the coastal section. Although conservation tasks have not been identified for the swallow-tailed kite, it utilizes lowland forests in this region, and a large communal roost is situated near Lake Okeechobee (Millsap 1987, Meyer 1998).

Dry prairies that have been converted to improved pasture may still provide suitable habitat for some target taxa. The Florida sandhill crane and crested caracara will forage in improved pastures, and the caracara will nest in improved pasture if cabbage palms *(Sabal palmetto*) remain. Caracara home ranges are positively associated with improved pastures, particularly ones with large areas of contiguous pasture (Morrison 1997, Morrison and Humphrey 2001). In regions outside of former prairie areas—parts of De Soto, Hardee, and Manatee counties—the caracara is absent or rare in seemingly suitable pastureland that was created by clearing flatwoods vegetation (Layne 1996). Fox squirrels may use improved pastures with remnant mast trees, and Florida grasshopper sparrows may use pastures with clumps of vegetation suitable for nesting cover. Improved pastures that support good populations of the gopher tortoise and pocket gopher may contain gopher frogs, pine snakes, indigo snakes, and Florida mice (Simons 1990).

The short-tailed hawk, caracara, and Florida sandhill crane probably colonized Florida during early- to mid-Pleistocene glacial periods when a circum-Gulf arid dispersal corridor existed; these taxa have probably been isolated in Florida for about 20,000 years (Webb 1990). In south-central Florida, important breeding areas for the short-tailed hawk are east of the Lake Wales, Mount Dora, and Orlando ridges, and along forested drainages—Arbuckle Creek, Fisheating Creek, and Kissimmee River—in the Okeechobee Plain (Millsap et al. 1996). In this region of Florida, short-tailed hawks mostly forage in dry prairie and scrub habitats, and they nest in strand and dome swamps (Ogden 1974, Millsap et al. 1989).

The caracara was historically common in the Central Florida prairie region (Howell 1932), with the Kissimmee Prairie remaining the population stronghold (Sprunt 1954). During surveys in 1976 (Layne 1978) and 1991 (Layne 1996), most caracaras were observed north and west of Lake Okeechobee in Charlotte, De Soto, Glades, Highlands, Hardee, Okeechobee, Polk, and Osceola counties (Layne 1978). The caracara's primary habitats were once dry prairies and associated marshes and prairie hammocks in the De Soto, Okeechobee, and Osceola plains (Layne 1996), but most caracaras are now found on large cattle ranches with improved pastures (Layne 1978, Morrison 1997). Caracaras require suitable nest trees, which are usually cabbage palms (>90%) and live oaks (Layne 1996). From 1972 through 1991, the presence of adult caracaras was recorded at 236 locations in 21 counties; the minimum estimate of the total population was 400–500 individuals in at least 27 counties (Layne 1996), and the population appears to be stable (Morrison 1997, 1999).

Breeding aggregations of the Florida grasshopper sparrow are known from only 6 protected locations (Delany et al. 1999). Suitable nesting habitat ranges from thick (34% shrub cover), low (57 cm) palmetto scrub to grass pastures with sparse (<10% shrub cover) or patchy cover of shrubs and saw palmetto (*Serenoa repens*) (Delany et al. 1985). A minimum viable population of 50 breeding pairs may require 240–1,348 ha of treeless prairie (Delany et al. 1995). Florida grasshopper sparrows require large (>50 ha), treeless, relatively poorly drained sites with frequent burning regimes (Delany 1996), which historically occurred in the dry prairies of south-central Florida (Howell 1932). Most grasshopper sparrows now live in dry prairies that are frequently burned to maintain the vegetation in an early successional stage, provided that shrubs, such as saw palmetto, and clumps of grass are available for nesting, and that bare ground is present for foraging (Delany 1996).

The Florida sandhill crane frequently uses improved pastures, dry and wet prairies, shallow freshwater marshes, and transition zones between habitat types (Nesbitt and Williams 1990). Many sandhill cranes breed in the Kissimmee Prairie–Lake Okeechobee area, where they often feed in improved pastures, although nesting habitat is scarce or absent there (Stevenson and Anderson 1994). The greater sandhill crane overwinters in Florida as far south as Osceola County (Stevenson and Anderson 1994). Since 1993, 228 whooping cranes have been introduced into the wild in the Kissimmee Prairie region, and the Florida population consisted of 76–85 surviving birds in 2001 (S. A. Nesbitt, pers. commun.). Nesting has occurred since 1998, but only 4 eggs have hatched. The first chick fledged in 2002, which was the first time a whooper chick has fledged in the wild in the United States in 63 years. The goal of the reintroduction program is to establish 125–200 birds, including 25 breeding pairs, by 2020 (Stap 1998). This was intended to be a nonmigrating population, but some birds have dispersed in summer as far north as Illinois and Michigan, probably because an ongoing drought in Florida has left much of the wetland habitat dry and unsuitable to cranes (S. A. Nesbitt, pers. commun.). In 2001, 7 subadult whooping cranes followed an ultra-light aircraft from Wisconsin to Florida's Chassahowitzka National Wildlife Refuge in an initial attempt to establish a new migratory flock of whooping cranes.

Although the limpkin is distributed throughout Florida, the Kissimmee Valley and western shore of Lake Okeechobee were historically population strongholds (Sprunt 1954). The most important habitat requirement of the limpkin is an abundance of the right-handed apple snail (*Pomacea paludosa*), its preferred prey item. Limpkins frequent well-vegetated wetlands and shorelines of lakes and rivers (Bryan 1996). The Florida snail kite is also dependent upon apple snails (Snyder and Snyder 1969) and utilizes marshes in the upper St. Johns River, Lake Kissimmee basin, and west side of Lake Okeechobee, especially when droughts occur in the Everglades (Sykes 1984, Takekawa and Beissinger 1989, Rodgers 1996). Snail kites prefer to forage above relatively open, shallow water with little emergent vegetation (Rodgers 1996).

The South Florida rainbow snake is included in this section because the only locality where it has been found, Fisheating Creek, is in Glades County. This subspecies is separated by 250 km from populations to the north, and it is known from only 3 specimens collected in 1949–1952 (Neill 1964). Surveys of Fisheating Creek, a relatively pristine stream flowing through cypress strand habitat, are needed to determine continued existence of this taxon (Moler 1992*f*).

During a survey of the Fisheating Creek area, a 90-cm-long American crocodile was captured in a small pool near Jerry Marsh in northern Glades County (Enge and Douglass 2000). Crocodiles in Florida are found primarily in mangrove swamps and along low-energy mangrove-lined bays, creeks, and inland swamps (Kushlan and Mazzotti 1989), but they occur in large inland freshwater lakes in Central America and may live sympatrically with alligators in areas of South Florida where salinities are low (Moler 1992*a*). This crocodile probably represents offspring of escapees from Gatorama, a tourist attraction ≈20 km straight-line distance (>27 km by water) south of the capture site, but all American crocodiles at Gatorama are thought to be of Jamaican origin (P. E. Moler, pers. commun.). Analysis of mtDNA sequence data, however, indicated that the captured animal was the offspring of a female from Florida (Enge and Douglass 2000). Surveys of Fisheating Creek and adjacent bodies of water are needed to determine the distribution, size, and origin of this crocodile population.

The South Florida mole kingsnake was described as a separate subspecies by Price (1987), and it has been reported in the interior dry prairie region from Okeechobee County, Glades County, and De Soto County near Arcadia (Layne et al. 1986; Price 1987; Hartmann 1988; Krysko and Hurt 1998; E. Ingram, snake hunter from LaBelle, pers. commun.; R. Tregembo, snake hunter from Arcadia, pers. commun.). Most Okeechobee specimens came from areas of former prairie habitat with interspersed marshes and prairie hammocks (Layne et al. 1986), and most De Soto County specimens came from areas of pastureland and citrus groves (Hartmann 1988).

Threats to Habitat or Wildlife

The large areas of dry prairies that formerly occurred just north and west of Lake Okeechobee and farther west through De Soto County are now one of Florida's most endangered natural landscapes (Noss et al. 1995). Virtually all dry prairies have been lost to improved cattle pasture (Layne et al. 1977), agriculture (Davis 1967, Mealor 1972, Callahan et al. 1990, DeSelm and Murdock 1993), pine or eucalyptus (*Eucalyptus* spp.) plantations, or housing developments (Layne 1996). The most extensive habitat changes have happened since the 1950s, and the decline in native dry prairies and pasturelands is expected to continue as land is converted to real estate and agricultural developments, such as citrus groves (Layne 1996). Only 19% of the original prairie grassland is estimated to remain in Central Florida (Shriver and Vickery 1999). As of 1994, only 16.6% of the remaining dry prairie habitat in Florida was found in conservation lands (Cox et al. 1994).

Open-range ranching (i.e., without fences) of dry prairies was practiced in southern Florida until the 1940s, when eradication of cattle tick fever allowed the use of improved cattle stock that made ranching profitable enough to warrant putting up fences, providing supplemental feed, and converting native range to improved pastures. Fencing also decreased the number of collisions between livestock and the increasing vehicular traffic, and it helped control screw worm infestation. Exotic grass species, such as bahia grass and Bermuda grass, were introduced into Florida in the 1920s to improve native range for cattle because native grasses only provided suitable grazing in spring and summer (DeSelm and Murdock 1993). Prairies and marshlands were the easiest lands to convert to improved pasture, which increased in acreage in peninsular Florida from 32% in 1925 to 65% in 1964 (DeSelm and Murdock 1993).

Over 1 million ha of native range were lost in Florida from 1954 to 1964, with ≈64% of the decline resulting from conversion to urban, suburban, recreational, and transportation uses (DeSelm and Murdock 1993). Land values and taxes increased in the mid-1960s in Osceola and Orange counties because of Walt Disney World acquisitions, which contributed to the urbanization of rangeland (DeSelm and Murdock 1993). Large areas of native dry prairies continue to be converted to improved pasture, and eucalyptus has been planted on some dry prairies in Glades County for pulpwood production (Moore and Swindel 1981). Winter burning associated with cattle operations may have shifted the vegetative dominance of dry prairies from grasses and forbs to saw palmetto (Hartman 1992). The southward expansion of citrus production is now probably responsible for most dry prairie losses (Hartman 1992). Although dry prairie habitat is not the best land for citrus production, it is being used because of the loss of prime citrus land to urbanization, increased citrus demand, and new drainage techniques (DeSelm and Murdock 1993).

In the past, many caracaras were shot and trapped along with vultures by ranchers, but these threats are probably minor nowadays, although immature caracaras are prone to highway mortality. Habitat loss is presently the primary threat to caracaras, and the continued conversion of prairie habitat and pastureland to citrus groves, sugar cane, and other uses will probably result in a significant population decline in the next 10 years (Layne 1996). Drainage and conversion of natural habitat to improved pastureland has probably decreased the food resources available to caracaras because of lower diversity and fewer wetlands (Layne 1996); however, caracaras apparently prefer improved pasture to natural prairie habitat (Morrison 1997, Morrison and Humphrey 2001).

Since the Florida grasshopper sparrow was listed, land-use changes have resulted in abandonment of 6 former breeding locations (Delany and Linda 1994). Although the 6 extant populations are probably more isolated than formerly due to habitat fragmentation, the genetic similarity of these populations indicates that either this isolation has occurred recently or genetic interchange occurs among populations (Delany et al. 2000).

Predation may be a problem for some prairie taxa. High predation rates on nests of grasshopper sparrows on Avon Park AFR in 1996 resulted in insufficient production of young to maintain current population levels, leading to concerns about the long-term viability of this taxon (Perkins et al. 1998). The impact of increasing coyote (*Canis latrans*) populations in Florida on sandhill and whooping crane populations may be a concern. The main source of mortality for introduced whooping cranes is predation by bobcats (*Lynx rufus*). Bobcats killed 33 of the first 41 cranes released at Three Lakes WMA because they tended to roost on dry, heavily vegetated areas. Subsequent habitat modification and conditioning of cranes to roost in water lowered the mortality rates. Mortality rates of released cranes dropped from 43% in 2000 to only 14% in 2001, despite the ongoing drought. In 2000, 1 of the 15 established pairs of whooping cranes in Florida produced 2 chicks that were killed by predators before fledging.

The snail kite and limpkin are dependent upon apple snails and are thus affected by habitat alterations that affect snail populations or availability. The introduction of nonnative aquatic vegetation has decreased the amount of suitable foraging area for the snail kite, and drainage and back-pumping of nutrient-laden water from agricultural and dairy sources into lakes Okeechobee and Kissimmee have caused eutrophication and snail dieoffs (Rodgers 1996). Nonnative aquatic plants may replace native forage plants for the apple snail, and herbiciding to kill nonnative vegetation may affect snail populations (Bryan 1996).

The meandering Kissimmee River in the Coastal Lowlands physiographic province between Orlando and Lake Okeechobee was channelized between 1962 and 1971, resulting in the loss of up to 14,000 ha of wetland habitat (Koebel 1995). Scheduled restoration of the Kissimmee River over the next 20 years will restore 70 km of river channel and 11,000 ha of wetlands, which will benefit over 320 fish and wildlife species, including invertebrates, fishes, wading birds, waterfowl, snail kites, and alligators (*Alligator mississippiensis*) (Dahm et al. 1995, Koebel 1995). High-ranking taxa that will probably benefit from the restoration are the mottled duck, Florida sandhill crane, greater sandhill crane, bald eagle, snail kite, wood stork, yellow-crowned night heron (*Nycticorax v. violaceus*), and limpkin. However, this restoration will have a detrimental impact on upland species, such as the caracara, that have colonized the pastureland and upland shrub communities created by the channelization.

Conservation and Management Strategies

Very little is known about the ecology of Florida's dry prairie, of which <17% is protected (Delany 1997). The continued existence of most dry prairies is dependent on large cattle ranches. The long growing season in South Florida permits year-round grazing, but the seasonal rainfall pattern makes poorly drained areas unsuitable for grazing during the summer, preserving native diversity. Native range still averaged 85% on individual ranches in 1970, and large native pastures several thousand acres in size were still common (Mealor 1972).

Natural maintenance of dry prairie vegetation was formerly dependent on frequent and extensive lightning-caused fires that typically occurred from late May through July. Maintenance of prairie vegetation now depends mostly on ranchers, who typically burn prairie habitat every 2–3 years during January or February just prior to initiation of spring growth in order to improve the quality of the range for cattle (DeSelm and Murdock 1993). In the absence of fire, shrubs invade and dominate grasslands. Saw palmetto will often dominate unburned dry prairies. Lack of burning has sometimes caused former prairie habitats to succeed to brushland or other more closed habitat types that are unsuitable for most wildlife species associated with dry prairies (DeSelm and Murdock 1993). Long-term fire exclusion in dry prairies adjacent to oak hammocks results in the invasion of live and laurel oaks into the prairies, but although the prairies develop oak canopies, they retain saw palmetto understories, unlike the cabbage palm understories found in the original hammocks (Huffman and Blanchard 1991).

Single burns conducted in winter or summer appear to be ineffective at reducing saw palmetto coverage in dry prairies, whereas roller chopping in winter or summer significantly reduces shrub coverage (Fitzgerald et al. 1995). Burning or roller chopping dry prairies in winter stimulates greater herbaceous biomass production than in summer (Fitzgerald et al. 1995). For dry prairie restoration, Fitzgerald et al. (1995) tentatively recommended chopping initially in winter to reduce shrub cover and stimulate herbaceous dominance, and to subsequently employ a lightning-season (May–September) fire regime. In dry prairies invaded by oaks, summer fires under wet conditions and winter fires kill shrubs and young oaks but do not affect large oaks, whereas a summer fire during dry conditions kills large oaks but not slash pines in areas with a saw palmetto understory (Huffman and Blanchard 1991). Soil moisture probably affects the efficiency with which chopping reduces shrub cover. Two studies suggested that double chopping worked best in the dry season (Hilmon et al. 1963, Moore 1974), whereas 1 study showed no seasonal differences, which was probably due to low soil moisture both seasons (Kalmbacher and Martin 1984). Another study indicated that single chopping was most effective in the wet season (Tanner et al. 1988). Repeated summer fires are typically more effective at reducing shrub cover than winter fires. In South Florida's palmetto prairies, herbaceous yield is highest 1 and 2 months after burns in May, and yield is lowest after burns in November and January (Hughes 1975). However, no differences in herbaceous yield existed 2 years after 3 or 4 biennial burn treatments in the months of October, November, January, March, and May (Hughes 1975).

Roller chopping of dry prairies provides more suitable open habitat for gopher tortoises than web plowing, but it also destroys more tortoise burrows (Tanner and Terry 1981). Burning shrub-dominated former dry prairies does not affect bird species richness and abundance, but winter and summer chopping reduce bird species richness and abundance, favoring more open grassland species (Fitzgerald and Tanner 1992). Mechanical site preparation of dry prairies in South Florida to establish commercial forests decreases wiregrass cover but increases northern bobwhite food plants and cattle forage species (Moore and Swindel 1981). Mechanical site preparation eliminates shrubs and increases herb production (unless bedding is done), but it alters herbaceous species composition (Swindel et al. 1982).

Dry prairie habitat occurs on some publicly owned lands, but additional large-scale acquisitions of dry prairie habitat and the associated matrix of upland and wetland habitats are needed. Caracaras are known to live in Kissimmee Lake State Park, Myakka River State Park, Tosohatchee State Reserve, Three Lakes WMA, Cecil E. Webb WMA, and the Avon Park AFR. Suitable grasshopper sparrow habitat is maintained on Three Lakes WMA, Avon Park AFR, and the National Audubon Society's Ordway-Whittell Kissimmee Prairie Sanctuary (Delany 1996), but the latter 2 areas may be acting as population sinks (Perkins et al. 1998). Sandhill cranes nest on Cecil E. Webb and Three Lakes WMAs, and Lake Kissimmee and Myakka River state parks (Nesbitt 1996*a*). Prescribed burning to restore or maintain prairie or open rangeland habitats, such as is being done at Avon Park AFR and Myakka River State Park (Fitzgerald et al. 1995), is necessary on these protected lands.

The purchase by The Nature Conservancy of a 19,000-ha former cattle ranch in Okeechobee County protected a contiguous block of >64,640 ha of dry prairie and associated habitats, including the adjoining Avon Park AFR and the 3,102-ha Ordway-Whittell Kissimmee Prairie Sanctuary (Hedges 1996). This new acquisition was named the Latt Maxcy Kissimmee Prairie State Preserve when it was purchased by the state using monies from the Conservation and Recreation Lands (CARL) program and the South Florida Water Management District's Save Our Rivers program. This preserve contains a mostly unaltered natural landscape that includes the largest remaining block of dry prairie habitat, and it has been identified by the FWC as a SHCA for the grasshopper sparrow, snail kite, sandhill crane, and caracara. Other highly ranked taxa identified in the preserve are the indigo snake, diamondback rattlesnake, gopher tortoise, wood stork (*Mycteria americana*), and scrub-jay (Hilsenbeck 1996). Most portions of the property have been prescription burned in late winter and early spring at 3-year intervals, but future management strategies will include growing season burns, control of feral hog (*Sus scrofa*) populations, and restoration of the natural hydrology by backfilling ditched sloughs and connected marshes (Hilsenbeck 1996).

Additional identification and acquisition of dry prairie habitat are needed, and the continued existence of large private cattle ranches should be encouraged. In 1999, ≈16,840 ha of land owned by Lykes Bros. Inc. in Glades County was conveyed to the state as a perpetual conservation easement, which will protect it from future development. This tract of land near Fisheating Creek represents the first of possibly 5 phases of land that may conserved as part of the Fisheating Creek Ecosystem Project. If all 5 phases are completed, the largest block of dry prairie habitat remaining in the world will be preserved. Active fire management and other native range management practices, such as occasional roller chopping, by Lykes Bros. have helped maintain much of the dry prairie habitat. Dry prairie and associated habitats on the Phase I lands support the gopher frog, gopher tortoise, indigo snake, pine snake, diamondback rattlesnake, scrub-jay, Florida sandhill crane, kestrel, caracara, bald eagle, red-cockaded woodpecker, and black bear (Enge and Douglass 2000). An additional 7,350 ha of wetlands along Fisheating Creek are now a wildlife management area, which protects the only known habitat of the South Florida rainbow snake, a high concentration of nesting swallow-tailed kites and short-tailed hawks, and the largest known premigration communal roost of the swallow-tailed kite. At its peak, this roost contains an estimated ⅓–½ of the total North American population, with maximum estimates of 1,350–2,200 birds since its discovery (Millsap 1987, Meyer 1998; K. Meyer, pers. commun.).

A conservation strategy for the caracara should be based on protecting known nest sites and large areas of open grassland habitats, particularly pastureland on cattle ranches (Morrison 1997, Morrison and Humphrey 2001). The traditional practice of burning native range on cattle ranches inadvertently provides suitable habitat for the caracara and grasshopper sparrow. These cattle ranches are probably key to maintaining a viable Florida population of the caracara (Morrison and Humphrey 2001), because <10% of the known caracara territories are entirely or partially located on public lands (Layne 1996). According to Cox et al. (1994), no existing conservation area contains more than 4 caracara territories, and only 20 territories are known to occur on established conservation areas. Planting of cabbage palms would provide future nesting habitat for the caracara. Road signage and the removal of carcasses from roads might reduce highway mortality of immature caracaras. Educational programs by the FWC and environmental organizations like Florida Audubon Society and Save Our American Raptors have increased public awareness of the caracara and its conservation needs, but similar efforts are needed for other prairie wildlife taxa and the dry prairie habitat type.

To manage for the Florida grasshopper sparrow, landowners should avoid intensive pasture improvements that eliminate foraging areas and potential nest sites, and winter burning should be conducted at 2–3-year intervals to maintain early successional vegetation (Delany 1996). In native dry prairie habitat, grasshopper sparrow breeding densities and reproductive success were higher on plots 0.5 yr after winter burning than on plots 2.5 yr after fire (Shriver and Vickery 2001). Late fall or winter burning is typically conducted to reduce potential nest mortality (Walsh et al. 1995), but the grasshopper sparrow has probably evolved with lightning-caused summer fires; sparrows immediately establish territories on summer burns and initiate a second bout of breeding activity (Shriver et al. 1996). Grazing cattle at 1 animal per 8 ha does not appear to be detrimental to sparrows, which will breed at locations 1 month after burning (Delany 1996) and 3 months after roller chopping (Delany and Cox 1986). Observations of sparrows breeding in abandoned agricultural plots that are reverting to prairie suggest that populations may be responsive to habitat restoration (Delany 1996). Research should be conducted on the possibility of restoring rangeland and dense, unburned scrub to native dry prairie habitat on existing conservation areas (Delany 1991, Cox et al. 1994). Because most populations of the Florida grasshopper sparrow are on private lands, ranchers need to be informed of their habitat requirements, and their cooperation must be obtained in implementing suitable range management practices.

To conserve the short-tailed hawk, known nesting areas and associated foraging habitat must be protected (Millsap et al. 1996) because hawks appear to have high breeding-site fidelity (Millsap et al. 1989). Restoration of mature swamp forest along and near Istokpoga Canal might reestablish breeding hawks in this important historical locality (McNair et al. 2001). Additional nesting sites need to be found (and subsequently protected) via low-elevation helicopter surveys during early morning (Millsap et al. 1996).

Burning, grazing, and mowing of upland pastures or prairies provide suitable foraging habitat for the sandhill crane, especially during the post-nesting period (Nesbitt 1996*a*). Detailed studies are needed on the impacts of citrus conversion and more intensive agricultural practices on the wildlife of dry prairies, including the possible effects of pesticides and herbicides (Layne 1996). A study has been conducted in south-central Florida on anuran use of temporary wetlands that were heavily influenced by an extensive series of ditches that had been used to convert a large marsh system to pastureland for cattle (Babbitt and Tanner 2000).

Conservation Tasks

Prior to re-scoring of taxa, the only taxa with sufficiently high biological scores to rate specific conservation tasks were the caracara, short-tailed hawk, burrowing owl, Florida sandhill crane, Florida grasshopper sparrow, South Florida mole kingsnake, and South Florida rainbow snake. After re-scoring, the biological score of the burrowing owl dropped from 24.3 to 13.3, reflecting overall stable or increasing population trends and distribution in Florida (Millsap and Bear 1997). Subsequently, we added the whooping crane, limpkin, snail kite, and Henslow's sparrow to the list of taxa to be considered in the dry prairie section because of sufficiently high biological scores (Appendix A), although some of these taxa have only limited occurrence in this region. The Florida grasshopper sparrow has 7 tasks assigned solely to it, the sandhill crane has 4 tasks, and the whooping crane, caracara, and short-tailed hawk have 3 tasks each. Several tasks that were identified when this plan was first developed have been completed and subsequently deleted.

Thirty-six tasks have been identified for this region, with 14 of them related to research and 5 to distributional surveys or species management (Appendix B). Several of the habitat protection and management tasks involve the implementation of habitat management practices on WMAs to maintain or increase populations of target taxa. Five tasks consider the dry prairie ecosystem in its entirety and attempt to increase scientific knowledge and public appreciation of this poorly understood ecosystem. The role of fire and livestock grazing in managing dry prairies and prairie wetlands needs further exploration. Another topic of interest is the comparative habitat values and functions of native prairie versus tame-grass pastures in relation to target taxa. Current sociopolitical trends have not fostered a good working relationship between resource managers and the farming community with regards to listed species, and prairie habitat continues to be converted to tame-grass pastures. The future survival of many wildlife species will depend on the extent of private grazing lands in native prairie and suitable improved pastures, so it is imperative that a cooperative relationship is fostered between various governmental agencies and private landowners, and that habitat protection incentives and restoration techniques are developed.

SOUTH FLORIDA ROCKLAND COMMUNITIES

Habitat Descriptions

The rockland communities of extreme southern Florida include pine rocklands and tropical, or rockland, hammock. The Keys contain 76% (4,682 ha) of the rockland hammock habitat identified by Cox et al. (1994), with most of the remaining hammocks occurring on Sanibel and Captiva islands in Lee County and on shell middens in the Ten Thousand Islands (Cox et al. 1994). However, these other hammocks do not contain many of the target vertebrate taxa and are not considered in this plan. Kautz et al. (1993) estimated that 6,175 ha of rockland hammock remained, mostly in the Florida Keys, especially on North Key Largo. Patches of rockland hammock remain in the Upper Keys on Key Largo and Elliott Key, and in the Lower Keys on Big Pine, Little Pine, No Name (contains the largest remaining patch totaling 148 ha), Ramrod, Summerland, Cudjoe, Sugarloaf, and Torch keys. Private lands in the Keys contain 453 patches of rockland hammock; the average size is 4.7 ha, with 52.5% of them being <1 ha in size (Cox et al. 1994). Pinelands of Big Cypress are intermediate between pine flatwoods and pine rocklands, and they contain few of the endemic rockland wildlife species (Snyder et al. 1990) and are therefore not included in this plan.

Estimates of remaining pine rockland habitat range from 5,168 ha (Cox et al. 1994) to 6,174 ha (O'Brien 1998). Cox et al. (1994) identified about 375 rockland pine stands totaling nearly 1,780 ha outside of Everglades National Park (ENP) in 1990, and the fragments ranged in size from 0.4 to 345 ha (average 4.9 ha). About 50% of these stands were in public ownership and averaged 19.4 ha in size (Cox et al. 1994). In contrast, O'Brien (1998) identified 420 pine rockland fragments totaling 1,524 ha, and only 14% were in public ownership, although 6 of the 7 largest sites were owned by Dade County. The largest remaining patches of pine rocklands are on Long Pine Key in ENP and on Big Pine Key (mostly in the National Key Deer Refuge) and Cudjoe Key (Cox et al. 1994). Long Pine Key is the principal upland area in ENP, with a maximum elevation of 5 m above sea level. Long Pine Key contains 4,650 ha of pineland (Snyder 1986) and 25 small hammocks (usually <10 ha) on islands of Miami oolitic limestone surrounded by wet prairies that extend west and southwest from Taylor Slough for ≈25 km into the southern interior of ENP (Olmsted et al. 1983). These pinelands are primarily the result of natural regeneration from scattered cull pine trees that remained after logging in the late 1930s and early 1940s (Taylor and Herndon 1981); however, ≈1,667 ha of pines on Long Pine Key were never logged (Olmsted et al. 1983).

Pine rocklands and rockland hammocks occur on limestone outcroppings of 3 distinct geological formations: the Miami, Key Largo, and Tamiami limestones (Hoffmeister 1974). The largest outcrop is of oolitic Miami limestone along the Miami Rock Ridge, which extends from Miami through Homestead to the Long Pine Key area of ENP. This ridge is 6–16 km wide and reaches >7 m above sea level in the Silver Bluff area of Miami, but it gradually tapers and decreases to <2 m above sea level in Long Pine Key (Snyder et al. 1990). The Upper Keys (Soldier to Big Pine Key) are composed of Key Largo limestone, whereas the Lower Keys are Miami limestone. Most keys are only 1–2 m above sea level, although small areas of Big Pine Key and Lignum Vitae Key are 4–5 m above sea level. An outcropping of older Tamiami limestone occurs in the southeastern third of Big Cypress Swamp. The Miami oolite and Key Largo limestone outcroppings have apparently been continuously exposed during rising sea levels over the last 14,000 years (Robbin 1984).

The surface of the Miami Rock Ridge is very irregular, and pinnacle rock (weathered oolitic limestone) and solution holes are common. Sandy soil is primarily restricted to occasional shallow depressions in the surface rock. The 72,700 ha of pre-Columbian pine rocklands in Dade County are divided into a series of islands by transverse channels (representing Pleistocene tidal erosion) of wet prairie habitat (Maguire 1995). Based on Davis' (1967) map, Florida contained 154,800 ha of pine rocklands prior to European settlement (Kautz et al. 1993).

Rockland hammock is a hardwood forest that represents an advanced successional stage of pine rockland. Hammocks occur on upland sites in areas where limestone is very near the surface or exposed. The diverse overstory is often predominated by trees ≥18 m tall, particularly live oak, wild tamarind (*Lysiloma latisiliquum*), and gumbo-limbo (*Bursera simaruba*) (Robertson 1953, Olmsted et al. 1981). Other typical overstory and subcanopy trees are stoppers (*Eugenia* spp.), pigeon plum (*Coccoloba diversifolia*), false mastic (*Mastichodendron foetidissimum*), willow bustic (*Bumelia salicifolia*), poisonwood (*Metopium toxiferum*), mahogany (*Swietenia mahagoni*), inkwood (*Exothea paniculata*), marlberry (*Ardisia escallonioides*), lancewood (*Nectandra coriacea*), strangler fig (*Ficus aurea*), wild coffee (*Psychotria* spp.), bustic (*Dipholis salicifolia*), black ironwood (*Krugiodendron ferreum*), paradise tree (*Simarouba glauca*), satin leaf (*Chrysophyllum oliviforme*), redbay (*Persea borbonia*), cabbage palm, laurel oak, and hackberry (*Celtis* spp.). The ground cover is typically very sparse because of the dense canopy, but species may include sea grape (*Coccoloba uvifera*), ferns, coontie (*Zamia integrifolia*), poison ivy (*Toxicodendron radicans*), greenbrier (*Smilax* spp.), and fox grape (*Vitis labrusca*). Most of the herbaceous flora consists of epiphytes: Spanish moss (*Tillandsia usneoides*), bromeliads, orchids, and vines (Florida Natural Areas Inventory 1990, Snyder et al. 1990). Fifty-nine plant taxa are rare or threatened, mostly epiphytic bromeliads, orchids, and ferns; at least 10 of these taxa are dependent upon solution holes (Gunderson 1994).

The more xeric hammocks in the Keys contain fewer temperate species (e.g., live oak, hackberry) than on the mainland, and the canopy trees tend to be smaller (Snyder et al. 1990). In the Upper Keys, canopy trees are typically 9–12 m tall, whereas in the more xeric Lower Keys and much of the Upper Keys south of lower Matecumbe Key, they are 6–7.5 m tall (Weiner 1979). A stunted, dense canopy of poisonwood, buttonwood (*Conocarpus erecta*), blolly (*Pisonia discolor*), and Key thatch palm (*Thrinax morrisii*) characterizes the latter habitat, which is sometimes called "low hammock" (Weiner 1979) or "Keys hammock thicket" (Duever 1984).

Rockland hammocks are interspersed throughout pine rocklands (Olmsted et al. 1983), between pine rocklands and sloughs (e.g., Royal Palm Hammock in ENP), on elevated outcrops on the upstream side of some tree islands in swale habitat, and scattered throughout marl prairies or tidal swamps (Craighead 1971). Rockland hammocks normally do not flood but are often dependent upon high water tables to maintain reservoirs in solution features of the limestone and to keep humidity levels high. The dense canopy minimizes daily temperature fluctuations, and its rounded profile deflects winds, limiting desiccation during dry periods and reducing interior storm damage (Snyder et al. 1990). The highly organic hammock soil forms an uneven layer over the limestone and burns readily when dry. Soil is absent on the limestone outcroppings, but it may accumulate to depths of $\geq$50 cm in solution holes (Snyder et al. 1990). Hammocks are frequently located within wetlands that serve as firebreaks, but hammocks may burn if the water table drops >40 cm below the surface or if the soil moisture content is <35% (Robertson 1953). Hammocks typically burn in a mosaic fashion (Olmsted and Loope 1984); the less fire-resistant trees often resprout or coppice from roots or underground stems, and opening of the canopy favors the regeneration of shade-intolerant tree species Olmsted et al. 1980, Snyder et al. 1990).

Pine rockland is an open-canopied forest of South Florida slash pines that has a patchy understory of tropical and temperate shrubs and palms with a variable ground cover of grasses and herbs. Scattered outcrops of pinnacle rock are common. Typical shrubs are saw palmetto, cabbage palm, silver palm (*Coccothrinax argentata*), gallberry (*Ilex glabra*), rough velvet seed (*Guettarda scabra*), blolly, locustberry (*Bursonima lucida*), myrsine (*Myrsine quianensis*), tetrazygia (*Tetrazygia bicolor*), varnish leaf (*Dodonaea viscosa*), and marlberry. Ground cover consists of broomsedge, wiregrass, muhly grass (*Muhlenbergia* spp.), rattlebox (*Crotalaria* spp.), partridge pea (*Cassia fasciculata*), coontie, and pinefern (*Anemia adiantifolia*) (Florida Natural Areas Inventory 1990, Snyder et al. 1990). The monotypic overstory of pines is in sharp contrast to the extremely diverse understory. In ENP, 186 understory species have been recorded (Loope et al. 1979), and up to 75 species of hardwoods may be present (Taylor and Herndon 1981). Of the 76 most ubiquitous understory species in pine rocklands, 44% are of West Indian origin, 33% are temperate, and 17% are endemic to South Florida (Loope et al. 1979). Fifty-one of the plant taxa are species of special concern, and 1 species is federally endangered (Gunderson 1994). Pine rocklands support 38 endemic plant species, of which 28 are restricted to this habitat (Avery and Loope 1980, Snyder et al. 1990).

Pine rockland occurs on relatively flat terrain that is moderately to well drained depending on the porosity of the limestone. Most sites are wet for only short periods following heavy rains, but some sites may be inundated with shallow, slow-flowing water for up to 60 days during the rainy season. Approximately 75% of the annual rainfall occurs between June and September. Miami receives >600 mm more mean annual rainfall than the Lower Keys (MacVicar and Lin 1984). Because limestone bedrock is at or near the surface, soils generally consist of small accumulations of sand, marl, and organic material in depressions and crevices in the rock surface. The lack of soil exacerbates the effects of drought. Exposed rock comprises up to 70% or more of the surface in Long Pine Key and >50% of the surface in the Lower Keys (Snyder et al. 1990). Pine rocklands are often bordered by wet prairies and sometimes by tidal swamps. This community is dependent upon periodic fires (every 3–10 years during pre-Columbian times) to prevent succession to tropical hammock. If understory development progresses longer than 8–10 years, fires are precluded or catastrophic (Robertson 1954, Loope and Dunevitz 1981, Snyder 1986). Analysis of fire regimes over the last few thousand years in South Florida indicates that human-induced fires have become more prevalent than lightning-induced fires (Snyder 1991). Understory plants reach heights of 2 m under fire regimes of 5–10 years (Gunderson 1994). Succession to tropical hammock with an overstory of relict pines may take only 20–30 years on the mainland of southern Florida (Robertson 1953, Alexander 1967, Hofstetter 1984), but in the more xeric Keys, succession may take 50 years (Alexander and Dickson 1972) or over a century (Carlson et al. 1993). Frequently recurring fires may eliminate hardwoods and favor an understory of palms, especially saw palmetto (Robertson 1953). Below-freezing temperatures help reduce tropical hardwood encroachment into pine rocklands, which have a relatively open understory and canopy compared to tropical hammocks. Freezes do not occur most years on the Miami Rock Ridge and are rare in the Keys, where they have long-lasting effects on cold-sensitive species (Snyder et al. 1990).

Wildlife Communities

Rockland communities may contain populations of the following state-listed taxa: Key deer (*Odocoileus virginianus clavium*); Key Largo woodrat (*Neotoma floridana smalli*); Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*); Florida mastiff bat; white-crowned pigeon (*Columba leucocephala*); Florida Keys mole skink (*Eumeces e. egregius*); Key ringneck snake (*Diadophis punctatus acricus*); rim rock crowned snake (*Tantilla oolitica*); indigo snake; and Lower Keys populations of the striped mud turtle (*Kinosternon baurii*), corn or red rat snake (*Elaphe g. guttata*), Florida brown snake (*Storeria dekayi victa*), and peninsula ribbon snake (*Thamnophis sauritus sackenii*). Rockland communities are also important to other taxa with high biological scores or declining population trends: gray kingbird (*Tyrannus dominicensis*), black-whiskered vireo (*Vireo altiloquus barbatulus*), and smooth-billed ani (*Crotophaga ani*). Rockland hammocks contain some of the rarest plants and animals in the United States (Layne 1974, Snyder et al. 1990), including the federally listed Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*) and Stock Island tree snail (*Orthalicus reses*). The Caribbean region, including South Florida, has been ranked as 1 of the top 8 top biodiversity hot spots in the world, based upon the occurrence of exceptional concentrations of endemic species and exceptional loss of habitat (Myers et al. 2000).

Although rockland vegetation has a decidedly West Indian character, most of the vertebrate fauna is from southeastern temperate North America, except for birds, because no land bridge ever existed to the West Indies (Robertson 1955, Duellman and Schwartz 1958, Layne 1984, Robertson and Kushlan 1984). Ten mammal and 5 reptile species are endemic to South Florida rocklands (Snyder et al. 1990). Most of the native mammals in the Keys are endemic taxa, and all but the fruit bat (*Artibeus jamaicensis*) are of North American origin (Lazell 1989). Approximately 20% of the reptiles are of Antillean or Bahamian origin, but the source of their introduction is often unknown; ≈10% of the reptiles are endemic subspecies (Lazell 1989). Eighty-eight percent of Florida's 36 introduced nonnative species of herpetofauna originated primarily from tropical regions, whereas 82% of the 136 indigenous herpetofaunal species are of temperate origin (Butterfield et al. 1997). Rockland hammock habitat contains 2 lizard species, the Florida reef gecko (*Sphaerodactylus n. notatus*) and bark anole (*Anolis distichus*), with West Indian affinities that probably came to Florida without man's intervention, unlike many introduced nonnative species now found in South Florida (Wilson and Porras 1983). Of the 18 nonnative herpetofaunal species from the West Indies, 7 immigrated to South Florida with cargo shipments, and the remaining 11 species were introduced intentionally and unintentionally, primarily through the pet trade (Butterfield et al. 1997). The number of vertebrate species in South Florida has increased due to the establishment of nonnative species, and at least one-third of all vertebrate species (excluding fish) are now either exotic or state-listed species (Forys and Allen 1999). Thirty-one nonnative herpetofaunal species have established breeding populations in Dade and Monroe counties, although most have apparently not dispersed far from their arrival sites and are restricted to disturbed habitats (Butterfield et al.1997).

The diversity of native herpetofauna in rockland habitats is reduced in the Keys because some mainland species have failed to colonize this chain of limestone islands or have been extirpated in the past (Auffenberg 1982, Auth 1989, Lazell 1989). The Upper Keys is less species rich than the Lower Keys, perhaps due to mainland species historically moving overland to the Lower Keys prior to land subsidence. Miami oolite composes the Lower Keys, islands of Florida Bay, and the southern mainland, whereas the Upper Keys are younger and occur on the Key Largo formation, a coral reef that apparently grew in the Pamlico Sea (Neill 1957). The Keys have fewer herpetofaunal species than the mainland because of the reduction in habitat types and surface fresh water, and the higher extinction rates characteristic of islands (Auth 1989). The distributions of amphibians and some reptiles are probably affected by the lower precipitation in the Keys compared to the rest of Florida, and by the absence of a pronounced wet season (Chen and Gerber 1990). Small patches of rockland communities probably have fewer wildlife species and are more susceptible to local extinctions than large patches.

Seawater surges in the relatively xeric Keys, whose rockland habitats may become flooded with salt water for 1–3 days following hurricanes, probably have drastic short-term effects on amphibian populations. The abundance of amphibians in the Keys depends upon the availability and proximity of freshwater breeding sites. Underground water may be accessible to some animals via solution holes (Craighead 1974), which also provide important refugia during the frequent ground fires that burn off the pine-needle litter. Adjacent freshwater wetlands provide breeding sites for rockland amphibians and sources of prey for reptiles preferring to live in the elevated, forested rocklands. Islands of rockland hammock may provide important refugia for wildlife, including nonhammock species, during severe flooding of surrounding wetlands (Duever et al. 1979).

Pine rocklands have sparse soils, but refugia for herpetofauna and mammals are provided by holes and crevices in the limestone, piles of rock rubble, and pockets of organic matter accumulating in solution holes and shallow depressions in the oolitic limestone. On the northern end of the Miami Rock Ridge and in the eastern Big Cypress pinelands, several centimeters of sand typically overlie the limestone, providing a substrate that can be used by sand-burrowing reptiles. On Long Pine Key and the Lower Keys, however, the surface is mostly limestone, and a fine sandy loam exists only in scattered shallow depressions.

The presence of fresh or brackish water in the more xeric Lower Keys is important to several highly ranked or listed reptile taxa or populations. The Lower Keys population of the striped mud turtle lives in small, usually temporary ponds with salinities <15 ppt, which typically occur in or along the edge of rockland hammocks (Dunson and Mazzotti 1989, Dunson 1992). Terrestrial habitats are used when the ponds dry up or become too saline. This population was once considered a distinct subspecies, the Key mud turtle (*Kinosternon baurii palmarum*) (Uzzell and Schwartz 1955), but subsequent studies that examined pigmentation, morphometrics, and mtDNA sequence data have shown that subspecific designation is unwarranted (Iverson 1978, Karl and Wilson 2001). The Lower Keys population of the brown snake inhabits pine rocklands and rockland hammocks, often near water (Moler 1992*d*). The Lower Keys population of the ribbon snake inhabits the edges of permanent freshwater bodies of water and tidal marshes and swamps (Moler 1992*e*).

Other highly ranked reptile taxa or populations in the Keys are apparently less dependent upon the presence of water. The Florida Keys mole skink inhabits pine rockland areas with sufficient areas of loose sand, and sandy shorelines in the Lower Keys and the Dry Tortugas (specimens from the Upper Keys are intergrades) (Christman 1992*b*). The Lower Keys population of the red rat snake inhabits pine rocklands and rockland hammocks, and because it adapts well to edificarian habitats, it is probably less threatened than many of the other Keys' species, although commercial collecting may be a problem despite its protected status. The Key ringneck snake has been found in pine rocklands and the edges of rockland hammocks on Big Pine, Little Torch, Middle Torch, and No Name keys (Christman and Moler 1992, Auth and Scott 1996). The federally threatened rim rock crowned snake is found along the eastern rim of the Miami Rock Ridge and on Key Largo, Upper Matecumbe Key, Grassy Key, and Key Vaca (Campbell and Moler 1992, Krysko and Decker 1996). Specimens have been found on both sandy and rocky substrates in pine rocklands, rockland hammocks, and edificarian situations (Campbell and Moler 1992).

Populations of the indigo snake are secure and widely distributed in ENP and Biscayne National Park, where they are most common in rockland communities, often using solution holes. However, their continued survival in the Keys depends upon protection of remaining habitats on Key Largo and in the Lower Keys from Big Pine Key to Sugarloaf Key (Steiner et al. 1983).

Approximately 8,000–9,000 pairs of the white-crowned pigeon probably nest on mangrove islands from Biscayne Bay southward through the Marquesas Keys, with >50% of the population nesting in Florida Bay in the Upper Keys (Bancroft 1996). White-crowned pigeons may fly >45 km to forage on the fruits of trees in various habitats on the southern tip of mainland Florida and in tropical hammocks in the Keys (Bancroft 1996). They are important in the seed dispersal of ≥35 species of trees, shrubs, and vines (Bancroft et al. 2000). The most important fruits for successful nesting are those of poisonwood, blolly, strangler fig, and short-leaf fig (*Ficus citrifolia*) (Bancroft and Bowman 1994). Over 70% of the woody plants in the Keys produce fleshy fruits that are eaten by birds and mammals (Sawicki 1997), and frugivorous birds probably facilitate succession of disturbed hammocks (Bancroft et al. 2000).

The Key deer, the smallest subspecies of white-tailed deer in North America (Barbour and Allen 1922), mostly utilizes pine rocklands in the Lower Keys (Silvy 1975), with 65–70% of the population occurring on Big Pine Key (Klimstra et al. 1974). The presence of fresh water determines which keys can support deer during the November–April dry season (Jacobson 1974, Klimstra et al. 1974).

The Key Largo woodrat and cotton mouse, both of which are endangered taxa, occur in rockland hammocks (i.e., dry tropical forest) on northern Key Largo. The cotton mouse occupies all seral stages, including recently burned and early-successional hammock forests (Goodyear 1985), and it may also occupy adjacent coastal strand habitat dominated by glasswort (*Salicornia* spp.) (Humphrey 1988*a*). It once occupied rockland hammocks throughout Key Largo and as far south as Tavernier on Plantation Key (Osgood 1909 in Layne 1974), but habitat destruction and fragmentation have apparently now restricted it to the northern end of Key Largo (Schwartz 1952, Barbour and Humphrey 1982). The woodrat is more restricted in its habitat use. It usually does not live in deforested and oldfield sites (Goodyear 1985), and it is uncommon in young forests (Humphrey 1988*a*). On northern Key Largo, the amount of upland habitat that is potentially suitable (i.e., could revert to forest after succession) for the cotton mouse and woodrat is estimated at 851 ha (Humphrey 1988*b*), whereas the amount of forested habitat that is presently suitable for the woodrat is ≈475 ha (Barbour and Humphrey 1982).

The Florida mastiff bat was considered common in the 1950s and 1960s in the Miami–Coral Gables area of Dade County, where it was found under barrel-tile roof shingles, in shafts of royal palm (*Roystonea regia*) leaves, and inside houses (G. T. Hubbell, pers. commun. to Belwood 1992). This species has apparently declined in urbanized Dade County, where none was found during a 1989 bat survey (Robson 1989). In 1979, a communal roost of these bats was found in a woodpecker cavity in a longleaf pine in flatwoods in Charlotte County (Belwood 1981), indicating that tree cavities may provide roosting sites in Florida.

Threats to Habitat or Wildlife

According to Bentzien (1987), over 98% of pine rockland habitat has been lost, whereas O'Brien (1998) claims that the loss is 96.2% in the Redland region, 97.3% in the Biscayne region, and 11% in Long Pine Key in ENP. An estimated 60–80% of the rockland hammocks in the Middle Keys have been lost (U.S. Fish and Wildlife service 1985*c*). These rockland habitats are highly fragmented and are embedded in a matrix of agricultural and residential landscapes (O'Brien 1998). Development has reduced the coverage of pine rocklands from 52,754 ha to 6,174 ha (O'Brien 1998). Approximately 10% of the pre-settlement rockland forests is conserved in parks, mostly in ENP (Snyder 1986). Many of the hammocks on the Keys and mainland were cleared for agriculture, firewood, and charcoal in the 1800s, and almost all pinelands were clear cut by 1950 (Snyder et al. 1990). Approximately 400 km^2 of pine rocklands once extended northeastward from Taylor Slough as far as the Miami River (Olmsted et al. 1983).

The pine rocklands of the Miami Rock Ridge once contained an estimated 500 hammocks ranging in size from 0.1 ha to >40 ha (Craighead 1974), but clearing for agriculture and residential development has resulted in the loss of 98% of the original Miami Rock Ridge pinelands outside of ENP (Snyder et al. 1990). Most of the remaining hammocks on the Miami Rock Ridge are not in danger of being cleared because they are now Dade County parks. The largest hammock on the Miami Rock Ridge, Brickell Hammock, was cleared in the early 1900s to build Miami, but >50% of the Dade County hammocks still remain (Snyder et al. 1990). In the Keys, however, most hammocks are privately owned and are in demand for commercial and residential development. Rockland hammocks require protection from fire, canopy disruption, and groundwater reduction, and organisms must be protected from collectors (Kruer 1992). About 50% of the rockland hammocks mapped by Kautz et al. (1993) occurred on conservation lands (Cox et al. 1994).

Three periods of deforestation of rockland hammocks have occurred in the Keys (Strong and Bancroft 1994*a*). In the 18th and early 19th centuries, Bahamians selectively logged trees. Many forests were subsequently cleared for agriculture in the late 19th century, but the fields were abandoned in the early 1900s. However, the construction of a freshwater pipeline in the 1940s eliminated the scarcity of fresh water and permitted extensive residential and commercial development of forests (Strong and Bancroft 1994*a*). Much of the hardwood forest on Key Largo was cleared for pineapples in the late 19th century, but a severe pineapple blight in 1906 terminated pineapple production by 1915, and most fields eventually became hammocks again (Humphrey 1992*e*). Selective logging of mahogany for furniture and lignum vitae for ships also occurred, and in the 1930s, some lime groves were established (Humphrey 1992*e*).

By 1991, the 95 pre-Columbian forests in the Upper Keys had been fragmented into 1,068 parcels, 987 of which were <5 ha in size (Bancroft et al. 1995). The Upper Keys lost 41.2% of its original 4,816 ha of forest, and the acreage in large fragments (>100 ha) decreased by 84% (Bancroft et al. 1995). Roadless keys lost 1% of their original forest, whereas the area from central Key Largo through Long Key, which is bisected by U.S. Highway 1, lost 65.8% of its forests, and the original 35 large forest fragments had increased to 850 small fragments in 1991 (Strong and Bancroft 1994*a*). Much of the northern half of Key Largo is protected within state and federal preserves, so it has lost only 29.7% of its forests, but the original 11 forest fragments increased to 165 in 1991 (Strong and Bancroft 1994*a*). Fortunately for wildlife, vigorous litigation during the past few years has slowed the previous uncontrolled rate of growth in the Keys (Morgenstern 1997).

Hammocks near the urbanized Atlantic Coast suffer from lowered water tables, and the solution holes lack water except during very wet periods (Alexander and Crook 1984). This lack of water may affect wildlife populations, especially amphibians. The dried-up solution holes and peaty soil probably have resulted in lower humidity in the hammocks and have allowed repeated fires to consume the top humus and entire peat layer, leaving exposed limestone (Craighead 1974). The Dade County hammocks that are preserved as parks have access paths and roads that reduce the water balance, increase trampling of young vegetation, and create an unfavorable seedbed for regeneration (Alexander and Crook 1984). Tropical hammocks that once occupied the central portion of barrier islands in Palm Beach, Broward, and Dade counties have been lost to urbanization, and most of the few remaining public-owned sites have been isolated by development or by invasion of nonnative plant species into the natural transition zones between hammock vegetation and adjacent tidal swamp or coastal strand communities (Johnson and Muller 1992*b*).

Because of habitat loss, FNAI considers 40 pine rockland plant taxa to be globally rare, and the Florida Department of Agriculture lists 34 taxa (Kruer 1992). Invasion of several dozen exotic plant species was facilitated by fragmentation of pine rocklands and disturbance along the edges. Brazilian pepper (*Schinus terebinthifolius*) is the worst invader of infrequently burned pinelands, but the fire-tolerant plume grass or Burma reed (*Neyraudia reynaudiana*) is also a problem (Wade et al. 1980, Loope and Dunevitz 1981). Tropical hammocks that have been damaged by fire are often colonized by native weedy species, such as Florida trema (*Trema floridana*) and bracken fern (*Pteridium aquilinum*), or by Australian pines (*Casuarina* spp.). Human cultivation has resulted in the establishment of nonnative trees, such as *Citrus* spp. and banana (*Musa* x *paradisicum*), in many hammocks (Gunderson 1994). Exotic plants, especially Australian pine, Brazilian pepper, and latherleaf (*Colubrina asiatica*), have invaded ≈2,833 ha of upland habitat in the Keys (Kruer et al. 1998). Areas of disturbed substrate adjacent to hammocks are often heavily infested with exotic plants that then rapidly invade the hammocks (Anonymous 1999).

The Keys are mostly only 1–2 m above sea level and are prone to inundation by seawater during tropical storms and hurricanes (Snyder et al. 1990). Hurricanes strike South Florida about every 3 years (Gentry 1974), and there is a 1 in 7 chance of Dade or Monroe County being struck in any given year (Fernald and Purdum 1992). In 1960, Hurricane Donna did relatively little damage to pine trees on Long Pine Key but damaged many of the large trees and caused extensive defoliation in hammocks on Long Pine Key and along the coast (Craighead and Gilbert 1962). Hurricane Donna destroyed >50% of the epiphytes in rockland habitats.

Hurricane Andrew struck South Florida on 24 August 1992. An intense eyewall 40 km in diameter with sustained winds >234 km per hour crossed Dade County, causing severe canopy damage in many pine rocklands and immediately killing 40–60% of the mature pine trees (Loope et al. 1994). One-third of the pine trees in Long Pine Key were snapped or uprooted by Andrew (Loope et al. 1994). Delayed tree mortality due to physical damage, drought, and insect infestations resulted in almost 90% loss of mature pines 18 months after the hurricane (Maguire 1995). The loss of pine needles for fuel will affect future fire regimes. Loss of pine trees in Long Pine Key may affect the 15–20 breeding pairs of the swallow-tailed kite, which nest in the tallest pines (Loope et al. 1994).

In hammocks on Elliott Key in Biscayne National Park and in Long Pine Key in ENP, Hurricane Andrew downed or snapped 20–30% of the larger trees and almost completely defoliated all trees (Loope et al. 1994). Where the storm surge was highest in the Keys, leaf and other natural litter were removed within 100–200 m of the shore. In Long Pine Key hammocks, canopy cover was reduced from nearly 100% to 30%, resulting in microclimate changes (increased sunlight and decreased relative humidity), faster drying of hammock soils, and increased fire hazard (Loope et al. 1994). Vascular epiphytes, of which 29 taxa reach their northern limits in South Florida, suffered the greatest mortality from the hurricane (Loope et al. 1994). An estimated 90% of canopy epiphytes and 50% of subcanopy epiphytes were lost to either wind damage or sunburn, and epiphytes will probably be more susceptible for several years to freezes and droughts until the canopy reheals (Loope et al. 1994). The spread of nonnative plant species into hammocks may have been accelerated by the hurricane dispersing propagules and opening up the canopy (Loope et al. 1994). Overall, 28% of the 90 regenerating plant species in hurricane-disturbed hammocks were nonnative, and nonnative vines negatively affected the regeneration of native species by forming dense "blankets" (Horvitz et al. 1998).

Habitat loss and fragmentation of rockland habitats threaten wildlife populations, especially in the Lower Keys. Destruction of wetlands by dredge-and-fill operations and reduction in groundwater levels are detrimental to the Key deer and Lower Keys' populations of the Florida brown snake, peninsula ribbon snake, and striped mud turtle. Some species, such as the rim rock crowned snake and red rat snake, can adapt to edificarian situations. Clearing of the remaining hammock fragments and removal of native fruit-producing trees, particularly poison wood, in suburban neighborhoods threaten the white-crowned pigeon (Bancroft 1996). Mosquito control programs may affect the food supply of insectivorous birds, amphibians, and reptiles.

In the future, populations of wildlife species that are habitat-specific and have limited ranges will likely become endangered or extinct as their habitat is destroyed, and populations of native and exotic species that are adapted to disturbed, urban, or agricultural environments will increase (Forys and Allen 1999). Butterfield et al. (1997) predict that South Florida's herpetofauna will continue to become more tropical than temperate in origin and that 11 Bahamian species will likely become future immigrants. Although Florida has almost twice as many nonnative herpetofaunal species as any other state, exotic species pose less of a threat to native herpetofauna than does uncontrolled human population growth and environmental modification (Wilson and Porras 1983, Butterfield et al. 1997). One-third of Florida's population lives along the southeastern coast between West Palm Beach and Miami in one of the least suitable areas environmentally for human development (Winsberg 1992).

Automobile traffic and predation by feral and domesticated pets are probably the main causes of direct mortality for many species. Feral and pet cats are a significant threat to many species of amphibians, reptiles, birds, and small mammals in the remaining rockland forest fragments. Species especially impacted by cat predation in various Florida habitats are mentioned in the appropriate sections of this report. An estimated 12.1–15.4 million cats spend at least part of their time outdoors in Florida and possibly kill as many as 271 million small mammals and 68 million birds annually (Florida Fish and Wildlife Conservation Commission 2001). The cat problem is not confined to Florida or to the United States. Cats have been implicated in the extinction or severe decline of wildlife populations on oceanic islands and in Australia, New Zealand, and England (Fitzgerald and Karl 1979, Jones and Coman 1981, Delroy et al. 1986, Churcher and Lawton 1987, Dobson 1988, Jurek 1994). The black rat (*Rattus rattus*) may compete with or prey upon the rice rat, woodrat, and cotton mouse. Other exotic animals that may pose a threat to some native species are the armadillo (*Dasypus novemcinctus*), feral hog, and red imported fire ant (Anonymous 1999). The 15 psittacine species that have been recorded nesting in the wild in South Florida (Snyder et al. 1990) are almost certainly dispersing seeds of exotic species (Anonymous 1999).

Key deer populations fell to an estimated low of 25 animals in the early 1950s due to overhunting and habitat loss (U.S. Fish and Wildlife Service 1985*b*). Protection from hunting and the establishment of the National Key Deer Refuge in 1957 resulted in a population increase to 400 deer by 1969 (Alexander and Dickson 1970), but the population decreased to 250–300 deer by 1982 (Hardin et al. 1984, Humphrey and Bell 1986) due to highway mortality and habitat loss on private lands (U.S. Fish and

Wildlife Service 1985*b*). A 1998 census estimated a population of 603 deer on just Big Pine and No Name keys compared to only 211 deer 30 years ago (Lopez et al. 1999). Vehicular traffic accounts for 75−80% of known annual mortality (Drummond 1989), with poaching and free-ranging dogs accounting for most of the remainder (Klimstra 1992). Recent changes in the sociobiology of the Key deer due to increasing contact and influence by humans (Folk and Klimstra 1991) have caused a contraction in its distribution and range, resulting in an unusually high concentration on Big Pine Key (Anonymous 1999). When humans feed deer, especially with enriched food, the behavior, morphology, and population structure of the herd is affected, and deer may be encouraged to frequent roadsides and inhabited areas where they are more prone to being killed by traffic and dogs.

Conservation and Management Strategies

Tropical hammocks on the Keys are mostly privately owned and will probably be cleared for commercial or residential developments if not protected. Large tracts of hammock are protected in Biscayne National Park, the Crocodile Lakes NWR, and the FDEP's North Key Largo Hammock Preserve in the Upper Keys and in the National Key Deer Refuge in the Lower Keys (Snyder et al. 1990). It has been recommended that county, state, and federal governments acquire and preserve all remaining forest fragments in the Keys >5 ha in size in order to protect several species that are currently not well represented in protected areas of the Upper and Lower Keys, and to provide forested "stepping stones" for genetic and individual exchange (Strong and Bancroft 1994*b*, Bancroft et al. 1995). Purchase of land on Big Pine Key is complicated by multiple ownership because parcels are ≤2 ha in size (DiSilvestro 1997). Between central Key Largo in the Upper Keys and Sugarloaf Key in the Lower Keys, 120 km of small, narrow islands have been extensively cleared of hammock vegetation (Strong and Bancroft 1994*a*). These islands contain some subcommunities and species that are poorly represented elsewhere in the Keys (Ross et al. 1992). Although the U.S. Fish and Wildlife Service has not designated critical habitat for the Key deer, the state has designated the Keys as an Area of Critical State Concern, which makes all decisions by the Monroe County Commission subject to state scrutiny (DiSilvestro 1997).

In 1994, a proposal (Tropical Flyways) for the acquisition of 334 ha of tropical hammock and 366 ha of adjacent tidal swamp in 17 sites from central Key Largo through Key Vaca was ranked high by the CARL program (Bancroft et al. 1995). Such a network of protected parcels would help reduce the risk of population extinction from catastrophic events like hurricanes, provide refugia for species to later recolonize devastated areas, and maintain dispersal processes necessary to repopulate areas (Bancroft et al. 1995). Habitat preservation in the Keys would benefit more than 250 species of plants and animals, 45 of which are rare or endangered (Sawicki 1997). In late 1995, the Tropical Flyways project was combined with the Nature Conservancy project in the Lower Keys to create 26 sites, and it was renamed the Florida Keys Ecosystem. By 1997, the state had purchased, primarily through the Monroe County Land Authority, nearly half of the acreage of the original 17 sites and all, or almost all, of 7 of the 26 sites in the Florida Keys Ecosystem project (Sawicki 1997).

Pine rockland is a fire "subclimax" community that is dependent upon frequent fires to retard hardwood succession. Winter prescribed burning using backing fires kills the largest trees and discourages seedling establishment, whereas natural lightning-caused fires (93% occur in May–September) result in highly variable age classes and densities of trees (Doren et al. 1993). Slash pines provide nesting and foraging habitat for wildlife, and their fallen needles comprise 70−80% of the total litter, which provides a flammable fuel that influences the frequency and intensity of fire and thus the diversity and density of understory vegetation. Prescribed fire has been used in ENP's pinelands since 1958 to control understory hardwood species, reduce fuel loads, and prevent shading of understory endemic plant species (Olmsted et al. 1983). After 22 years of winter burning, the densities of silver palm, cabbage palm, and saw palmetto were either not affected or increased (Taylor and Herndon 1981). Frequent winter burning may cause a predominance of varnish leaf, sumac, tetrazygia, and wax myrtle (Robertson 1953). Most shrubs are top-killed by winter fire but recover to pre-fire levels in ≈4 years (Taylor and Herndon 1981).

Burning of pine rocklands benefits Key deer by temporarily increasing the nutritive quality of browse and by later increasing browse quantity, but residents oppose burning adjacent to the refuge (Carlson et al. 1993). Burning every 10–20 years is sufficient to retard succession and maintain pine savannas on Big Pine Key, but more frequent fires (every 5–10 years) would be more beneficial in maintaining quality browse (Carlson et al. 1993). Longer fire intervals result in the extinction of endemic plants and plant species important in the Key deer diet. Absence of fire leads to reduced herbaceous cover and invasion by hammock trees, such as stoppers and pigeon plum (Carlson et al. 1993). Carlson et al. (1993) recommended development of a prescribed fire plan for specified areas to be burned every 5, 15, 25, or 75 years to maintain the natural diversity of communities.

The highest population densities of the striped mud turtle in the Lower Keys apparently occur in mosquito control ditches on Summerland Key, which the management plan for Key deer recommends filling in to prevent drowning of fawns (Dunson 1992). Approximately 55 km of ditches occur on refuge lands, and some of these ditches have been filled (Anonymous 1999). Big Pine Key does not contain a very large population of the striped mud turtle despite apparently suitable habitat, and most of the occupied hammock ponds are on private lands that are usually slated for development. Dunson (1992) recommended a thorough survey of all suitable habitat and a measurement of population sizes on public and private lands. The maintenance of manmade water holes for Key deer may benefit mud turtles and other herpetofauna dependent upon fresh water.

Conservation strategies that would benefit the white-crowned pigeon in the Florida Keys are (1) government acquisition of remaining tropical hammock fragments; (2) public education to encourage the retention and planting of native trees that fruit during the nesting season, such as blolly, strongbark (*Bourreria ovata*), and poisonwood (severe allergic reactions by many humans to the latter species will limit its use to habitat preserves); (3) high-power lines at the same elevation above the ground to minimize pigeon collisions, and (4) cooperation with Caribbean governments to conserve migratory and wintering habitats (tropical hammocks and mangroves), and to prevent overharvesting and illegal taking of pigeons (Bancroft 1996).

An introduction of 14 Key Largo cotton mice and 19 Key Largo woodrats to Lignum Vitae Key in 1970 (Brown and Williams 1971) was successful until at least the early 1980s (Barbour and Humphrey 1982), but the populations apparently no longer exist (Humphrey 1992*e*, *f*). Densities of the Key Largo cotton mouse and woodrat appear to be higher away from housing subdivisions for undetermined reasons (Humphrey 1988*a*). The woodrat will utilize some unforested habitats if piles of rubble—junk, building materials, tree debris, coral rock—are available, so a mitigation technique for developments on northern Key Largo is to place artificial substrates for burrow sites (Goodyear 1985, Humphrey 1992*f*). Much of the remaining habitat for these taxa is contained in existing or proposed federal and state land acquisitions.

Control of feral dogs and cats, black rats, raccoons (*Procyon lotor*), and fire ants would probably reduce mortality of rare rodent taxa. Poisoning or trapping of house mice and black rats may inadvertently kill cotton mice, woodrats, or rice rats. Many wildlife species would benefit from restoration of natural tidal flow and hydrology by placing culverts, removing fill, managing mosquito ditches, and improving the quality of freshwater sources. Private landowners should be encouraged to remove exotic vegetation and dumped trash, preserve natural vegetation, restore disturbed areas, and maintain natural waterflow in order to help preserve habitat suitable for native wildlife species (Anonymous 1999).

Since 1979, Miami-Dade County's Environmentally Endangered Lands Covenant Program has provided tax breaks to owners of rockland habitats who are willing to preserve and manage them for a 10-year period (Anonymous 1999). Development of hammocks on the Miami Rock Ridge is regulated, and a development permit is required from the Dade County Department of Environ mental Resources Management (DERM). The Forest Resources Program within Miami-Dade DERM has regulatory authority over all natural forest communities, including county- and city-owned parcels, and this program provides public and private owners of rockland habitats with the following technical assistance: preparation of management plans, herbicide training, prescribed fire coordination, plant identification workshops, and site-specific consultations (Anonymous 1999). Regulatory authority over rocklands in the Keys is found in the local comprehensive plan, which is enforced by the Department of Community Affairs. Development of rockland habitats in the Keys is not precluded, and property owners compete for 255 permits annually through the Rate of Growth Ordinance (Anonymous 1999).

Management of tropical hammock preserves has been minimal until recently, but the Miami-Dade County Park and Recreation Department's Natural Areas Management Section (NAM) has done a substantial amount of management work (primarily exotic plant control) in hammocks since Hurricane Andrew (Anonymous 1999). Both NAM and DERM have actively tried to restore the urban fragments of pine rocklands after Hurricane Andrew destroyed most of the adult pine trees. The fine fuels normally provided by fallen pine needles have to be supplemented by establishing the grass/forb understory; these fine fuels are needed to produce fires of the correct temperature that are relatively smoke-free and readily extinguished, and that provide proper conditions for pine regeneration. Several agencies in Miami-Dade County have also planted pine seedlings in the pine rockland fragments to replace the mature trees that were killed by the hurricane (Anonymous 1999). In the Florida Keys, exotic plant control in rockland habitats has been initiated by the Florida Audubon Society, Florida Keys Invasive Exotic Task Force, Department of Transportation, USFWS, FWC, and Florida Park Service.

Replanting can restore tropical hammocks that have been completely destroyed (Gann 1995, Anonymous 1996), but the plant and animal diversity will probably never fully recover unless a natural hammock is nearby. Creation of hammocks via natural regeneration is problematic nowadays because of the prevalence of exotic species (Horvitz 1994, Horvitz et al. 1995). Since 1987, homeowners and schools have attempted to create pine rocklands, and many herbs and shrubs are readily established. The long-term establishment of South Florida slash pine has been problematic, however, possibly because of the lack of mycorrhizal fungi in the pine roots. Maintenance of these pine rockland fragments is complicated by their dependence upon fire, which is almost totally precluded in residential areas, although the use of fire analogs (e.g., shrub trimming and raking of pine needle duff) may be a possibility (Anonymous 1999).

Conservation Tasks

South Florida rockland communities have suffered severe habitat loss and fragmentation to the detriment of several endemic taxa and unique populations. Four mammal, 1 bird, and 3 reptile taxa are targeted because of their high biological scores (Appendix A). High-ranking taxa that occur in this region but are included under other sections are the Florida mastiff bat, Lower Keys rice rat, Lower Keys cotton rat, short-tailed hawk, crocodile, indigo snake, and diamondback rattlesnake. Scores have not yet been developed for the fruit bat, *Artibeus jamaicensis*, which has apparently established a population in Key West, where it is probably dependent upon native fruiting trees in hammocks and planted fruit trees for sustenance (Lazell 1989, Frank 1997). Lower Keys populations of an additional 4 reptile taxa are included because they are listed by the state and FCREPA, but no scores exist for them because they are not considered discrete taxa. Other taxa that can occur in rockland habitats and have sufficiently high scores for inclusion in multi-species tasks are the Florida scarlet snake, Florida kingsnake, Florida box turtle, Florida mud turtle, barking treefrog, oak toad (*Bufo quercicus*), and Florida chorus frog.

Extensive destruction and fragmentation of rockland habitat in Dade County and the Keys have affected the current distribution of rockland taxa. Although habitat acquisition is the single most important thing that can be done to preserve rockland wildlife, this type of task is beyond the scope of this report. The rockland forest fragments presently protected in the Keys are inadequate to prevent the extinction of some taxa from catastrophic events like hurricanes, so a network of protected fragments is necessary to provide refugia and the corridors necessary for populations to later recolonize devastated areas. Nineteen conservation tasks have been identified for rockland communities (Appendix B). Research and species management have 5 tasks each. Four needed distributional surveys and 3 public education tasks are identified. Six tasks pertain to either the Key Largo woodrat or cotton mouse, and 4 tasks are specific to the Key deer. All 4 survey tasks and 1 research task target herpetofaunal communities. Only 2 tasks are given the highest priority: documenting the distribution and population size of established exotic lizard species and studying the effects of habitat alteration on the Key Largo woodrat and cotton mouse (Appendix B).

NORTHWEST FLORIDA STREAMS AND WETLANDS

Northwest Florida encompasses most of the biologically vulnerable amphibian and fish taxa identified by Millsap et al. (1990), although the wetland habitats occupied by these taxa are often dissimilar. All the vulnerable fish taxa are found in streams or their backwaters, whereas most of the vulnerable amphibian taxa breed in ephemeral wetlands or small seeps. Ranges of vulnerable freshwater turtle taxa (Millsap et al. 1990), many of which occupy habitats similar to those occupied by fish taxa, largely overlap this same geographic region. Thus, the ranges of high-ranking turtles, amphibians, and fishes determine the geographic scope of this section of the conservation plan. This geographic region is roughly bounded to the south and east by the Suwannee, Santa Fe, and New rivers, and it extends to the borders of Georgia and Alabama on the north and west. Only 2 highly ranked fish taxa, the blueback herring (*Alosa aestivalis*) and Lake Eustis minnow (*Cyprinodon variegatus hubbsi*) (Appendix A), do not occur at least partially in this region. Rare or imperiled fish taxa that occur in this geographic region, but were not originally ranked by Millsap et al. (1990), are the mountain mullet (*Agonostomus monticola*), river goby (*Awaous banana* [= *tajasica*]), and southern starhead topminnow (*Fundulus dispar blairae*) (Hoehn 1998).

Habitat Descriptions

The extensive Floridan Aquifer underlies all of Florida in the upper strata of limestones and discharges 300 artesian springs that, along with surface drainage, produce more than 1,700 rivers of varying sizes (Nordlie 1990). Classification of Florida's flowing waters is difficult. The most widely used system defines sand-bottomed streams, calcareous streams, swamp-and-bog streams, larger rivers, and canals (Beck 1965). The Florida Natural Areas Inventory (1990) classifies riverine systems as seepage streams, alluvial streams, blackwater streams, and spring-run streams. A river may fit into different categories due to natural variation as it flows from its headwaters to its mouth and due to human alteration along its course, such as from dam construction or channelization.

Northwest Florida contains 17 of the 27 first magnitude (i.e., average discharge ≥ 2.83 m^3 per second) artesian springs and spring groups in Florida (Rosenau et al. 1977). The Northern Region (Puri and Vernon 1964) is well drained with lakes that are generally perched above the Floridan Aquifer, and most of Florida's largest springs are along river valleys. The clear, alkaline water of spring-run streams usually has relatively constant flow because of uniform discharge of the spring(s), although the streams are influenced by surface and groundwater fluctuations (Wharton et al. 1982).

Blackwater streams, the most common stream type in northern Florida, carry primarily dissolved organic matters and derive relatively few nutrients from their watersheds, which are dominated by flatwoods with sandy substrates. The water is clear but stained brown by the presence of humic substances derived from swamp drainages. Water levels rise and fall rapidly in response to local rainfall, and the high banks confine the water except during major floods. These streams have narrower floodplains than alluvial rivers, and groundwater seepage provides much of the discharge (Florida Natural Areas Inventory 1990).

Alluvial (whitewater or silt-laden) streams originate in high uplands composed of soils with high clay content; surface runoff typically results in turbid water containing a high content of suspended particulates (i.e., clays, silts, sands, detritus). These streams usually flood once or twice each year during winter or early spring, and occasionally in summer. Flooding flushes biological waste materials from the floodplains, and it renourishes them with detritus, minerals, and nutrients from the surrounding uplands and upstream communities. Flooding also increases the habitat available to aquatic animals normally confined to the main channel, and it disperses seeds and small animals. Alluvial streams are characterized by extensive floodplains and natural levees (Florida Natural Areas Inventory 1990).

The Escambia, Choctawhatchee, and Apalachicola rivers are the major alluvial rivers in the Panhandle and have most of their stream catchments north of Florida in clastic-dominated sediments, although many of their tributaries are either blackwater or spring-run streams (Wolfe et al. 1988). The Apalachicola River has the largest drainage basin, the greatest average discharge, and the greatest total length of any Florida river, but only a small fraction of the total system is contained within the Panhandle (Nordlie 1990). The Apalachicola River floods in January–April, and its floodplain ranges from 2.3–6.5 km wide (Leitman et al. 1982) and remains inundated for 1–5 months (Foose 1983). Its floodplain forest covers 450 km^2 and contains >40 tree species (Wharton et al. 1977). Relief, hydrology, and species diversity determine the 5 forest types described in the Apalachicola River floodplain (Leitman et al. 1982).

The greatest difference between annual rainfall and potential evapotranspiration occurs in the Panhandle, where stream discharge is greatest during winter and spring as far east as the Suwannee River drainage (Kenner 1975). The Suwannee River in northern peninsular Florida ranks second in drainage basin size, average discharge, and total length. Other major rivers in northwestern peninsular Florida that are covered by this conservation plan are the Econfina, Fenholloway, Steinhatchee, Withlacoochee (North), Alapaha, and Santa Fe rivers. Additional large Panhandle rivers are Holmes Creek and the Perdido, Blackwater, Yellow, Shoal, Chipola, St. Marks, and Aucilla rivers.

The types and extent of wetland and stream habitats vary greatly across Northwest Florida. Isolated wetlands include many shallow ponds, depression marshes, dome swamps, and baygalls, especially in flatwoods habitat. Four major environmental variables contribute to the overall structural and functional diversity of wetlands: hydrologic regime (depth and duration of flooded conditions), fire frequency, organic matter accumulation, and water source (Kirkman 1995). The greater topographic relief in the Panhandle results in more seepage wetlands, such as shrub bogs, herb bogs, and baygalls. Many bog streams in the Panhandle are formed by a steady lateral seepage from adjacent sand ridges. These substrates are constantly wet and support fire-resistant bog-type vegetation. In contrast, bog-fed streams flow only intermittently when significant runoff from rainfall exceeds the water storage capacity of expansive bog-filled depressions perched on layers of clay (Wharton et al. 1982). Examples of bog-fed streams that flood rapidly and drain gradually are the New and Sopchoppy rivers, which drain huge shrub bogs and baygalls in the Bradwell Bay Wilderness Area in Apalachicola National Forest.

Floodplain wetlands (i.e., bottomland forest, floodplain forest, floodplain swamp, strand swamp, and swale habitats) are flat and have alluvial sand or peat substrates that are periodically flooded, but not permanently inundated, by rivers. Bottomland forest habitat is rarely inundated (not annually) and consists of a low-lying, closed-canopy forest of tall, straight trees—water oak (*Quercus nigra*), live oak, red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), and spruce pine (*P. glabra*)—with either a dense, shrubby understory and little ground cover, or an open understory and a ground cover of ferns, herbs, and grasses (Florida Natural Areas Inventory 1990). Floodplain forest habitat is a hardwood forest—overcup oak (*Quercus lyrata*), water hickory (*Carya aquatica*), diamond-leaf oak (*Q. laurifolia*), and swamp chestnut oak (*Q. michauxii*)—that occurs on drier soils at slight elevations (i.e., on levees, ridges, terraces) within the floodplain, primarily along alluvial rivers in the Panhandle. The forest is flooded during most years for 2–50% of the growing season, and the understory is open and park like or dense and nearly impenetrable (Florida Natural Areas Inventory 1990). Floodplain forests along spring-run streams flood less frequently because most of the water comes from the limestone aquifer. Floodplain swamp habitat occurs on soils that are flooded for most of the year, and the vegetation consists of buttressed hydrophytic trees—bald cypress (*Taxodium distichum*) and tupelo (*Nyssa* spp.)—and generally a very sparse understory and ground cover (Florida Natural Areas Inventory 1990). Strand swamp is a shallow, forested, usually elongated depression or channel dominated by bald cypress. The peat and sand soils occur over limestone and are inundated for 200–300 days annually (Florida Natural Areas Inventory 1990).

Basin wetlands (i.e., basin marsh, basin swamp, depression marsh, and dome swamp habitats) occur in shallow, closed (except during high water) basins. They have peat or sand substrates that are usually inundated and contain wetland woody or herbaceous vegetation (Florida Natural Areas Inventory 1990). Succession is arrested in marshes by fluctuating water levels and relatively frequent fires (Kushlan 1990). Basin marsh habitat is an herbaceous or shrubby wetland situated in a relatively large, irregular-shaped basin (formerly a shallow lake) with a hydroperiod around 200 days per year and a fire frequency of 1–10 years (Florida Natural Areas Inventory 1990). Basin swamp habitat is a forest of hydrophytic trees—blackgum (*Nyssa biflora*), pond cypress (*Taxodium ascendens*), bays (*Persea* spp.), slash pine—and shrubs situated in a relatively large, irregular-shaped basin not associated with rivers. It has a hydroperiod of 200–300 days annually and a fire frequency of 5–150 years (Florida Natural Areas Inventory 1990). Depression marsh habitat consists of herbaceous vegetation in a shallow, usually rounded depression in sand substrate. It has a variable hydroperiod (drying most years and sometimes inundated <50 days) and burns frequently (Florida Natural Areas Inventory 1990). Dome swamp is a shallow, forested (predominately pond cypress, blackgum, and slash pine), usually circular depression that generally presents a domed profile because smaller trees grow in the shallower water along the periphery. It typically occurs in sandy flatwoods and in karst areas and has a hydroperiod of 200–300 days annually, with water remaining the longest in the center of the dome. Fires occur relatively frequently around the margins of domes and occasionally burn through the interior (Florida Natural Areas Inventory 1990).

Most basin wetlands in Florida are supplied by shallow, acid ground water, although deep ground water slowly seeping from limestone outcrops supplies the water in hydric hammocks in the Big Bend region (Ewel 1990). Dome swamps, the most common basin wetlands, are scattered throughout a poorly drained matrix of flatwoods and pine plantations in northern Florida. Water levels in dome swamps normally fluctuate dramatically annually or biannually. Gum ponds in the Panhandle have longer hydroperiods, less extreme water fluctuations, and lower fire frequency than cypress ponds (Clewell 1971, Wharton et al. 1977). Marshes in flatwoods and upland habitats that are perched above the water table depend on local rainfall, sporadic surface runoff, and seepage from adjacent uplands for water (Kushlan 1990).

Seepage wetlands, which include baygall and seepage slope habitats, occur on sloped or flat sands or peat with high moisture levels that are maintained by downslope seepage. Baygall habitat is a dense, tall forest of generally straight-boled, evergreen hardwoods—sweetbay, swamp bay, and loblolly bay (*Gordonia lasianthus*)—with a mostly open understory of shrubs and ferns. The floor is carpeted by sphagnum moss (*Sphagnum* spp.) and is often interlaced with convoluted tree roots. Baygalls occur in peat-filled seepage depressions at the base of sandy slopes, at the edge of floodplains, or in flat areas with high lowland water tables. The peat substrate remains saturated by seepage flow. Bog habitats occur where acidic peat soils have accumulated in a depression. The deep peat is kept saturated or inundated by capillary action, not seepage flow. These bogs are actually very small basin wetlands that occur around the shores of lakes and in dome swamps, ponds, and sinkholes (Florida Natural Areas Inventory 1990). The peat-filled depressions occupied by baygall swamps and shrub bogs are fed by ground water draining from higher terrain, and they are drained by small blackwater streams (Wharton et al. 1977).

Seepage slope habitat is a shrub thicket (i.e., shrub bog) or boggy meadow (i.e., herb bog) on, or at the base of, a slope where downslope seepage maintains saturated soil conditions. Although the soils are rarely inundated, small pools and rivulets are common in seepage slope habitats, especially during rainy weather. Typical plants are slash/longleaf/pond (*Pinus serotina*) pine, swamp titi (*Cyrilla racemiflora)*, black titi (*Cliftonia monophylla*), fetterbush (*Lyonia lucida*), myrtle-leaved holly (*Ilex myrtifolia*), and insectivorous plants. Herb bogs are maintained by fires every 5 years or less, whereas shrub bogs burn only every 20–50 years (Florida Natural Areas Inventory 1990). In the Panhandle, herb bogs, or savannas, often separate shrub bogs from pine flatwoods; these herb bogs are maintained by fire every 3–8 years (Wharton et al. 1977, Coultas et al. 1979, Folkerts 1982). Shrub and herb bogs occur on slopes where the terrain drops below the water table, which is usually perched atop an impermeable layer of clay or rock, allowing the water that has percolated down through the sand to trickle or seep out. The slopes may be very gradual or as steep as 10–20^{o} (Means 1990). On very gradual slopes along stream valleys in flatwoods, such as in the Gulf Coastal Lowlands, the perched water table is intersected and seeps out laterally over a fairly broad zone, and these extensive herb bogs are sometimes called savannas (Clewell 1971, Wolfe et al. 1988). Clewell (1971) recognized 4 variations of savannas that consistently have higher soil moisture levels than pine flatwoods, and the wetter *Pleea* phase may have increased in acreage after logging of wet flatwoods in the Apalachicola National Forest caused water tables to rise (Wolfe et al. 1988).

Most seepage slope habitats occur in deep sands in northeastern Florida and in the Panhandle westerly of the Ochlockonee River, especially below Cody Scarp, a marine terrace about 30 m above sea level that extends almost straight eastward across the Panhandle to a point in the upper Suwannee River valley before turning southward (Puri and Vernon 1964, Brooks 1981). Seepage slope habitats in the Panhandle are relatively few in number and are typically small in scope; many have been converted to pine plantations (Clewell 1986). Taxa restricted to seepage slope bogs are potentially vulnerable to changes in the abundance and quality of those habitats.

Slope forest habitat occurs on steep slopes that are only present in the more rolling topography of northern peninsular and Panhandle Florida, particularly westerly of the Ochlockonee River. Slope forest habitat is a well-developed, closed-canopy forest of upland hardwoods on a steep slope, often with a seepage stream at the base (Florida Natural Areas Inventory 1990). Slope forests occur along both gully-eroded and steephead ravines in the Panhandle and, less commonly, in northern peninsular Florida. Gully-eroded ravines are formed by the scouring action of rainwater surface runoff, and water flows in the stream channels only during and shortly after a rainfall (Wolfe et al. 1988). Steephead ravines occur in deep sands south of Cody Scarp where ground water leaks out on a sloping surface and undercuts the sand, creating a steep-walled amphitheater that erodes headward from the valley bottom. The bottom of steephead valleys may be 30 m below the surrounding flat or gently rolling sandhill habitat, and the sloping sides may be as steep as 45^o and are covered in upland hardwood vegetation (Means 1975, Wolfe et al. 1988, Means 1991). The spring-fed steephead streams have a constant flow of high-quality water of relatively constant temperature (~21^o C; Means 1975, 1991). Many of the best-developed steepheads are along the first-order branches of Sweetwater and Beaverdam creeks north of Bristol and on Eglin Air Force Base (AFB) (Means 1985*a*).

Wet prairie habitat is a treeless plain with a sparse to dense ground cover of wiregrass, toothache grass (*Ctenium aromaticum*), maidencane (*Panicum hemitomon*), spikerush (*Eleocharis* spp.), and beakrush (*Rhynchospora* spp.). Wet prairies are seasonally inundated or saturated for 50–100 days annually and burn every 2–4 years (Florida Natural Areas Inventory 1990). Hydric hammock is a well-developed hardwood—diamond-leaf oak, red maple, swamp bay (*Persea palustris*), sweetbay, water oak, and southern magnolia (*Magnolia grandiflora*)—and cabbage palm forest with a variable understory often dominated by palms and ferns. It occurs on low, wet sites where limestone may be near the surface. The saturated soil is briefly inundated following heavy rains. Extensive areas of hydric hammock may occur inland of coastal communities such as tidal marsh and maritime hammock, and hydric hammock often grades into floodplain, strand, or basin swamps; upland mixed or hardwood forest; slope forest; baygall; or wet flatwoods (Florida Natural Areas Inventory 1990).

Water-filled caves are considered in this section because of their importance to the Georgia blind salamander (*Haideotriton wallacei*). The Marianna Lowlands physiographic region in the Panhandle is the southwestern end of a large karst plain known as the Dougherty Plain in Georgia (Wolfe et al. 1988). Tertiary limestones, which lie close to the surface, have been eroded by dissolution to form vertical and horizontal shafts. When groundwater levels fell in response to dropping sea levels, the uppermost horizontal shafts became air-filled passageways suitable for colonization by bats and other wildlife.

Wildlife Communities

Five turtle, 7 anuran, 8 salamander, and 27 fish taxa with biological scores ≥17 occur in streams and wetlands in the portion of Northwest Florida covered by this section of the conservation plan. Three of the anuran (gopher frog, ornate chorus frog, and barking treefrog) and 3 of the salamander (striped newt, tiger salamander, and mole salamander) taxa mostly utilize ephemeral wetlands in xeric uplands, so they were discussed in the interior scrub and sandhill section, although the ranges of 4 of these species do not extend very far south in peninsular Florida Although the oak toad uses a variety of upland habitats, it was also included in some conservation tasks in the scrub/sandhill section. Three reptile, 5 amphibian, and 1 fish taxa have action scores high enough (≥35) to warrant inclusion in the Northwest Florida wetland section of the plan, and 4 reptile, 3 amphibian, and 13 fish taxa are included because of their declining population trends (Appendix A).

Distributions of fishes, amphibians, and turtles in the Panhandle probably reflect interglacial rises in sea level that embayed the Escambia/Blackwater/Yellow River basin, the Choctawhatchee/Alaqua basin, and the Apalachicola River basin (Neill 1957). These larger streams represent the eastern range limit for many fish taxa characteristic of the Mississippi River Valley and Gulf Coastal Plain, and the western range limit for fish taxa from the Atlantic Coastal Plain (Bailey et al. 1954). The Apalachicola River was embayed farther inland than any other river, and it formed a broad saltwater channel during long periods of the Pleistocene that presented an important barrier to the east-west distribution of many species (Neill 1957). Many of the endemic and "northern" aquatic and semiaquatic wildlife taxa in the Apalachicola, Choctawhatchee, and Escambia rivers are present because populations were probably able to survive during Pleistocene sea level rises by retreating to the headwaters in higher country, whereas rivers with headwaters in lowlands (e.g., Ochlockonee and Suwannee) were inundated by seawater and lack endemics (Neill 1957).

The Apalachicola and Ochlockonee rivers have quite different fish faunas, despite poorly defined drainage divides in the coastal plain that would seem to offer easy passage between drainages for many lowland species (Gilbert 1987). These 2 drainages have been physiographically independent for a long time, although Telogia Creek, a tributary of the Ochlockonee River, appears to have been captured from the Apalachicola River (Gilbert 1987). Three fish species are endemic to the Apalachicola River in Florida: grayfin redhorse (*Maxostoma* sp. nov. cf. *poecilurum*), bluestripe shiner (*Cyprinella callitaenia*), and shoal bass (*Micropterus* sp. nov. cf. *coosae*) (Yerger 1977, Gilbert 1992). Cody Scarp forms an important boundary for fishes in the Ochlockonee (Swift et al. 1977), Apalachicola, and Suwannee (Gilbert 1987) drainages. In rolling hills north of the scarp, the streams have more mature, meandering channels. In flat lands south of the scarp, the streams are sluggish and swampy, except where they flow over the scarp with its steeper gradient (Gilbert 1987).

Assemblages of fish and aquatic amphibians and reptiles in streams vary depending on the source and quality of the water (e.g., dissolved oxygen, pH, hardness, salinity, turbidity, temperature), which may change seasonally.

Other factors affecting riverine aquatic wildlife are water depth, substratum (e.g., sand, muck), litter (e.g., leaf beds, woody debris), aquatic vegetation, eutrophication, predators, water velocity, and flood events. The diverse turtle and fish communities in alluvial Panhandle rivers apparently result from the diverse vegetation provided by riverbanks and floodplain swamps; rooted and aquatic vegetation are limited in the stream channel due to water depth, current velocity, high-water turbidity and color, and fluctuating water levels (Wolfe et al. 1988). Some aquatic species are restricted to 1 or a few river drainages, particularly in the Panhandle. The highest number of rare and imperiled fish taxa (14) is found in the Escambia River basin, followed by the Apalachicola River basin and the Choctawhatchee River-Holmes Creek basin (Hoehn 1998). Many species with high biological scores have restricted distributions in Florida and are found in streams or their floodplains in Northwest Florida: one-toed amphiuma (*Amphiuma pholeter*), four-toed salamander (*Hemidactylium scutatum*), Apalachicola dusky salamander (*Desmognathus apalachicolae*), Florida bog frog (*Rana okaloosae*), Escambia map turtle, Barbour's map turtle (*Graptemys barbouri*), Suwannee cooter (*Pseudemys concinna suwanniensis*), alligator snapping turtle (*Macroclemys temminckii*), crystal darter (*Crystallaria asprella*), Okaloosa darter (*Etheostoma okaloosae*), harlequin darter (*E. histrio*), goldstripe darter (*E. parvipinne*), Florida sand darter (*E. bifascia*), blackmouth shiner (*Notropis melanostomus*), flagfin shiner (*N. signipinnis*), bandfin shiner (*N. zonistius*), blacktip shiner (*Lythrurus atrapiculus*), cypress minnow (*Hybognathus hayi*), grayfin redhorse, river redhorse (*M. carinatum*), spotted sucker (*Minytrema melanops*), shoal bass, alligator gar (*Atractosteus spatula*), and southern brook lamprey (*Ichthyomyzon gagei*) (Appendix A). Omnivorous turtles, such as the Suwannee cooter, are especially abundant in spring-run streams because light penetration in the clear water allows higher plant productivity than in alluvial and blackwater streams (Wolfe et al. 1988).

At least 16 species of amphibians and reptiles primarily live in streams and associated seepage habitats, and may be eliminated by impoundments placed on sections of streams (P. E. Moler, pers. commun.). The seal salamander is known in Florida from only 5 adjacent, small, seepage streams in ravines on the south side of Canoe Creek in Escambia County (Means 1992*d*). The Florida bog frog was first discovered in 1982 (Moler 1985*a*) and is known from 35 sites in Walton, Okaloosa, and Santa Rosa counties, mostly on Eglin AFB (Moler 1992*c*, Printiss and Hipes 1999). It lives in shallow, boggy seepage areas along small seepage streams that are tributaries of the Yellow and East Bay rivers. The bog frog prefers early successional shrub bog communities with beds of sphagnum moss and an overstory that is usually dominated by black titi and sometimes by Atlantic white cedar (*Chamaecyparis thyoides*), although disturbed sites, such as utility right-of-way crossings, may be used in more mature hardwood forest (Moler 1992*c*).

The Panhandle has the third highest freshwater turtle species diversity in the world, with the Escambia River basin containing the most species (13) in Florida (Iverson and Etchberger 1989). The Alabama map turtle (*Graptemys pulchra*) has been split into 3 species, with the Escambia map turtle being the species found in Florida in the Escambia and Yellow rivers (Lovich and McCoy 1992). The Barbour's map turtle was thought to be endemic to the Apalachicola River system, but specimens have recently been found in the Ochlockonee and Choctawhatchee rivers (Enge et al. 1996*a,* Wallace 2000). The alligator snapping turtle ranges as far south as the Suwannee River basin.

Ephemeral ponds and wetlands are important resources for amphibian taxa that depend upon these sites for successful completion of their life cycles. Temporary ponds are beneficial to many amphibian species because of the flush of primary productivity following flooding, and the elimination of fish and other large predators when they dry up (Wilbur 1980). Nine anuran and 4 salamander species in Florida breed only in small, isolated wetlands, and 13 other anuran and 6 salamander species use these wetlands in addition to other habitats (Moler and Franz 1987). Other herpetofaunal taxa are dependent upon permanent marsh and swamp habitats. Marsh and swamp habitats may be extensive in some areas, but taxa using those sites may be dependent upon specific microhabitat features that are relatively rare or limited in distribution. Movements of animals from wetlands to uplands may be important because they often represent the only significant flow of nutrients and energy in that direction.

Seepage wetlands may have a diverse amphibian community and provide foraging sites for herpetofauna of surrounding habitat types. Burrowing crayfish (*Cambarus* and *Procambarus*) are common and are important in redistributing leached nutrients to the surface (Edmiston and Tuck 1987). Crayfish burrows provide moist refugia, particularly when wetlands dry up, for amphibian species like the two-toed amphiuma (*Amphiuma means*), eastern lesser siren (*Siren i. intermedia*), southern dusky salamander (*Desmognathus auriculatus*), mud salamander (*Pseudotriton montanus* subsp.), flatwoods salamander (*Ambystoma cingulatum*), and gopher frog (Carr 1940, Mount 1975, Wolfe et al. 1988, Ashton 1992). The shady, moist conditions of baygalls and shrub bogs, and the sunny, moist conditions of herb bogs provide favorable conditions for amphibian species tolerant of acid pHs ranging from 3.5 to 5.0 (Means 1990). Despite their small areal coverage, seepage slope habitats are important because they often contain species with relatively high biological or action scores: Pine Barrens treefrog (*Hyla andersonii*), southern coal skink (*Eumeces anthracinus pluvialis*), and Gulf crayfish snake (*Regina rigida sinicola*) (Enge 2002). The disjunct population of Pine Barrens treefrogs in Florida and Alabama are known from about 150 localities in Santa Rosa, Okaloosa, Walton, and Holmes counties in Florida (Means 1992*c*).

The closed nature and annual wet-dry cycle of basin wetlands tend to eliminate or reduce fish populations, which makes them important breeding sites for many amphibian species. The distribution and abundance of breeding amphibians within a particular wetland are dependent upon wetland size and location, relationship to terrestrial and aquatic systems, flooding regime, water quality, substrate, and vegetation structure. Seasonal fluctuations in water levels, dissolved oxygen, and temperature require adaptations by resident aquatic herpetofauna. Amphiumas, sirens, dwarf sirens, and other aquatic herpetofauna are able to survive in wet mud and crayfish burrows during periods of drought and other adverse conditions in basin wetlands (Freeman 1958). The ephemeral and often isolated nature of depression and basin marshes make them important breeding sites for highly ranked species of upland amphibians: striped newt, tiger salamander, mole salamander, barking treefrog, ornate chorus frog, gopher frog, and oak toad (LaClaire and Franz 1990; Dodd 1992*a*; LaClaire 1992; Dodd 1993, 1994; Palis and Jensen 1995; Enge and Wood 1999–2000, 2001; Greenberg *in press*; Means and Means *in press*). Most of these upland amphibian taxa were discussed in the interior scrub and sandhill section. Dome swamps are important amphibian breeding sites and reservoirs for semiaquatic and aquatic species, especially in flatwoods habitats (Harris and Vickers 1984, Enge and Marion 1986). Cypress dome and gum swamps are used for breeding by the flatwoods salamander and gopher frog, and in extreme northern peninsular Florida, they provide suitable habitat for the carpenter frog (*Rana virgatipes*) and many-lined salamander (*Stereochilus marginatus*), which occur east of the area under consideration in this section.

About 15 caves and sinkholes in the Marianna Lowlands–Dougherty Plain, primarily in Jackson County, contain populations of the aquatic Georgia blind salamander, which is confined to subterranean waters. Mostly immature individuals are found in caves, whereas older ones are mostly found in solution tunnels in deeper water (Means 1992*b*).

Steepheads provide relatively constant year-round environmental conditions for wildlife because of the presence of spring-fed streams and the protection of steep valley walls (Means 1975, 1977). Many amphibians live on the bottom of the ravines where leaf litter accumulates in the seeps or streams. The constant water flow in steephead streams allows salamanders, particularly ones with longer larval periods, to live year-round all the way to the headwaters, whereas they must live further downstream in gully-eroded ravines. During droughts, some aquatic species are able to survive in gully-eroded ravines by seeking moist refugia or traveling further downstream (Wolfe et al. 1988). The entire range of the federally endangered Okaloosa darter (*Etheostoma okaloosae*) is contained in steephead streams flowing into western Choctawhatchee Bay from Eglin AFB (Wolfe et al. 1988). Steephead ravines provide habitat for several herpetofaunal taxa with relatively high biological or action scores: Florida bog frog, four-toed salamander, Apalachicola dusky salamander, "least" siren (*Siren* cf. *intermedia*), and one-toed amphiuma (Enge 1998*a*, 2002).

The topographic gradient of slope forest habitat encompasses a broad soil moisture gradient that is potentially suitable for a wide spectrum of herpetofauna. Near the top of the slope, conditions are relatively dry and favor herpetofauna characteristic of xeric hammock, sandhill, or upland pine forest. Further down the slope, the vegetation is more characteristic of upland hardwood or upland mixed forests, and the increased soil moisture favors a more diverse amphibian community. Near the bottom of the slope, the bottomland forest habitat is suitable for aquatic and semiaquatic amphibians, particularly along streams or spring seeps. Slope forests in Panhandle ravines contain many rare, endemic, or relict plants and animals (Wolfe et al. 1988). The closed canopy and steep sidewalls of ravines create a higher and more continuous humidity during the summer, particularly on the cooler north-facing slopes, which get less direct sunfall (Wolfe et al. 1988). These conditions are suitable for relict species from more northern climes, particularly amphibian species. Four-toed salamanders have been found at 11 localities in 3 Panhandle counties (Means 1992*a*, Printiss and Hipes 1999; P. E. Moler, pers. commun.; Enge, pers. obs.), including slope forest habitat along seepage streams in Gadsden County (Enge et al. 1996*b*, Enge 1998*b*).

The soil of hydric hammocks is generally saturated but not inundated, which restricts the occurrence of some aquatic herpetofauna, although the one-toed amphiuma may be present (Enge and Wood 1998, 1999–2000). Floodplain wetlands with flowing water will be more depauperate in herpetofauna than wetlands with still water. Floodplain swamps tend to have a more diverse turtle community than other floodplain wetlands. The relative abundance of herpetofaunal species is often low in any particular forested floodplain wetland, but species richness across the varied spectrum that comprises any particular habitat type is relatively high.

Threats to Habitat or Wildlife

The Florida Panhandle was identified by Chaplin et al. (2000) as 1 of the 6 most significant biodiversity hot spots in the United States due to 53 imperiled species—mostly plants, freshwater fishes and mussels, amphibians, and reptiles—occurring in a 3,100 mi^2 area. The primary threats to species in the Panhandle were identified as dams, development pressures, altered fire regimes, and intensive silviculture.

Over 50% of all pre-settlement wetlands in Florida have been lost (Ewel 1988), and herbaceous (marsh) wetlands in Florida declined by 51% from 1936 to 1995, primarily due to extensive wetland drainage in central and southern Florida (Kautz 1998). The loss and degradation of wetlands in Florida affect both resident aquatic and semiaquatic species, and upland amphibian species in adjacent habitats that need wetlands for breeding sites (Delis et al. 1996). Populations of terrestrial species that rely on the productive wetlands to supply some of their food are also affected. Extinctions of local populations of upland amphibians probably occur naturally during extended droughts, but habitat loss and fragmentation have exacerbated the situation, making extinctions more likely by isolating and reducing the number of suitable amphibian breeding sites (Dodd 1992*a*). Droughts have occurred in regular cycles of varying duration and intensity throughout the last several hundred years in the southeastern United States (Stahle et al. 1985, 1988; Blasing et al. 1988).

Florida is apparently not experiencing the dramatic declines in amphibian populations seen in some parts of the world (e.g., Blaustein and Wake 1990, Wyman 1990, Blaustein et al. 1994, Phillips 1994), and most declines in amphibian populations can be explained by habitat loss or degradation. However, some dusky salamander (*Desmognathus* spp.) populations may be inexplicably declining in Florida (Dodd 1998, Means 2002). Although North Florida's human population is growing, the growth rate is much slower than in South Florida. North Florida contained two-thirds of the population in 1900 but now only contains 20% (Winsberg 1992).

Small, isolated wetlands are extremely valuable for conserving regional biodiversity, but they will continue being lost because of inadequate protection from development by current or proposed legislation (Semlitsch and Bodie 1998). The majority of wetlands, at least in the southeastern Atlantic Coastal Plain, are <2 ha in size, and loss of these small, isolated wetlands would cause a direct reduction in connectivity among remaining species populations (Semlitsch and Bodie 1998). The use of ephemeral wetlands as water retention basins stabilizes water levels and may result in emergent vegetation replacing the grasses and sedges required by many amphibian species for egg attachment (LaClaire 1992). Soil erosion and sedimentation often alter the plant community structure and water quality of temporary ponds, which affects the ponds' suitability for breeding amphibians (LaClaire 1992). Soil disturbances from ORV use and bulldozing roads or firelines may alter water patterns and drainage, affecting the use of ponds by certain breeding amphibians (LaClaire 1992, Palis 1992). Increasing or decreasing the natural hydroperiod of a wetland may drastically restructure the amphibian community. Amphibian species requiring ephemeral wetlands are detrimentally affected when temporary ponds are blasted to create fishing ponds and when fish are introduced into formerly fishless ponds. Ditching cypress ponds detrimentally affects some amphibian species (Harris and Vickers 1984).

Feral hogs are potentially a threat to amphibian communities that utilize ephemeral wetlands, forested wetlands, and seepage areas (Singer et al. 1984, Printiss and Hipes 1999). Hogs prey upon a variety of vertebrates (Wood and Barrett 1979), and their rooting activities destroy vegetation and debris that serve as cover for adult and larval amphibians, and as egg attachment sites. The presence of hogs and cattle near streams and wetlands may degrade water quality through defecation, runoff from feedlots, and siltation resulting from substrate disturbance or overgrazing.

Highway mortality of wildlife can be especially high along roads traversing or adjacent to wetland habitats (Hellman and Telford 1956, Bernardino and Dalrymple 1992, Palis 1994, Smith 1996, Ashley and Robinson 1996, O'Neil and O'Neil 1997, Means 1999, Smith et al. *in press*). Roads may hinder movements of amphibians to breeding ponds and can effectively isolate populations of some amphibian and other wildlife species (Mader 1984, Langton 1989, Laan and Verboom 1990, Fahrig et al. 1995, Joly and Morand 1997, deMaynadier and Hunter 1998, Gibbs 1998, Vos and Chardon 1998).

Fire-sensitive evergreen shrubs are usually prevalent downhill in wetter sites near stream bottoms, but they will invade upslope into herb bogs in the absence of fire. Historically, periodic fires sweeping downslope from adjacent longleaf pine forests maintained open, grassy herb bogs along the seepage zone. Hardwood encroachment into herb bogs leads to increased evapotranspiration and lower groundwater levels, eliminating seepage pools that provide larval habitat for species like the Pine Barrens treefrog (Means and Moler 1979). Remaining seepage bog habitats are typically small (0.4–2.0 ha) (Folkerts 1982). By 1982, humans had destroyed or severely altered an estimated 97% of the pre-Columbian acreage of Gulf Coast bogs through drainage for pine monoculture or agriculture, fire suppression, alteration of fire periodicity and seasonality, grazing, pond construction, and urbanization (Folkerts 1982). Since then, the rate of destruction has increased significantly, and additional damage has been done by off-road vehicle traffic and increased herbicide use in forests and along highways (Folkerts 1991). Inadvertent damming of seepage streams by roads sometimes floods bogs upstream of roads. Bogs downslope of roads are sometimes silted in by runoff of clay, silt, and sand from the roads, especially after heavy rains and recent road-grading activities (Enge 2002).

In 1995, 25% of all commercial forests in Florida consisted of lowland forests, which comprised 52% of all hardwood forests (Kautz 1998). Almost all swamps were logged between the late 1800s and 1950, especially for old-growth bald cypress (Ewel 1990). Besides the logging of large cypress and hardwood trees, an average of 15 large snags per kilometer were removed annually from the rivers that drained the swamps. These practices greatly reduced the average size and age of trees, and the extent, hydroperiod, and quality of aquatic habitat (Sedell et al. 1981 in Harris and Mulholland 1983). Most of the floodplain forests along the Apalachicola River are privately owned and have been repeatedly logged since 1870, but the rapid second growth and the inaccessibility of much of the floodplain have protected it (Clewell 1977). Clear cutting floodplain forests is detrimental to salamander populations and some frog populations, but small clearcuts may benefit frog, turtle, lizard, and snake species that prefer open habitats and higher temperatures and insolation (Phelps and Lancia 1995). Clear cutting of southern Appalachian forests may have killed 75–80% of the salamanders due to the physiological stress associated with desiccation (Petranka et al. 1993).

In 1970, 69% of all commercial pine forests were natural stands, whereas in 1995, 62% of commercial pine forests were plantations (Kautz 1998). Pine plantations often provide less favorable conditions for herpetofauna than naturally regenerated pine forests because of the scarcity of refugia, sparse ground cover, and dense canopy. Larval surveys of amphibians using temporary ponds in the Panhandle indicated that conversion of the surrounding longleaf pine savannas to sand pine plantations apparently detrimentally affected populations of 5 species, including the striped newt, mole salamander, and gopher frog (Means and Means *in press*). Clear cutting and site preparation of pine flatwoods in North Florida negatively impacted overall amphibian numbers, apparently by reducing reproductive success of some species in the ditched dome swamps (Enge and Marion 1986).

Ditching and draining of dome swamps and pine flatwoods have dropped surface water tables, which may be disastrous to aquatic or fossorial amphibians, such as the one-toed amphiuma and flatwoods salamander (Ashton 1992). Ditched dome swamps have shorter hydroperiods and fewer aquatic and semiaquatic amphibians than unditched ones (Harris and Vickers 1984). Many flatwoods marshes have been drained by a general lowering of the water table or by ditching, and most are used for cattle grazing (Kushlan 1990). Ditches and trenched firelines have the greatest impact on wetlands in sloping terrain that are fed by lateral seepage of surficial ground water, such as seepage bogs. Even shallow firelines plowed parallel to the margin of seepage wetlands to protect them unnecessarily from fire can at least partially dry them up because the ground water is converted to surface water, and thus experiences higher rates of evaporation (Bacchus 1995). Groundwater levels of wetlands may be significantly lowered by large surface excavations—stormwater ponds, borrow pits, manmade lakes, and mining—in upland areas up to 1.6 km away (Bacchus 1995).

Winter burning of pinewoods has been suspected of being detrimental to winter-breeding amphibians, but this has not been proven (U.S. Fish and Wildlife Service 1980). Amphibian populations dependent upon basin wetlands in pinewoods may be impacted by clear cutting in and adjacent to wetlands, chemical herbicide spraying, road construction, drainage pattern alterations, and mechanical site preparation (Christman 1992*c*). In North Florida, drainage and protection from fire have increased the dominance of black gum, bays, and slash pine in dome swamps. Drainage of dome swamps leads to poor cypress regeneration, increased shrub and hardwood density, and increased fire potential (Marois and Ewel 1983). However, cypress-dominated swamps with normal hydroperiods are probably dependent upon fire to prevent them from developing into mixed hardwood swamps, whereas very frequent fires may form willow thickets or marshes (Ewel and Mitsch 1978, Ewel 1995). Access roads may alter drainage patterns, and even firelines may affect dome swamps. Dome swamps are sometimes used for wastewater disposal because their plant communities can tolerate long hydroperiods and low dissolved oxygen levels (Ewel and Odum 1984). North Florida dome swamps used for wastewater treatment contained high adult populations of a few anuran species that were attracted to the arthropods feeding on the mats of decaying organic matter, but the ponds acted as anuran population sinks from the surrounding flatwoods because of high larval mortality in the anaerobic water (Jetter and Harris 1976).

Changes in the water regime of forested wetlands, especially changes that affect trees during the growing season, will change the forest type within 1 rotation of the forest (Riekirk 1983). The water regime of forested wetlands, and thereby the structure and functioning of wetlands, is permanently affected by the construction of elevated roadbeds, levees, and drainage structures (Wharton et al. 1977). Forested wetlands are natural flood storage areas that are beneficial to fish and wildlife, and they serve as sediment and nutrient traps. Water management districts and the FDEP often purchase forested wetlands for use as flood and stormwater storage areas, but their use for large-scale filtering of point-source effluents requires an FDEP permit to avoid pollution of state waters. Because the soils of forested wetlands have little load-bearing capacity, logging and other mechanical disturbances will cause them to disintegrate and may result in sediment pollution and alteration of water circulation. Clear cutting generally reduces forest evapotranspiration, which may create a "wetter" class of wetlands (Riekirk 1983).

Phosphate mining in pine flatwoods, dome swamps, and baygalls in North Florida permanently alters the habitat and pollutes streams. Blackwater streams have limited buffering capacity and are seriously impacted by agricultural or industrial pollution. Mined areas were restored as uplands in the past, but recent efforts strive to restore the former ecosystems, although successful swamp restoration has yet to be demonstrated. The construction of gas pipeline trenches through, or adjacent to, wetlands could threaten local populations of amphibians by intercepting migrations to or from breeding ponds, altering water tables, or affecting water quality through pollution by contaminants or sedimentation from erosion (Enge et al. 1996*b*).

Pollution of the shallow ground water that feeds seepage streams may result from use of fertilizers or biocides on surrounding uplands, or dumping of hazardous wastes in the drainage basin (Florida Natural Areas Inventory 1990). Spring-run streams can be threatened by excessive water withdrawal from the aquifer through deep wells, and improper application or disposal of agricultural, residential, and industrial pollutants may leach into the ground water and eventually infiltrate the deep aquifer (Florida Natural Areas Inventory 1990). Pollution of the aquifer may be irrevocable and could impact the unique troglobitic species in caves and underground streams. Agricultural pollution of ground water and changes in the groundwater level resulting from stream impoundment or groundwater use, such as center-pivot irrigation, pose the greatest threats to Georgia blind salamanders (Means 1992*b*). Groundwater withdrawal by municipal and industrial wells has the greatest potential to drain wetlands, but agricultural and golf course irrigation and residential wells may also drain wetlands (Bacchus 1995). Overall, agricultural practices are responsible for water-quality impairment of 72% of the nation's stream miles assessed by the Environmental Protection Agency (1994), and agriculture is the leading cause of nutrient enrichment in rivers and lakes (Puckett 1995). Biologists consider the major threat to imperiled freshwater amphibians, fishes, and invertebrates in the eastern United States to be agricultural nonpoint pollution, which leads to streambed sedimentation, suspended sediment loading, and nutrient loading (Richter et al. 1997).

Deforestation of slope forests can result in sedimentation of seepage streams through increased surface erosion, and increased insolation can create an unfavorable microclimate for certain amphibian species and result in excessive vegetative growth along the streams (Wolfe et al. 1988). Seepage communities along steep-walled stream valleys have been eliminated by impounding of the streams to form lakes in residential developments, which restricts the upstream movement of aquatic reptiles, amphibians, and fishes, and destroys important stream habitat for species like the bog frog (Moler 1992*c*).

Rivers and streams in the Florida Panhandle and Alabama may represent an endangered ecosystem, and they support a diverse aquatic fauna that includes many listed turtles, fishes, snails, and mussels (Lydeard and Mayden 1995). Many of the larger springs and spring runs are extensively used for recreation, particularly fishing, canoeing, SCUBA diving, snorkeling, tubing, and swimming. Excessive recreational use, such as occurred in Ichetucknee Springs prior to daily quotas and use restrictions by the FDEP (Dutoit 1979), may destroy rooted aquatic vegetation and constantly disturb basking snakes and turtles. Consumptive use by industries and municipalities along the Escambia River, Econfina Creek, and Georgia–Alabama portions of Panhandle rivers are reducing the flow of rivers in Florida, and discussions are occurring concerning the diversion of North Florida water to farther south in the peninsula (T. Hoehn, pers. commun.). Fortunately, Florida lacks many of the industries that are responsible for severe water pollution, and the streams affected by polluting industries—phosphate mining, pulp and paper mills—lack distinctive faunas (Gilbert 1992). Agricultural or other chemical pollution of certain Panhandle streams, such as the Escambia River, would seriously threaten endemic populations, especially during low water levels. The Escambia River drainage comprises the entire Florida range of at least 6 high-ranking fish (plus 2 possibly introduced taxa listed by FCREPA and 1 unranked native taxon), 1 turtle, and 1 amphibian species. Most rare and imperiled fish species that inhabit small streams cannot survive in highly turbid or sediment-laden water, which are characterized by depressed dissolved oxygen levels and increased temperatures (Hoehn 1998). In the Apalachicola River, predation by introduced flathead catfish (*Pylodictis olivaris*) has led to drastic population decreases of the spotted bullhead, snail bullhead, and redbreast sunfish (*Lepomis auritus*) (D. G. Bass, pers. commun.), resulting in their recent inclusion as high-ranking or declining species (Appendix A).

The major threat to alluvial rivers is damming, such as has occurred on the Apalachicola and Ochlockonee rivers, which disrupts the natural flood cycle, traps upstream nutrients, alters water temperatures, destroys upstream floodplains through long-term flooding, and prevents movements of aquatic animals. The only dam on the Apalachicola River, the Jim Woodruff Lock and Dam, was constructed in the mid-1950s for navigation and hydropower (Gilbert 1992). This dam truncated the migration routes of several anadromous fish species—Alabama shad (*Alosa alabamae*), striped bass (*Morone saxatilis*), and Gulf sturgeon (*Oxyrinchus desotoi*)—that were once abundant. Plans are being discussed for dams on the Choctawhatchee and Pea rivers (T. Hoehn, pers. commun.). Seasonal flooding is important to stream biota, and unnecessary flood control should be prevented (Felley 1992). Erosional siltation or dredging and filling may destroy important rocky areas in streams that support clam and mussel populations eaten by map turtles (*Graptemys* spp.) and provide spawning areas for various fish taxa. Siltation is the leading cause of water-quality impairment across the United States and affects 45% of the river miles assessed by the Environmental Protection Agency (1994).

Removal of deadwood impeding navigation in river channels decreases above-water basking and sleeping sites, and underwater feeding sites and refugia for various turtle species, especially map turtles (Lindeman 1999). Woody snags have even been removed from sections of small rivers such as the Blackwater in order to allow the passage of canoes (Bass and Cox 1985), and a commercial operator is dredging up submerged ancient cypress logs from the Blackwater River. The ecosystem of typical small streams in the Gulf Coastal Plain revolves around debris and large woody snags (Felley 1992), and this habitat is also highly productive in large rivers like the Apalachicola (Ager et al. 1985). In southeastern blackwater streams, the biomass of invertebrates on a surface area basis on submerged snags is 20–50 times higher than on sandy bottoms and 5–10 times higher than on muddy bottoms, and overall invertebrate production is 3–4 times higher on snags than in benthic habitats (Benke et al. 1984, 1985; Thorp et al. 1985).

Conservation and Management Strategies

Little is known about the abundance, life histories, or distributions of some taxa that use wetland and stream habitats. Natural and anthropogenic changes to the quality and abundance of such habitats can cause unknown changes to resident wildlife populations. Research is needed to understand the potential effects of habitat changes on these cryptic or secretive taxa, and to develop effective conservation and management strategies.

Most amphibians, especially salamanders, in forested wetlands would be least impacted by conducting small clearcuts that retain nearby habitats that could serve as population reservoirs for recolonization, and by managing forests on long rotation times (Enge and Marion 1986). In clearcut areas of southern Appalachian and New York, salamander populations have recovery times of about 60 years (Pough et al. 1987, Petranka et al. 1993). Coarse woody debris should be left on the site after harvesting (Enge and Marion 1986, Phelps and Lancia 1995), and leaf litter, an important component of amphibian habitat, should be minimally disturbed (Pough et al. 1987, DeGraaf and Rudis 1990, Petranka et al. 1993). Log removal by ground machinery, such as skidders, should be restricted to small areas, and helicopters should be used whenever practical (Buhlmann et al. 1988, Clawson et al. 1997). Some amphibians may temporarily benefit from logging because of reduced evapotranspiration raising groundwater levels, and skidder tire ruts may provide fish-free breeding sites (Phelps and Lancia 1995).

The basins of temporary ponds in upland habitats need to have their natural hydrology maintained. Regulatory agencies interested in protecting pond-breeding amphibians need to consider the isolation, size, and length and timing of the hydroperiod of the wetland (Semlitsch and Bodie 1998, Snodgrass et al. 2000, Paton and Crouch 2002). Some amphibians use pond basins even while they are dry (Dodd and Charest 1988, Dodd 1992*a*), so mechanical disturbances from logging equipment, bulldozers, or ORVs need to be prevented year-round. Excessive woody vegetation that has invaded ephemeral wetlands is most easily removed by fire, which also reduces the buildup of organic matter and increases the availability of nutrients (LaClaire 1992). Breeding ponds of the flatwoods salamander, gopher frog, and striped newt should be protected from disturbance (e.g., ditching, drainage, logging, pesticides), and a buffer zone should be established in the surrounding habitat to protect terrestrial refugia from ORV use, clear cutting, and intensive mechanical site preparation (Ashton 1992, Christman and Means 1992, Dodd and LaClaire 1995, Palis and Jensen 1995). When establishing terrestrial buffer zones to conserve wetland-breeding amphibians, both a distance and a directional component need to be considered, preferably derived from long-term studies of migratory patterns (Dodd and Cade 1998).

Decimation of wildlife populations by highways traversing wetlands or intercepting movement routes between wetland and upland habitats can be reduced by the construction of roadside barriers in conjunction with underpasses, tunnels, or culverts (Foster and Humphrey 1995, Finch 2000, Smith et al. *in press*). Safe passages across highways can be especially effective in minimizing mortality of amphibians moving to and from breeding ponds (Langton 1989, Tyning 1989).

Many wetlands in Florida are maintained by periodic, low-intensity fires that arrest or redirect ecological succession, favor certain species, mineralize nutrients, and consume biomass (Lugo 1995). Prescribed burning of wetlands is a valuable management tool, but fires may be devastating to wildlife, vegetation, and organic soils in wetlands where water levels have been lowered through anthropogenic activities below those associated with natural drought cycles (Bacchus 1995). Fire in herbaceous depression wetlands during drought periods apparently promotes vegetative species richness (Kirkman 1995). Land managers must consider both weather conditions and groundwater levels of wetlands before initiating burns (Bacchus 1995).

Reclamation of freshwater marshes, such as after phosphate mining, is most successfully accomplished by adding topsoil instead of allowing natural revegetation of the overburden. Topsoiling encourages the establishment of sufficient late successional plant species to compete with aggressive weedy species, such as cattails (*Typha latifolia*) (Erwin and Best 1985). A mitigation technique could require replacing a destroyed temporary pond with a new one, but the creation of ephemeral wetlands is not as simple as permanent wetlands and requires an understanding of regional hydrology. A typical monitoring program of created or restored marshes should include (1) a post-construction, pre-planting survey of project contours and elevations; (2) ground and surface water elevation data collection; (3) water quality data collection; (4) biological monitoring (including macroinvertebrates); (5) evaluation of vegetation species diversity, percent cover, and frequency; and (6) wildlife utilization (Erwin 1990). Critical information gaps and research needs regarding marsh restoration are (1) site selection and design, (2) project construction techniques, (3) comparative studies of the biological communities and processes in created and natural systems, and (4) the role of uplands and transitional habitats (Erwin 1990). Experimental construction of ponds provided partial mitigation for the loss of natural amphibian breeding habitat, but the amphibian community differed from that of natural wetlands because of the longer hydroperiod (created ponds were permanent), limited availability of colonists of some species, and differences between created and natural ponds in size, substrates, vegetation, and surrounding terrestrial habitats (Pechmann et al. 2001).

In 1999, the flatwoods salamander was listed as a federally threatened species, making its management and conservation needs an important consideration for resource agencies. Conversion of longleaf pine flatwoods with a wiregrass understory to bedded slash pine plantations has apparently caused declines in flatwoods salamander populations (Means et al. 1996). To preserve or restore flatwoods salamander habitat, prescribed burning of pine flatwoods should ideally be conducted between May and September when post-larval life stages are underground. Lightning-season fires are more effective at controlling the shrubby vegetation that encroaches into breeding ponds and the herbaceous wetland/upland ecotones (Palis and Jensen 1995, Palis 1996). Important components of breeding ponds are apparently sufficient hydroperiod (≈90 days) and graminaceous ground cover (Sekerak et al. 1996). According to the U.S. Fish and Wildlife Service (1999), the following forestry practices surrounding a known flatwoods salamander breeding pond would be unlikely to violate Section 9 of the Endangered Species Act, if conducted during dry periods and at a minimum of 10-year intervals: (1) selective timber harvesting in pine flatwoods habitat within 164 m of the pond if a basal area of 4.2–4.7 m^2 is maintained, and (2) clear cutting up to 25% of the area within 164–450 m of the pond if 75% of the area is maintained in pine flatwoods habitat at the recommended basal area. In addition, skid trails should be minimized and located parallel to the wetland edge, and all log landings should be located >450 m from the pond. Soil disturbance should be kept to a minimum, and intensive mechanical site preparation should not be used. A flatwoods salamander breeding site cannot be destroyed or altered by discharging or dumping fill material, toxic chemicals, silt, or other pollutants; draining; ditching; tilling; bedding; clear cutting; diverting or altering surface- or groundwater flow; and operating vehicles within the wetland (U.S. Fish and Wildlife Service 1999).

The small, scattered hillside seepage bogs utilized by larval Pine Barrens treefrogs need to be preserved through specific habitat management practices, such as fire, on state and federal lands like Blackwater River State Forest and Eglin AFB. An estimated 72% of available Pine Barrens treefrog habitat is in conservation areas (Cox et al. 1994). Fire also may be needed to maintain the early successional communities along small streams utilized by the Florida bog frog on Eglin AFB. The military status of Eglin AFB protects it from commercial or residential development and preserves local populations of target taxa, but silt-laden runoff from range roads and other disturbed areas degrades some wetland habitat (Printiss and Hipes 1999). Research is needed to determine the adult habitat use of the Pine Barrens treefrog and the population ecology of the bog frog.

Population monitoring of high-ranking taxa should be conducted at selected sites in Florida, especially on public lands that are being impacted by various land-use practices. Suitable monitoring techniques do not exist for some amphibian taxa (especially salamanders). The effects of rainfall on amphibian movements and reproductive output, which may experience large annual fluctuations (Pechmann et al. 1989, 1991; Dodd 1992*a*), complicate monitoring of amphibian populations. The U.S. Geological Survey has developed the Amphibian Research and Monitoring Initiative (AMRI) to conduct long-term monitoring to determine trends in amphibian populations on federal lands and to conduct research into causes of amphibian declines and malformations. Several northeastern states and Canadian provinces have implemented anuran call-count surveys, and a similar survey has recently been developed for the Southeast, including Florida. However, the utility of such call-count surveys in the Southeast is debatable because of the diversity of anuran species, year-round breeding seasons, annual variability in breeding activity, ephemeral nature of many wetlands, and widespread distribution of suitable anuran breeding habitat. Dip-netting surveys of ponds are typically used to detect larvae of the flatwoods salamander and striped newt.

Nature reserves designed to protect amphibians should include enough wetland breeding sites to support sufficiently large populations to preserve genetic variation, which for amphibians such as the barking treefrog would be at least 2 ponds (Murphy et al. 1993). Additional ponds may be required to ensure long-term viability of populations from demographic stochasticity, natural catastrophes, and unpredictable environmental changes (Shaffer 1987). For amphibians that breed in ephemeral or semi-permanent ponds, an assortment of ponds, including possibly manmade ones, may be necessary to ensure that suitable breeding sites are present during all but the most severe droughts. Amphibians that have been extirpated from an area due to drought conditions or anthropogenic causes can be restored most easily by introducing larvae into suitable wetlands. Although a few amphibian translocations have apparently been successful (at least in the short term), the effectiveness of translocation as a management tool is unclear and may have negative consequences (Seigel and Dodd 2002, Trenham and Marsh 2002). Ponds that have become unsuitable for breeding amphibians because of the presence of fish could be poisoned with rotenone, although this is toxic to larval amphibians and possibly even turtles (Fontenot et al. 1994, McCoid and Bettoli 1996). Managers should preserve sufficient terrestrial habitat between ponds to permit dispersal of amphibians among ponds (Marsh and Trenham 2001). If habitat corridors are not possible, managers may create gene flow by transferring individuals among subpopulations (Murphy et al. 1993). To develop effective conservation and management plans for amphibians, we need to know the amount and quality of habitat surrounding breeding ponds that are necessary to support genetically viable populations. The effects of pond isolation on amphibian colonization and extinction appear to be important primarily when the terrestrial habitats surrounding ponds are highly altered (Marsh and Trenham 2001).

The fragile communities of caves must be protected from disturbances by spelunkers and divers, and from alterations around cave entrances that might upset detrital inputs and air circulation patterns (Florida Natural Areas Inventory 1990). Most biologically important caves in the Panhandle are privately owned, so attempts should be made to purchase caves critical to rare invertebrates, amphibians, and bats (Franz et al. 1994). Potential sources of groundwater pollution in the vicinity of these caves should be assessed and remedied.

Commercial forestry operations that convert bottomland hardwood forests to pine plantations often employ herbiciding of remaining vegetation and new sprouts, or site preparation—slash chopping and burning, windrowing, and bedding—before planting pine trees (Riekirk 1983). Bedding and windrowing often alter water runoff and retention patterns by creating debris and dirt dams. Elevated access roads in wetlands form levees that significantly alter water regimes and forest growth and composition (Wharton et al. 1977), unless sufficient culverts or bridges are present (Riekirk 1983). Conversion of hardwoods to pines is probably detrimental to many amphibian populations and results in a reduction in the number of den trees and cavities available for wildlife. Logging in forested wetlands should be diameter-limit, selection, shelterwood, or patchcut harvests of up to 60-year recurrence, and logging should be limited to the drier seasons to minimize impacts on the integrity and load-bearing capacity of the soils (Riekirk 1983). Natural regeneration after clear cutting will maintain tree species diversity through sprouting and reseeding.

The 1982 Stormwater Rule requires retention of runoff from the first inch of rainfall, but forest lands are exempted when conforming to silvicultural Best Management Practices (BMPs) for nonpoint source pollution control. Silvicultural BMPs were implemented in Florida on a voluntary basis in 1979, protect open waters by (1) soil conservation measures; (2) filtering through forest vegetation of Special Management Zones (SMZs); (3) providing adequate crossings of streams, ditches, and wetlands within the SMZ; and (4) avoiding the use of fertilizers or pesticides within the SMZ (Riekirk 1983). The use of buffer zones 11 to 90 m wide between a forest clearcut and a stream is apparently effective in preventing water quality problems (Florida Department of Environmental Protection 1997). The FDEP and the 5 water management districts develop and enforce water management rules, and local governments can aid in water pollution control by judicious land zoning in wetlands, restricting population density in sensitive areas, and confining commercial and industrial development to less problematic areas. Land-use policies along streams should forbid encroachment onto floodplains and promote reduction of soil erosion (Felley 1992).

In October 1995, the Environmental Resource Permitting (ERP) went into effect, which combined the jurisdiction of the FDEP and water management districts in issuing permits for dredging and filling of wetlands. The ERP stipulates that the impacts on fish and wildlife and their habitats have to be considered for wetlands >0.2 ha in size and for smaller isolated wetlands that are (1) used by threatened or endangered species, (2) part of a larger wetland system at seasonal high water level, or (3) of more than minimal value to fish and wildlife (Hart and Newman 1995). Existing wetland regulations that establish buffer zones around wetlands in upland habitats are probably inadequate to preserve many amphibian and reptile populations. In a study of freshwater turtles using a Carolina bay in South Carolina, current federal wetland regulations protected 11.9 ha of habitat from potential development but failed to protect any of the nests and hibernation burrows in the surrounding uplands. In order to preserve 90% of the turtle nests and hibernacula, the buffer zone would need to be increased 73 m (protecting an additional 23.0 ha) beyond the federally delineated boundary (Burke and Gibbons 1995). For pond-breeding salamanders, a terrestrial buffer zone extending 164 m from a wetland's edge would encompass 95% of the population; all post-breeding adults and newly metamorphosed juveniles were found outside the current federally delineated wetland boundary (Semlitsch 1998).

Federal legislation that protects water resources includes the Clean Water, the Fish and Wildlife Coordination, and the National Wildlife and Scenic Rivers acts (summarized by LaClaire 1997). Watersheds are often considered appropriate organizational units for inventory, planning, and management purposes (Young et al. 1983, Noss and Harris 1986, Karr 1990, Williams and Williams 1992) because many ecological processes operate within watersheds (Odum 1971). The ideal strategy to preserve rare aquatic species is to protect and restore the biological integrity of entire watersheds through land acquisition, but this is usually not feasible either logistically (because of ownership complexity) or financially. The Surface Water Improvement and Management (SWIM) Act was passed by the Florida Legislature because of concerns for the ecological, aesthetic, recreational, and economic values of the state's surface water bodies, which are frequently degraded by alteration or disruption of the ecological systems that are important in purifying surface water and providing wildlife habitat. According to Sheldon (1988), the best strategy for river protection is to focus conservation efforts on the largest tributaries that retain their original faunas in as many regions as possible. Various criteria or protocols have been recommended to help prioritize conservation and management efforts of aquatic ecosystems (e.g., Carroll and Meffe 1994, Angermeier and

Winston 1997). Areas identified for protection would include those with (1) relatively high numbers of endemic, rare, and declining species or keystone species; (2) small, fragmented habitats; and (3) systems exhibiting low resilience to perturbations (Carroll and Meffe 1994).

Dredging of the Apalachicola River and disposal of the dredged material along the banks by the U.S. Corps of Engineers added ca. 40 km of sand habitat from 1947 through 1980, and sport fish populations were reduced by 75% in these sandy areas (Hoehn 2001). These prominent dredged spoil mounds on the lower Apalachicola River provide nesting habitat for the alligator snapping turtle, but these spoil mounds are becoming completely wooded and unsuitable (Ewert and Jackson 1994). Turtles would benefit by maintaining some open areas for nesting on these spoil mounds, but a better management practice would be to maintain open space on existing beaches and to increase the height of lower beaches by periodically depositing 1–2 m of sand in early fall or winter, which would benefit nesting alligator snapping turtles, Barbour's map turtles, and Gulf Coast spiny softshells (*Apalone spinifera aspera*) (Ewert and Jackson 1994). The navigation channel on the Apalachicola River is the third most expensive in the country to maintain, and releases of sufficient water from Lake Seminole to float barges during periods of low water sometimes strand and kill thousands of fish in backwaters (Hoehn 2001). Removal of deadwood probably has a detrimental impact on map turtle populations, so snagging operators could anchor deadwood near bridge supports to provide deepwater, fast-current substrates that would not impede boat traffic (Lindeman 1999). A major management aim that would benefit plants and animals in streams is retention and enhancement of snag habitat (Felley 1992). Possession limits of 1 or 2 individuals and prohibition of commercialization restrict harvesting of the Barbour's map turtle, Escambia map turtle, Suwannee cooter, and alligator snapping turtle for food or pets.

Concerns over worldwide declining amphibian populations have resulted in the creation of the Declining Amphibian Populations Task Force (DAPTF), which consists of a network of >3,000 scientists and conservationists in more than 90 countries. The federal government maintains 2 national, interactive amphibian databases on the Internet: the North American Amphibian Monitoring Program (NAAMP) and the North American Reporting Center for Amphibian Malformations (NARCAM). In 1998, Partners in Amphibian and Reptile Conservation (PARC) was formed to conserve amphibians, reptiles, and their habitats as integral parts of our ecosystem and culture through proactive public–private partnerships. It is modeled after the Partners in Flight program for birds and is intended to stimulate communication and cooperation among government agencies, the forest products industry, the pet trade, private property owners, universities, foundations, and the public (Gibbons and Stangel 1999). Because ≈90% of all forest lands in the Southeast is in private ownership (Bullock and Wall 1995), incentives must be developed to encourage and reward landowners for conserving species and habitat on their lands instead of converting forest lands in response to the pressures of population growth and competing economic interests.

Conservation Tasks

Most amphibians and fishes and some turtles have high potential fecundity but relatively low actual fecundity because of low survivorship of eggs and young to adulthood. A component of the biological score is the reproductive potential of a taxon for population recovery, which includes the average number of offspring produced annually by an adult female (Millsap et al. 1990). This component of the biological score tends to bias against amphibians, fishes, and some turtles having scores as high as birds and mammals, so we reduced the biological score necessary for taxon-specific tasks from 24 to 21 in this section. Thus, 3 turtle, 7 amphibian, and 14 fish taxa have high enough biological scores to warrant taxon-specific tasks, but 2 of the amphibian taxa—striped newt and gopher frog—were already covered in the sandhill/scrub section. Two turtle, 8 amphibian and 10 fish taxa have high enough biological scores to include in multi-taxa tasks, but 5 of the amphibian taxa were already covered in the sandhill/scrub section. Four reptile, 4 amphibian, and 1 fish taxa have high enough action scores for conservation tasks, and an additional 5 reptile, 3 amphibian, and 17 fish taxa have declining population trends in Florida (Appendix A). All fish taxa need to be re-scored, which will probably result in more taxa being added to the list, especially since some taxa are missing. The 2 subspecies of river cooter (*Pseudemys concinna*) have recently been given species status, as have the 2 subspecies of Florida cooter (*P. floridana*) (Seidel 1994, 1995), but this new taxonomy has been challenged (Jackson 1995). Before more conservation tasks are identified for these turtle taxa, particularly the Suwannee cooter, their systematic status should be resolved.

Fifty-two conservation tasks have been identified for taxa inhibiting streams and wetlands of Northwest Florida. Sixteen tasks are related to research, 14 are distributional surveys, and 8 are population-monitoring studies. Four tasks are specific to the bog frog, and 3 tasks target the flatwoods salamander or bluenose shiner (*Pteronotropis welaka*). A museum record of a diamondback water snake (*Nerodia rhombifer*) exists from the Escambia River drainage, so we included a distributional survey task for this taxon, although it was not included in the list of taxa occurring in Florida. Distributional survey and population monitoring tasks were identified for the seal salamander when its biological score was 24 (Millsap et al. 1990), but these tasks have since been deleted because its score is now only 13 due to taxonomic revision, although the range of the disjunct population in Florida remains extremely small (Moler 1992*d*).

Forestry and other land management practices may lead to degradation of both permanent and ephemeral habitats critical to the successful completion of amphibian or fish life cycles. Needed conservation tasks relating to habitat quality include assessing aquifer water quality for the Georgia blind salamander and the effects of forestry practices, ORV vehicle use, roads, and feral hogs on herpetofauna inhabiting sensitive wetlands and streams on public lands, especially in the Panhandle. Management plans and recommendations could then be developed to reduce the impacts of pollution on amphibians and fishes, and to protect sites or habitats with rare amphibians and fishes and critical areas of riverine habitat that support high densities of turtles. Certain target taxa—Pine Barrens treefrog, bog frog, flatwoods salamander, Alabama shad—with restricted geographic ranges or habitat requirements need proper management practices implemented in order to maintain or increase population sizes. Additional information is needed on the ecology of the Florida bog frog, shoal bass, and bluenose shiner.

COASTAL COMMUNITIES

Because of the large number of target taxa that have been identified using coastal communities (Gore et al. 1991), discussion of the coastal section of this plan is divided into 3 subsections: coastal upland habitats (i.e., beach/dune, coastal grassland, coastal strand, maritime hammock), tidal marsh habitat, and tidal swamp habitat. Coastal conservation tasks, however, have not been separated into these 3 subsections (Appendix B).

A total of 1,200 km of Florida's 1,900 km of coastline (excluding the Keys) is sandy and occurs primarily in the form of offshore barrier islands (Johnson and Barbour 1990). Florida has 80 barrier islands that encompass 189,356 ha (Bellis 1995). Over the last several decades, most of Florida's coast has been eroding landward at an average of 0.3–0.6 m/yr (Doyle et al. 1984, Pilkey et al. 1984). Tidal marshes cover ≈200,000 ha (1.4%) of Florida and are most extensive (1) along the Gulf Coast from Hernando to Wakulla County; (2) behind the barrier islands along the Atlantic Coast in Nassau, Duval, and St. Johns counties; and (3) between freshwater marshes and tidal swamps at the southern tip of Florida (Kautz et al. 1993). Tidal swamps cover ≈220,000 ha (1.6%) of Florida, mostly along the Gulf Coast from Charlotte Harbor southward through the Florida Keys (Kautz et al. 1993). Tidal marshes and swamps occur most extensively in areas that lack sandy sediment and have low or zero wave energy because of extremely gradual offshore slopes. Florida has the second longest intertidal zone of any state (Durako et al. 1985), and 75% of the population resides in coastal areas.

Many high-ranking wildlife taxa are included in the coastal section, although they are not restricted to coastal habitats and could have been included under other sections. For example, colonial-nesting wading birds are included here, although most of the species also forage and nest in inland freshwater wetlands. The various subspecies of mink are included here because they typically inhabit tidal marshes in Florida, although the Everglades mink may be more abundant in swamp forests in the Everglades and Big Cypress Swamp (Humphrey and Zin 1982). Most subspecies of mole skinks and crowned snakes were covered in the sandhill–scrub or rocklands section, but the Cedar Key mole skink (*Eumeces egregius insularis*) and coastal dunes crowned snake (*Tantilla relicta pamlica*) live in coastal habitats and are included here. This is the only section of the conservation plan that is predominated by avian taxa, including numerous shorebirds, wading birds, rails, seaside sparrows, marsh wrens, and declining neotropical migrant songbirds. The Lower Keys marsh rabbit, Key rice rat (*Oryzomys argentatus*), and Lower Keys cotton rat (*Sigmodon hispidus exsputus*) could have been considered in the South Florida rocklands section, but they typically inhabit coastal habitats instead of rockland habitats.

Coastal Upland Habitat Descriptions

The beaches along Florida's coast can be divided into 5 regions based on the vegetation that occurs within the beach and foredune, transitional, and stable dune zones: (1) northeast coast as far south as Cape Canaveral; (2) southeast coast from Cape Canaveral southward to Cape Florida; (3) south coast beaches of Cape Sable, the Ten Thousand Islands, and the Florida Keys; (4) southwestern coast from Cape Romano to Anclote Keys north of Tampa; and (5) the Panhandle westerly of the Ochlockonee River mouth (Johnson and Barbour 1990).

Beach dune habitat occurs along shorelines with high-energy waves that deposit sand to form an open beach. Onshore winds blow the sand inland, creating foredunes that are sparsely to densely vegetated with pioneer species, especially sea oats (*Uniola paniculata*). Other typical species are beach cordgrass (*Spartina* spp.), sand spur (*Cenchrus* spp.), dune panic grass (*Panicum amarulum*), railroad vine (*Ipomoea pes-caprae*), beach morning glory (*I. stolonifera*), seashore paspalum (*Paspalum distichum*), and beach elder (*Iva imbricata*). The stems of vegetation are important in trapping wind-blown sand, and their roots are important in stabilizing the shifting sands into nearly static beach dunes. As a cape or barrier island grows seaward by depositing successive new beaches, a ridge and swale topography develops (Johnson and Barbour 1990).

Coastal grassland and overwash plain are low, flat or gently undulating areas behind the foredunes that are often found on broader barrier islands, capes, and spits, especially along the Gulf Coast. Coastal grassland is characterized by barren sand or a sparse to dense ground cover of grasses—muhly grass, bluestem grasses (*Andropogon* spp. and *Schizachyrium* spp.), sea oats, beach cordgrass, dune panic grass—and herbaceous species: beach morning glory, camphor weed (*Heterotheca subaxillaris*), beach elder, and sea purslane (*Sesuvium* spp.). Shrub cover, such as wax myrtle and groundsel (*Baccharis* spp.), is typically sparse. Major storms that overwash the dunes (especially low, dissected dunes) inundate coastal grasslands with salt water, sand, and debris. This new sand will be colonized by pioneer vegetation and eventually, in the absence of major storms, may grow shrubs and trees and succeed to coastal strand, maritime hammock, or flatwoods (Florida Natural Areas Inventory 1990, Johnson and Barbour 1990).

Coastal strands and maritime hammocks are mostly found along shorelines subject to high-energy waves. Coastal strand habitat is a dense thicket of salt-tolerant shrubs—saw palmetto, sand live oak, cabbage palm, myrtle oak, yaupon (*Ilex vomitoria*), sea grape, Spanish bayonet (*Yucca aloifolia*)—and prickly pear (*Opuntia* spp.) that occurs on stabilized, wind-deposited dunes. The shrubs are usually located in the ecotonal community between the beach dunes and maritime hammock or scrub, where they are often dwarfed and pruned by salt spray-laden winds. The substrate of deep, wind-deposited dune sand is stable as long as the vegetation remains undisturbed. Maritime influences, storms, and occasional fires usually inhibit succession to forest (Florida Natural Areas Inventory 1990, Johnson and Barbour 1990). Coastal strand habitat covered only 5,377 ha in 1989 (Kautz et al. 1993).

Maritime hammock habitat is a band of hardwood forest with a dense, wind-pruned canopy that occurs on old coastal dunes. The stream-lined profile prevents hurricanes from uprooting trees, and the dense canopy minimizes temperature fluctuations. The tree growth that leads to the formation of maritime hammocks often begins in interdunal swales where moisture is higher. The buildup of humus retains moisture, but the soils are generally well drained because of deep underlying sands. The mesic conditions inhibit fire, which typically occurs every 25–100 years (Florida Natural Areas Inventory 1990). Typical tree species are live oak, cabbage palm, redbay, American holly (*Ilex opaca*), southern magnolia, and southern red cedar (*Juniperus silicicola*), with more tropical species (e.g., sea grape and gumbo-limbo) occurring in South Florida. Maritime hammock is the most common coastal upland habitat along the southwestern Gulf Coast (Johnson and Muller 1992*c*).

Coastal Upland Wildlife Communities

Wildlife species that use beach dunes must tolerate or avoid xeric conditions, loose substrates, wind, salt spray, intense sunlight, and storms. Seven extant rodent taxa with biological scores ≥17 have been identified in this section of the conservation plan as utilizing beaches, dunes, coastal grasslands, coastal strands, or maritime hammocks (Appendix A). Forty-four coastal avian taxa (i.e., shorebirds, raptors, and neotropical migrants) and 7 reptilian taxa (i.e., 4 nesting sea turtles, 2 mole skinks, and the coastal dunes crowned snake) with biological scores ≥17 mostly use upland habitats while in coastal areas. Neotropical migrant birds often use maritime hammocks, and 35 additional neotropical migrants with biological scores <17 are included in the coastal section because they are suspected of having declining population trends (Appendix A). The diamondback rattlesnake and gopher tortoise are discussed in other sections, but they may attain high population densities in coastal uplands (Cox et al. 1987; Breininger et al. 1994). The island glass lizard (*Ophisaurus compressus*) also occurs in some coastal upland areas, but it has too low of a biological score to warrant taxon-specific tasks.

Florida beaches provide potential nesting habitat for 5 species of sea turtle. Approximately 90% of loggerhead (*Caretta caretta*) nesting in the southeastern United States occurs on Florida beaches, making this nesting aggregation the second largest for the species in the world. Annual numbers of loggerhead nests reported in 1979–1992 ranged from 10,121 to 68,614, with 91.5% of nesting occurring from Brevard County southward to Broward County (Meylan et al. 1995). Some of the densest nesting concentrations in the world are found at Jupiter Island–Juno Beach, Hutchinson Island, and southern Brevard County (Dodd 1992*b*). Adult loggerheads inhabit all Florida coastal waters, and the Indian River Lagoon system is important to subadults (Ehrhart and Witherington 1992). Most green turtle (*Chelonia mydas*) nesting in Florida (≈375 adult females) occurs from Volusia to Dade County, especially at Melbourne Beach, Hutchinson Island, and Jupiter Island (Ehrhart and Witherington 1992). The Florida nesting population is of regional significance, with numbers of reported nests ranging from 62 to 2,509 in 1979–1992 (Meylan et al. 1995). Important foraging areas for immature green turtles are Homosassa Bay to the Cedar Keys, the Indian River Lagoon system, and Florida Bay (Ehrhart and Witherington 1992). The only regular nesting by the leatherback turtle *(Dermochelys coriacea*) in the continental United States occurs in Florida (Meylan et al. 1995), and the Atlantic ridley (*Lepidochelys kempii*) occasionally nests here (Johnson et al. 1999). Nesting activity by the Atlantic hawksbill (*Eretmochelys i. imbricata*) is rare in Florida (Lund 1985, Conley and Hoffman 1987), and this species has consequently not been ranked (Millsap et al. 1990).

There were once 7 subspecies of the oldfield mouse (*Peromyscus polionotus*) in Florida that were adapted to living in dunes and had very pale pelage. The pallid beach mouse occurred just north of the Ponce de Leon Inlet in Volusia County (Howell 1939), but it is now extinct (Ehrhart 1978, Humphrey and Barbour 1981). All the beach mouse subspecies have biological scores ≥28 (Appendix A). Four subspecies of beach mouse, all of which are isolated by inlets, live on Panhandle barrier islands between the St. Joseph Peninsula in Gulf County and Perdido Key in Escambia County. The most endangered subspecies, the Perdido Key beach mouse (*P. p. trissyllepsis*), occurs in only 10.4 km of habitat at Gulf Islands National Seashore, Florida, and 2.6 km of habitat on the western tip of Perdido Key at Gulf State Park, Alabama (Humphrey and Barbour 1981, Oli et al. 2001). Remaining suitable beach-dune habitat for the Choctawhatchee beach mouse (*P. p. allophrys*) extends for 6.5 km at Topsail Hill and 9.4 km on Shell Island (Humphrey and Barbour 1981). The St. Andrews beach mouse (*P. p. peninsularis*) is now restricted to 8 km of dunes in St. Joseph Peninsula State Park and on Crooked Island East on Tyndall AFB. The 2 extant Atlantic Coast subspecies are the southeastern (*P. p. niveiventris*) and Anastasia Island (*P. p. phasma*) beach mice. The southeastern subspecies historically ranged from south of Ponce de Leon inlet in Volusia County to Hollywood Beach in Broward County, but real estate development and beach erosion have probably extirpated it south of Ft. Pierce in St. Lucie County and have severely fragmented its range northward to Cape Canaveral (Stout 1992). Local populations at Canaveral National Seashore and Cape Canaveral Air Force Station appear to be secure, and populations still remain northward to coastal dunes opposite Mosquito Lagoon (Humphrey et al. 1987, Stout 1992). Public lands that contain populations are Sebastian Inlet State Recreation Area (SRA) in Indian River County and Turtle Trail Public Beach Access and Ft. Pierce Inlet SRA in St. Lucie County (Stout 1992). The endangered Anastasia Island beach mouse still occurs on Anastasia Island in Anastasia SRA and Fort Matanzas National Monument, but it has apparently been eliminated from its historic range in the northern half of St. Johns County (Humphrey et al. 1987, Humphrey 1992*a*). Relocation of 55 adults in October 1992 successfully reestablished a population in Guana River State Park by (Frank 1996). This taxon is quite distinctive genetically from the other subspecies (Sealander et al. 1971, Ramsey 1973), and its geographic variation should be reevaluated (Humphrey and Frank 1992).

There were once 2 Florida subspecies of cotton mice adapted to coastal habitats, mostly maritime hammock and adjacent dune grassland (Bangs 1898, Howell 1939). Howell (1939) described the Chadwick Beach cotton mouse from near Englewood, Charlotte County, but it is apparently now extinct (Repenning and Humphrey 1986, Millsap and Holder 1989, Humphrey 1992*c*). The Anastasia Island cotton mouse may have been only a disjunct, undifferentiated population of the mainland race (*Peromyscus g. gossypinus*; Humphrey 1992*b*). This taxon has probably been extirpated for decades, although small, fragmented patches of suitable habitat remain (Humphrey et al. 1988, Humphrey 1992*b*).

The Lower Keys cotton rat (*Sigmodon hispidus exsputus*) occurs in the Big Pine group of the Lower Keys where it inhabits beach dunes, coastal strands, rockland hammocks, and the edges of tidal swamps (Layne 1974). The systematics of the various subspecies of cotton rats needs to be resolved. Bangs (1898) described the red-rumped or Cape Sable cotton rat (*S. h. spadicipygus*) from Key Largo, and the cotton rats from Plantation Key to Key Vaca have not been critically examined (Lazell 1989).

Coastal woodlands provide important food and shelter to neotropical migrant songbirds, which are defined as species breeding in Nearctic North America and wintering in Neotropical Central and South America, South Florida, and the West Indies (Hagan and Johnston 1992). The 3 broad groups of neotropical migrants in Florida include those that (1) both breed in Florida and winter in Florida or further south, (2) breed in more northern latitudes and winter in Florida, and (3) migrate through Florida. Florida is uniquely situated at the southern breeding range of some species, the northern range of tropical-breeding species, the northern range of many wintering species, and on the migration route of many species. About 45 nonbreeding songbird species commonly migrate through Florida, and another 34 species breed in Florida but winter in the tropics (Robertson and Woolfenden 1992).

In Florida, migrant songbirds may either cross the Gulf of Mexico to Mexico (trans-Gulf migrants) or travel down the peninsula through the island chains to South America or Mexico (peninsular migrants) (Stevenson 1957, Buskirk 1980). Most spring migrants probably cross the Gulf, but many fall migrants move around the Gulf (circum-Gulf migrants) (Able 1972). Trans-Gulf migrants that exhibit declining population trends include the prothonotary warbler (*Protonotaria citrea*), wood thrush (*Hylocichla mustelina*), and eastern kingbird (*Tyrannus tyrannus*). The northern prairie warbler (*Dendroica d. discolor*) and indigo bunting (*Passerina cyanea*) are declining species that have both trans-Gulf and peninsular migration patterns (Stevenson 1957; J. Cox, pers. commun.).

Songbirds generally migrate at night either individually or in flocks of $\geq$20 birds at elevations of $\approx$600–1,500 m (Gauthreaux 1972, Kerlinger 1995). Along 1.6 km of Louisiana coastline, an average of 4,800 birds arrived per hour during a 12-hour period (Gauthreaux 1971), and up to 1 million songbirds have been recorded along a 1.6-km stretch during the 5-hour passage of a cold front (Able 1972). Censuses of coastal barrier islands indicate an average of 25–30 species arrives per day, but highs of 60 species are not uncommon in April. In spring, migration may be biased westward due to prevailing easterly winds, so numbers are reduced everywhere except in Florida's Panhandle. In fall, migration may be biased toward the Atlantic Coast due to prevailing westerlies (Stevenson 1957, Moore et al. 1993).

Coastal woodlands along the Gulf of Mexico are important to many landbirds as they migrate to and from Latin America. Gulf Coast woodlands are more important for most species during spring migration than South Atlantic Coast woodlands (Moore and Woodrey 1994). The wooded barrier islands along the northern Gulf Coast provide the last foraging opportunity before fall migrants cross 1,000 km of water, and these islands are the first potential landfall for birds returning north in spring (Moore et al. 1990). Migrating landbirds "funnel" southward along the South Atlantic coastline. Landbirds select among available habitats based on food availability, competition, and shelter from predators and adverse weather (Moore and Simons 1992). Coastal migrants most frequently use scrub and brush, pine forests, relict dunes, oak hammocks, mangroves, and marshes (Moore and Simons 1992, Pranty 1996). Large patches of maritime hammock are important to migrant landbirds in northeastern Florida (Cox 1988).

Habitat use by migrating landbirds also depends on weather conditions. During clear days with a south wind in spring, birds bypass coastal areas and fly inland ≥80 km to use forest and bottomland tracts (Lowery 1945, Gauthreaux 1971), whereas during stormy weather or a north wind, birds are forced to stay at coastal sites (Moore and Kerlinger 1987). In years with frequent bad weather, 10% of the birds landing in an area will remain for ≥1 day, while most birds continue their migration the same night as their arrival (Gauthreaux 1971, 1972; Moore and Kerlinger 1987). Some birds may stop because of dehydration rather than starvation. Mortality associated with intercontinental migration may be substantial, and yearling migrants suffer greater mortality than adult migrants. In a typical year, only 35% of the young will live to return the following spring (Kerlinger 1995).

Many migrating shorebird species that breed at higher latitudes feed and rest during spring and fall in Florida, and at least 25 shorebird species overwinter in Florida (Sprandel et al. 1997), including the state and federally threatened piping (*Charadrius melodus*) and Cuban snowy (*C. alexandrinus tenuirostis*) plovers. Other highly ranked shorebirds that winter in Florida are the American oystercatcher (*Haematopus palliatus*), whimbrel (*Numenius phaeopus*), marbled godwit (*Limosa fedoa*), ruddy turnstone (*Arenaria interpres*), red knot (*Calidris canutus*), and sanderling (*C. alba*).

At least 7 shorebird species breed in Florida's coastal habitats, including the highly ranked Cuban snowy plover, American oystercatcher, Wilson's plover (*Charadrius wilsonia*), and black skimmer (*Rynchops niger*) (Stevenson and Anderson 1994). Eleven species of gulls and terns nest in Florida, including the highly ranked royal (*Sterna maxima*), roseate (*S. dougalli*), gull-billed (*S. nilotica*), and least (*S. antillarum*) terns (Stevenson and Anderson 1994). Bare beaches are used for nesting by the least tern, royal tern, black skimmer, and snowy plover, whereas the oystercatcher prefers sparsely vegetated beaches. Because of loss of beach habitat to real estate development and human disturbance, many least terns and black skimmers now nest on tar-and-gravel rooftops (Fisk 1978, Gore 1991, Zambrano et al. 1997, Hovis and Gore 2000), and some shorebirds commonly nest on dredged spoil islands. One hundred shorebird colonies have been recorded on spoil islands, and 41 colonies on causeways in Florida (Sprandel 1999).

The most important wintering site for shorebirds in the Panhandle is Lanark Reef in Franklin County, which provides a mixture of undisturbed roosting and nearby feeding areas (Sprandel et al. 1997). This site hosts ≥3% of the flyway's population of the piping plover, oystercatcher, willet (*Catoptrophorus semipalmatus)*, and marbled godwit (Harrington et al. 1989; Sprandel et al. 1997). The most common wintering shorebird in the Panhandle is the dunlin (*Calidris alpina*), but the Panhandle is also important in winter to the snowy plovers, piping plover, oystercatcher, and willet (Sprandel et al. 1997).

In the Panhandle, the snowy plover nests from Franklin to Escambia County (Chase and Gore 1989), and the oystercatcher nests near Apalachee and Apalachicola bays (Below 1996). In 1993, 4,431 least tern nests were found in the Panhandle, and 139 royal tern nests were found on Lanark Reef (Hovis and Gore 2000). The laughing gull commonly nests in the Panhandle (Hovis and Gore 2000), and in 1998, 105 Caspian terns nested on a dredged spoil island at the mouth of the Apalachicola River (McNair and Gore 2000). Intensive surveys of the Panhandle found 386 black skimmer nests at 12 sites in 1990 (Gore 1991) and 283 nests at 10 sites in 1993 (Hovis and Gore 2000).

From Hernando to Lee County along the southwestern Gulf Coast, many barrier islands and large bays (often lined with mangroves) occur along coastlines with moderate-energy waves (Fernald and Purdum 1992). Although most of the sandy beaches have been developed, a statewide winter shorebird survey indicated that 7 of the top 10 sites were near Tampa Bay: Shell Key, Honeymoon Island, the Island north of Bunces Pass, Three Rooker Bar (north and southeast ends), Point Pinellas (west oyster bar), and Caladesi Island (Dunedin Pass) (Sprandel et al. 1997). The Tampa Bay area contains up to 20% of the flyway population of the Wilson's plover, 10% of the snowy plover, and 5% of the piping plover, willet, and marbled godwit (Sprandel et al. 1997). The snowy plover, Wilson's plover, and oystercatcher breed from Pinellas County southward to Marco Island, and important concentrations of the royal, sandwich (*Sterna sandvicensis acuflavidus*), and Caspian (*S. caspia*) terns breed in the Tampa Bay area (Paul and Woolfenden 1985; Paul 1987, 1991; Paul and Below 1991). Spoil islands in Hillsborough Bay provide breeding sites for many shorebirds (Sprandel 1999).

The southeastern Atlantic Coast from northern Biscayne Bay in Dade County to Sebastian Inlet in Indian River County has a narrow shoreline that has been intensively developed. No significant concentrations of wintering shorebirds occur here, but breeding shorebird species include the least tern, royal tern, and black skimmer. The Caribbean population of the roseate tern breeds in the Florida Keys (1 of the 2 sites is a rooftop in Marathon) and the Dry Tortugas (Smith 1996, Zambrano et al. 2000).

The sooty tern (*Sterna fuscata*) and brown noddy (*Anous s. stolidus*) breed only in the Dry Tortugas (Robertson 1996, Robertson and Robertson 1996).

The northeastern Atlantic Coast has greater tidal fluctuations and more bays and lagoons than the southeastern coast (Fernald and Purdum 1992). Royal terns nest in Nassau Sound (Paul 1989) and on the Banana River spoil islands in Brevard County (Paul 1987). Along the northeastern coast (Duval to Brevard County), 81% of 1,720 least tern nests but only 6% of 311 black skimmer nests were found on roofs in 1993 (Hovis and Gore 2000). In the 1993 shorebird survey, 311 black skimmer nests were found at 4 sites and 12 Wilson's plover nests (83 adults, however) were found at 7 sites in northeastern Florida (Hovis and Gore 2000). Shorebird nesting has declined at Bird Island in Duval County (Sprandel 1999). Nesting of the common tern (*Sterna hirundo*) and gull-billed tern has apparently declined in Florida, particularly along the northeast coast (Sprandel 1999). Nesting oystercatchers are sparsely distributed along the Atlantic Coast as far south as Palm Beach County.

Several raptor species are associated with both migrating songbirds and shorebirds: Arctic peregrine falcon (*Falco peregrinus tundrius*), merlin (*F. columbarius*), Cooper's hawk (*Accipiter cooperii*), and sharp-shinned hawk (*A. striatus*). Raptors migrate along the Panhandle Coast, along South Florida and the Keys, and over the Gulf of Mexico to Cuba and the Caribbean (Kerlinger 1989, Raim et al. 1989, Andres 1991, Duncan 1994). In 1996 and 1997, full-season counts in the Florida Keys averaged >26,000 raptors of 16 species (Brashear 1998, Brashear and Stoddard 2001). Exceptionally high numbers of peregrine falcons pass through the Keys during their autumnal migration, and Grassy Key may experience more sightings (>1,600) than any other watch-site in the United States (Brashear 1998, Brashear and Stoddard 2001). Florida supports an estimated 200+ peregrine falcons in winter based on >30 Christmas bird counts (CBC), assuming these counts represent one-sixth of the wintering population (B. A. Millsap and G. L. Sprandel, unpubl. data). Peregrines that winter along the Gulf of Mexico and Florida are encountered most frequently along the coast in coastal flats and wetlands, and they are presumed to be associated with winter shorebird concentrations (Page and Whitacre 1975; Buchanan et al. 1986; Enderson et al. 1995; B. A. Millsap, pers. obs.). Merlins appear in CBC data in higher numbers than peregrines and are also encountered along the coast. Like the peregrine, the merlin's main diet is small birds, including many neotropical migrant songbirds and shorebirds (Boyce 1985, Raim et al. 1989, Smallwood and Meyer 1996). The Cooper's hawk is the only one of these species that breeds in Florida, where it most frequently nests in oak-dominated forests of the interior peninsula (Toland and Millsap 1996). Cooper's hawks prey on birds that are not strictly neotropical migrants (Toland and Millsap 1996), but the smaller sharp-shinned hawk commonly feeds on songbirds. The sharp-shinned hawk is more common in winter in Florida than the Cooper's hawk, and its migration patterns closely parallel those of songbirds, except it heads counterclockwise along the Panhandle Coast instead of crossing the Gulf of Mexico (Kerlinger 1989; however, see Andres 1991).

Threats to Coastal Upland Habitat or Wildlife

Florida's population increased to 16 million people in 2000, and 80% of recent growth has occurred along the coasts (Paul 1996). More than 75% of Florida's human population resides in coastal counties, and up to 49 million people visit Florida annually (Bureau of Economic and Business Research 1999). Beachfront development in the form of high-rise buildings on the foredunes is most intense near large cities: Jacksonville, Palm Beach, Fort Lauderdale, Miami, and Clearwater–St. Petersburg (Doyle et al. 1984, Pilkey et al. 1984). Seawalls built to prevent further beach erosion actually destroy beaches, and beach nourishment (i.e., the placement of fill to counteract beach erosion) is expensive and often only a short-term solution. Coastal habitat is also lost to dredging and excavation, spoil disposal, impounding, and sediment diversions (Senner and Howe 1984).

By 1975, nearly 20% of Florida's barrier islands were developed (Lins 1980), especially along the southeastern Atlantic Coast. The Panhandle's coastline contains the highest percentage of protected habitat, and the "sea island" barriers in Duval and Nassau counties and the Cape Canaveral complex are also protected. However, no large sections of coastline are protected along the Atlantic Coast south of Cape Canaveral. The Archie Carr NWR in Brevard and Indian River counties is intended to protect important sea turtle nesting beaches, but less than half of the proposed land has been purchased, and beachfront development continues to occur (Meylan et al. 1995). Large portions of coastline are protected in ENP and on several islands along the southern Gulf Coast.

An estimated 3,800 ha of coastal wetlands have been lost to development since European settlement (Kautz et al. 1993). Coastal strands and maritime hammocks once formed a nearly continuous band along the Atlantic Coast, but they are now highly fragmented by resort and residential developments. Coastal strand is probably the most rapidly disappearing habitat in Florida (Florida Natural Areas Inventory 1990), and Johnson and Barbour (1990) estimate that <50% of the original coastal strand habitat remains. Of the 5,377 ha of coastal strand habitat mapped by Kautz et al. (1993), 50.2% occurs on conservation lands (Cox et al. 1994).

In the Panhandle from Escambia to Franklin County, 64% of coastal upland communities are in natural condition, and almost 80% of the acreage is publicly owned (Johnson and Muller 1992*a*). In the 6 southwestern counties with continuous sandy coastlines, 32% of coastal upland communities are in natural condition, with the highest percentage in the southernmost counties: Charlotte, Lee, and Collier (Johnson and Muller 1992*c*). Over 50% of remaining coastal upland communities is in public ownership (Johnson and Muller 1992*c*). Keewaydin Island, a long, narrow barrier island in Collier County, contains ≈50% of the beach dune acreage and >40 ha of maritime hammock in private ownership (Johnson and Muller 1992*c*). Privately owned parcels (and thus available for public acquisition) of coastal upland habitats ≥4 ha in size decrease numerically from Brevard to Dade County along the southeastern coast (Johnson and Muller 1992*b*). Maritime hammock is the only habitat inadequately represented on publicly owned lands along the southeastern Atlantic Coast; the largest and most mature privately owned hammock is North Sebastian Inlet in Brevard County (Johnson and Muller 1992*b*).

Wind and water erosion of beach dunes occur where pedestrian or ORV traffic damages vegetation, creating a gap or blowout. This gap continually widens until it slowly revegetates and stabilizes. The sand from the gap moves inland and destabilizes other beach dunes by rapidly burying their vegetation. These gaps allow storm surges to easily access inland communities. Wave energy, land elevation, and tidal range influence the amount of damage that can occur during storms. Storms on the Atlantic Coast generally erode the foredune without overwashing or breaching the barrier islands, and winter storms (nor'easters) may cause more erosion than hurricanes (Pilkey et al. 1984). Tropical storms or hurricanes cause most of the damage on the Gulf Coast, which is less protected because of its lower elevations and lower wave-energy regime (Johnson and Barbour 1990). Raking drift off of recreational beaches removes seeds and nutrients, and thus interferes with natural restoration of foredune damage by storms (Oertel and Lassen 1976). Attempts to restore storm-damaged dunes by creating new ones with bulldozers, instead of letting dune grasses gradually rebuild dunes, often results in sand being blown inland instead.

The introduced, nonnative Australian pine (*Casuarina equisetifolia*) has spread along South Florida beaches that have been disturbed by human activity (e.g., dumping of dredged spoil) or storm overwash, such as has occurred at Cape Sable in ENP. The dense shade produced by Australian pines eliminates native vegetation, and the dense root mat inhibits sea turtles and crocodiles from digging their nests (Klukas 1973, Klukas et al. 1979). Coastal strands are susceptible to invasion by Australian pine and Brazilian pepper.

The popularity of coastal waters for fishing, boating, beachcombing, and picnicking has resulted in regular, and sometimes almost constant, disturbance of foraging, roosting, and nesting birds. Even protected areas have come under pressure from persons going ashore and intentionally or unknowingly disturbing local wildlife. Airboats and jet skis offer access to extremely shallow areas that were formerly protected by their inaccessibility, and thereby pose new threats to wildlife. The noise and prop wash of airboats can be very disruptive to roosting or nesting birds (Rodgers and Smith 1997)

Four of the 6 extant Florida subspecies of beach mouse are listed by the state as endangered, and 1 subspecies is threatened (Florida Fish and Wildlife Conservation Commission 1999). The only unlisted subspecies, the Santa Rosa beach mouse (*Peromyscus polionotus leucocephalus*), had a large portion of its habitat devastated in 1995 by Hurricane Opal. This subspecies shows the greatest difference from the other Gulf Coast subspecies in its mitochondrial DNA nucleotide sequence, and its long-term preservation should be emphasized (Wooten 1994). Beach mice are vulnerable to habitat loss from coastal development, mortality and habitat destruction from tropical storms, predation by house cats (Bowen 1968, Holliman 1983, Frank 1996) and other predators, genetic isolation of small populations (U.S. Fish and Wildlife Service 1987), and competition with house mice (*Mus musculus*) (Briese and Smith 1973, Humphrey and Barbour 1981; however, see Frank and Humphrey 1996). If catastrophic events, such as hurricanes, are considered, population viability analyses indicate that virtually all populations of Gulf Coast beach mice appear in substantial danger of extinction, unless current levels of habitat fragmentation are reversed (Oli et al. 2001). More than two-thirds of the habitat of the Choctawhatchee beach mouse has been lost to coastal development (Bowen 1968), and much of the privately owned habitat of the Anastasia Island beach mouse has been developed (Frank 1996).

Panhandle populations of beach mice have been severely affected by hurricanes in the past 20 years, which sometimes destroy the frontal and primary dune habitats that typically support the highest densities of beach mice. Stout (1992) concluded that southeastern beach mice on Cape Canaveral are apparently unaffected or benefit from storm damage to primary dunes and human disturbance of vegetation. Mota et al. (2001) found that southeastern beach mouse populations apparently recovered on Canaveral National Seashore after 7 years of relatively low disturbance due to closure to the general public of the southern portion of Playalinda Beach, but populations remained higher near the space shuttle launch pads at Kennedy Space Center. In 1975, Hurricane Eloise damaged much of the nonbarrier coast from Destin to Panama City, particularly Grayton Beach SRA. In 1979, Hurricane Frederick washed over ≥90% of Perdido Key and Santa Rosa Island, destroying most of the vegetative cover (Doyle et al. 1984). The population of beach mice on Gulf Islands National Seashore was apparently extirpated by the hurricane (Meyers 1983) but was reestablished by translocation of 17 pairs of mice from Gulf State Park in 1986–87 (Holler et al. 1989). In 1985, hurricanes Elena and Kate destroyed or cut back most of the foredunes from St. Joseph Peninsula to Dog Island (Clark 1986).

In October 1995, Hurricane Opal flooded and destroyed much of the Panhandle's beach mouse habitat. Narrow barrier islands—Johnson Beach at Gulf Islands National Seashore, Ft. Pickens and Santa Rosa units of Gulf Islands National Seashore on Santa Rosa Island, and Shell Island off of Panama City—were overwashed by the storm surge, resulting in an estimated 80% loss of dune habitat (Moyers and Mitchell 1996). Areas with high primary dunes—St. Joseph State Park, Topsail Hill, and Grayton Beach—had their foredunes and the foreslopes of their primary dunes washed away, leaving escarpments 5–8 m high in front of the primary dunes. Post-hurricane surveys for beach mice indicated extant but reduced and fragmented populations on all public areas (Moyers and Mitchell 1996). Beach mice usually survived in areas with extensive secondary and scrub dune habitat, and on remaining "islands" of eroded primary dunes. Damage of dune vegetation by wind, sea spray, and flooding resulted in significant loss of food resources for beach mice, but vegetation (especially scrub oaks) on secondary and scrub dunes was believed to provide sufficient food for mice to survive the winter (Moyers and Mitchell 1996, Swilling et al. 1998). Santa Rosa and Perdido Key beach mice experienced severe habitat loss. The Santa Rosa beach mouse formerly occupied 96% of the undeveloped stretches (57 km) of Santa Rosa Island (Gore and Schaefer 1993), whereas the Perdido Key beach mouse had limited suitable habitat prior to the hurricane, making its continued existence tenuous (Moyers and Mitchell 1996). Hurricane Opal eliminated the Perdido Key beach mouse population at Gulf State Park and would have eliminated the subspecies, whose total population fluctuates around 100 individuals, if mice had not been translocated to Gulf Islands National Seashore in the late 1980s (Oli et al. 2001). A new population of this subspecies has apparently been established by recent translocations of individuals from the sole remaining population at Gulf Islands National Seashore to Perdido Key State Preserve, Florida.

Trends in neotropical migrant songbirds are difficult to detect due to their wide geographic range, the complexity of the data, and the variability in data and observers. However, a variety of species have apparently experienced significant declines. In the eastern United States in 1976–1988, populations of 6 neotropical species significantly increased, and 21 significantly decreased (Sauer and Droege 1992). James et al. (1992) found increases in 14 of 15 neotropical species in lowlands (7 of 8 species in the lower coastal plain, including North Florida) and decreases in all 14 species in uplands in the southeastern United States. In Florida, 4 breeding bird species showed increasing trends and 15 species declining trends (Cox 1987). Radar data interpreted from coastal areas suggested that trans-Gulf migration was about half what is was in the 1960s, with the most serious declines exhibited by the earliest migrating populations (Gauthreaux et al. 1992). Over 50% of coastal habitat has been estimated lost to development (Johnson and Barbour 1990), which means that birds may be crowded into the few remaining patches or forced into unsuitable areas where food, water, and protection from predators are scarce.

Shorebirds, gulls, and terns are threatened by human disturbance, environmental contaminants, and habitat loss and degradation (Senner and Howe 1984). The transitory beach habitats used by shorebirds are created and maintained by natural processes: inlet movements and breakthroughs, storm overwashes, and sandbar formation and scouring. Man has increasingly tried to control these natural processes by stabilizing inlets and shorelines, and by building extensive dune systems that have caused both direct and indirect losses of nesting and overwintering habitat (U.S. Fish and Wildlife Service 1985*a*). Manmade structures—seawalls, jetties, beach nourishment, and groins—have reduced habitat by eliminating foraging and roosting areas (Stephen 1995, U.S. Department of the Interior 1985). Development of coastal property is a major threat, even if the foredunes are left intact, because of the resulting increased human activity on the beach. The loss of a single site can be serious because breeding gulls and terns nest in relatively few colonies (Clapp and Buckley 1984), and wintering shorebirds congregate in relatively few places (Sprandel et al. 1997).

Disturbance of birds by people walking or running, ORVs, and domestic pets is of concern because many birds overwinter close to coastal urban areas. Undisturbed periods of resting and feeding are believed to be important to wintering shorebirds (Senner and Howe 1984), which apparently do not become acclimated to disturbance (Roberts and Evans 1993). Disturbed birds frequently vacate or move to different areas when disturbed (Burger 1981, Pfister et al. 1992, Klein et al. 1995) or reduce their foraging time (Burger and Gochfeld 1991, Staine and Burger 1994). Gulls, terns, and oystercatchers are susceptible to stress from flushing by recreational boats and vehicles on isolated roosting, feeding, and nesting areas. Walking humans, vehicles, and unrestrained pets may kill eggs and chicks. Flushed adults expend time and energy needed to tend eggs and feed chicks, and more importantly, eggs and chicks are exposed to the sun, wind, and predators. Because most least terns in Florida now nest on roofs (Hovis and Robson 1989, Gore 1991, Zambrano et al. 1997, Hovis and Gore 2000), the replacement of suitable gravel-and-tar roofs by a plastic polymer material that does not provide nesting habitat is a serious concern (Gore and Kinnison 1993).

Spills of crude oil may pose a local threat to shorebirds, gulls, terns, and common loons (*Gavia immer*) along Florida's coast. The ports of Ft. Lauderdale (Port Everglades) receive large amounts of petroleum, and Tampa and Jacksonville receive large amounts of pollutants (Florida Department of Natural Resources 1988, Fernald and Purdum 1992). Several experimental studies have shown that even slight oiling can reduce hatching success of gull and tern species (White et al. 1979, Clapp and Buckley 1984, Hoffman 1990). Ingestion of oil by feeding marine birds may cause death by dehydration (Ohlendorf et al. 1978), and oiled feathers result in loss of thermal insulation and increased preening time (Smith and Bleakney 1969, Larsen and Richardson 1990). During the 1993 Tampa Bay oil spill, shorebirds were not heavily oiled initially, but about 9% of the shorebirds on Shell Key were oiled 1 week after the spill (P. Blair, pers. commun to Douglass 1993).

Oil spills and dissolved-oil fractions may affect shorebirds by causing mortality to seagrass beds and to invertebrates, which readily take up the oil (National Research Council 1985). Seagrasses inhabit shallow coastal waters, where they improve water quality and provide nutrition and shelter to marine fishes, wading birds, manatees, and sea turtles (Sargent et al. 1995). Biological effects of spills are usually greater in lower energy environments where oil accumulates, so there may be a greater impact along the Gulf Coast because of its lower energy waters and more abundant shorebirds. Tropical marine systems that are biologically structured—coral reefs, mangroves, and seagrass beds—tend to hold sediment in place. The oil stays trapped in sediment until heavy rains cause the oil to be released, which in effect causes another spill (Jackson et al. 1989).

Other pollutants that may reach coastal wetlands and impact seabirds and shorebirds are organochlorine pesticides and herbicides (Senner and Howe 1984, Fry 1992, Nisbet 1994). These compounds may affect egg laying or poison adult birds (Flickinger and King 1972, Ohlendorf et al. 1978). Only 2 regularly monitored NOAA sites in Florida (Little Oyster Bar near Panama City and Postil Point in Choctawhatchee Bay) recorded high levels of DDT, DDE, or DDD (O'Connor 1992), but concentrations may be higher at specific locations. Although DDT has been banned in the United States since 1972, it is still commonly used in South America where many shorebirds winter (Morrison and Ross 1989).

Heavy-metal loads are typically low but can be toxic to shorebirds at high concentrations, although little is known about contamination or variations in toxicity levels among shorebird populations. The main source of heavy metals in estuaries is probably the direct discharge of effluent from manufacturing and refining sites (e.g., Vermeer and Castilla 1991). High levels of some heavy metal were found at 13 of 32 NOAA sites monitored in Florida (O'Connor 1992). Because gulls, terns, and loons feed on fish that may have accumulated toxic materials from polluted waters, they should be considered vulnerable to chemical contamination (Hays and Risebrough 1972, Blus and Prouty 1979).

Some areas in Florida may pose specific environmental threats to shorebird populations. In Florida Bay, the decrease in fresh water reaching the Bay, die-offs of seagrass, and increase in nutrients and algal blooms have reduced the amount of habitat available for marine organisms (Bancroft 1993, Paulic and Hand 1994). Increases in nitrogen and phosphate inputs, along with pesticides, from agricultural activities around Lake Okeechobee (e.g., sugarcane farms) contribute to the problem (Schrope 2001). NOAA researchers reported finding detectable levels of pesticides in 5 of 34 sampling stations in South Florida, and evidence exists of high levels of PCBs and DDTs (Kirchhoff 1995). High mercury levels have been discovered in oysters at specific sites (Cantillo et al. 1993), and mercury has also been found in cormorants, mergansers, and great egret (*Ardea albus*) nestlings (Kirchhoff 1995, Sepúlveda et al. 1999).

The Tampa Bay estuary, which has been impacted by 1.9 million people living in the metropolitan area, is important to wintering and breeding shorebirds (Sprandel et al. 1997). Inputs of pathogens and toxic chemicals have contaminated some parts of the Tampa Bay estuary, and eutrophication has occurred because of stormwater runoff, atmospheric deposition, and wastewater treatment plants. Hillsborough Bay is consistently classified as having poor water quality with high toxicity (Paulic and Hand 1994, Long et al. 1995). Compared to other sites nationwide, oysters from Tampa Bay have high concentrations of mercury, zinc, and chlordane, and the bay sediments have high concentrations of DDT, other chlorinated pesticides, and lead (Long et al. 1991). Benson et al. (1994) found high selenium levels in McKay Bay.

Entanglement by discarded human artifacts, such as fishing line and kite string, has injured and killed seabirds, including terns (Howe et al. 1978, Fry 1992). Commercial fishing operations may potentially impact seabirds (Fry 1992), but their impacts are believed to be low in the Southeast (Clapp and Buckley 1984). Some shorebird species forage in seagrass beds and are adversely impacted by scarring of seagrass beds by boats, which is especially prevalent in Florida Keys, Tampa Bay, Charlotte Harbor, and the north Indian River Lagoon (Sargent et al. 1995). Dredge-and-fill operations and shoreline alterations have destroyed 40% of seagrass beds in Tampa Bay since 1950, and seagrass is also affected by eutrophication, turbidity from runoff, and increased freshwater inflows (Paulic and Hand 1994).

Major threats to nesting sea turtles are (1) coastal armoring (i.e., the use of seawalls, rock revetments, riprap, sandbags, retaining walls, geotextile tubes, groins, and jetties) destroying suitable beach habitat, (2) egg predation, (3) beachfront lights disorienting hatchlings, and (4) beach-cleaning operations. Natural disasters also affect nesting success. For example, Hurricane Floyd washed out about 3,000 of the nearly 21,000 sea turtle nests in and near the Archie Carr NWR in 1999, and beach destruction stimulated residents to pursue seawall permits. Coastal development has led to the disturbance of nesting females and nest destruction by ORVs. Threats to sea turtles in the water include incidental capture by fishing nets, poaching, collisions with powerboats, entanglement or ingestion of synthetic debris, and contact with chemical pollutants (Ehrhart and Witherington 1992, Meylan et al. 1995). Fibropapillomatosis, a viral disease that is characterized by the development of multiple tumors on the skin and internal organs, has seriously impacted green turtle populations in Florida and is now affecting loggerheads. Approximately 50% of juvenile green turtles in Indian River Lagoon and Florida Bay have fibropapillomas, which may indicate some environmental contaminant in nearshore areas (Herbst and Klein 1995). The major immediate threat to loggerheads, particularly juveniles, is accidental drowning in shrimp trawls, which could be minimized by the use of turtle excluder devices (TEDs), particularly in the spring and summer months (Henwood et al. 1992, Seidel and McVea 1995). The removal of large predators and the presence of household garbage in developed coastal areas have led to larger populations of raccoons, which are major predators on sea turtle eggs.

Beach nourishment may decrease nesting success of sea turtles by compacting the sand and creating escarpments that block turtles from reaching their nesting sites. Beach nourishment may decrease the survivorship of sea turtle eggs and hatchlings by altering beach characteristics—sand compaction, gaseous environment, hydric environment, contaminant levels, nutrient availability, thermal environment—or covering incubating eggs with excess sand (Crain et al. 1995). Early in the sea turtle nesting season, shading of beaches by large condominiums could affect the sex of hatchling turtles by lowering temperatures below the pivotal temperature (Mrosovsky et al. 1995).

Coastal Upland Conservation or Management Strategies

Implementation of comprehensive coastal zone management is complicated because many levels of government are involved. Cooperation and commitment on the part of private citizens and local, state, and federal governments are needed to protect coastal upland habitat and to ensure that human activities are compatible with wildlife needs. Locally, beach dunes subjected to heavy foot traffic should be protected by boardwalks, and ORV use should be prohibited in dunes. Coastal developments that affect sand sources for beach-dune replenishment should be discouraged (Florida Natural Areas Inventory 1990). Natural regeneration of storm-damaged dunes by dune grasses should be encouraged, and sand fences may be an option to stabilize dune sand.

Removal of large exotic trees from maritime hammocks should be conducted in phases to minimize canopy disruptions that would allow wind damage (Florida Natural Areas Inventory 1990). Disruption of barrier island preserves by roads can be minimized by running roads perpendicular to the parallel dune ridge system, except when bypassing major wetlands; a wetland bypass should follow the ridge line away from the deepest part of the wetland (Gaddy and Kohlsaat 1987). Roads should create few patches of forest to minimize species-area effects, and on most islands, roads should skirt either end of the island to preserve a large, undisturbed central area (Gaddy and Kohlsaat 1987). On barrier islands that are undergoing beach erosion, roads should terminate short of the beach, and foot traffic should be diverted from the ends of the island because these areas are more likely to be agrading and often provide the best habitat for nesting least terns and sea turtles (Bellis 1995).

Nesting sea turtles would benefit from adopting beach lighting ordinances, restricting ORV use of beaches during the nesting season, restoring beaches via dredging during winter months, controlling raccoons (however, see Ratnaswamy and Warren 1998) and coyotes or removing eggs to protected nurseries, and acquiring important nesting beaches, such as the Archie Carr NWR (Meylan et al. 1995). Current nesting distributions of the various sea turtle species need to be maintained to preserve genetic diversity and to ameliorate the effects of periodic natural catastrophes, such as hurricanes, and the long-term rise in sea levels. The dominant criterion in making management decisions concerning nesting beaches should not be nest density, because rare or depleted sea turtle species—green turtle, leatherback, and hawksbill—in Florida will be exterminated and current nesting distributions reduced (Meylan et al. 1995). An Index Nesting Beach Survey program has been in effect since 1989 to monitor nesting trends in sea turtle populations. Systematic stranding surveys of most accessible beaches in the United States (i.e., Sea Turtle Stranding and Salvage Network) appear to provide a cost-effective means of evaluating the effectiveness of TED regulations and are useful in determining other sources of mortality.

Additional fragmentation of beach mouse populations needs to be minimized by prohibiting further coastal development, restricting foot traffic in dunes (e.g., provide public restroom facilities on the beach in state parks), and prohibiting beach driving. Preserves designed for the Anastasia Island beach mouse may have to be several square kilometers in size because beach mouse populations are extremely sensitive to habitat modification and the presence of house cats (Gore and Schaefer 1993, Frank 1996, Frank and Humphrey 1996). In areas where coastal scrub is undergoing succession to maritime hammock, prescribed fire may be used to set back succession and maintain habitat suitable for beach mice (Frank 1996, Frank and Humphrey 1996). Any scrub dune habitat should be preserved because it helps mitigate the deleterious effects of hurricanes by providing food to mice on damaged foredunes and providing source populations for recolonization of previously destroyed habitat (Swilling et al. 1998, Oli et al. 2001). Beach mice can be maintained and bred in captivity, as has been done at Auburn University with Choctawhatchee and Perdido Key beach mice, and captive colonies can be used to reestablish populations after dune habitat is restored following storm damage (Hill 1989, Frank 1996).

An intensive public education campaign on the negative impacts of cats on wildlife populations might be beneficial to beach mouse populations (Frank and Humphrey 1996), but efforts to control cats through licensing and leash laws generally meet with little success or public support (Proulx 1988). The FWC is one of >2,000 organizations that support the Cats Indoors! program of the American Bird Conservancy, which teaches and encourages pet owners to keep their cats indoors (Florida Fish and Wildlife Conservation Commission 2001). Resident managers of publicly owned lands should be prohibited from having cats as pets, and local ordinances in coastal areas should limit the number of cats, have strict leash laws, and have a mandatory sterilization program (Frank 1996, Frank and Humphrey 1996). In some areas, a control program for cats should be implemented, and concession stands or refuse facilities that attract feral cats should be eliminated (Frank 1996, Frank and Humphrey 1996). Many agencies and groups oppose the practice of Trap-Neuter-Release for controlling large numbers of feral cats that congregate in "cat colonies" where food is provided intentionally or unintentionally by humans (Florida Fish and Wildlife Conservation Commission 2001).

After Hurricane Opal made landfall in October 1995, biologists tried to help beach mouse populations recover by planting sea oats and using sand fencing to speed dune restoration. Supplemental feeding with sunflower seeds was initiated until dune vegetation recovered in areas lacking scrub vegetation, or where habitat loss was extensive. Fox control was conducted to reduce predation pressure on Perdido Key beach mouse populations. Because of habitat damage and reduced population sizes, plans were postponed to reintroduce Perdido Key beach mice to Perdido Key SRA and St. Andrews beach mice to Crooked Island at Tyndall AFB. Planned translocations of Choctawhatchee beach mice from Shell Island to Grayton Beach SRA were also postponed (Moyers and Mitchell 1996).

Conservation of neotropical migrant songbirds in Florida requires that stopover habitats near the northern Gulf of Mexico be protected (Moore et al. 1993). Winter can be a time of intense pressure due to mortality associated with stress from migratory flights, occupation of unfamiliar habitat by juvenile birds, and increased competition for food due to inflated densities of potential competitors (Morse 1980). Monitoring efforts should be initiated to identify important conservation areas for both neotropical migrants and raptors, and regular migration counts should be conducted at some of these key areas. Establishment of a raptor migration count site in the Florida Keys would represent the only major observation site on the Atlantic Coast south of Assategue, Virginia, and long-term banding efforts in the Keys would help show the relationship among flyways (Brashear and Stoddard 2001). Brashear and Stoddard (2001) recommended that the privately owned Boot Key be preserved as a critical wildlife area because of its importance to migrating raptors as a stopover area and to roosting and foraging white-crowned pigeons. Mangrove forests and tropical hammocks on the undeveloped Boot Key provide suitable habitat for raptor prey and for roosts, but roadside Australian pines should also be retained because of heavy use by roosting falcons (Brashear and Stoddard 2001). Migration counts and mist-netting operations for neotropical songbirds, coupled with rate of fat deposition, may be useful in documenting use of key migration sites (Moore and Woodrey 1994). A more thorough understanding of transient ecology and the effects of habitat alteration is needed (Rappole 1995). Florida studies of habitat use in winter, perhaps by Winter Population Studies (Lowe 1994), might provide information on winter densities and habitat carrying capacities. Management practices that reduce food (fruit or insects) should be scrutinized (Moore et al. 1993). Coastal woodland restoration efforts should include native fruit-bearing shrubs, vines, and trees, and they should emphasize public-private partnerships (Hunter 1996). Migrants and their habitats should be included as significant coastal resources in state and county coastal zone programs. Communication is needed between managers, scientists, and the public across international boundaries because neotropical migrants may be limited by factors on their summer breeding grounds, wintering grounds, or migratory routes (Sherry and Holmes 1992, Rappole 1995).

Statewide annual surveys of ground colonies of colonial nesting shorebirds would help identify trends in population size and changes in colony locations of least terns and black skimmers, and annual surveys would provide abundance and distribution information for several poorly known species, such as gull-billed, Caspian, and roseate terns (Hovis and Gore 2000). Haig and Oring (1987) proposed continent-wide censuses of piping plovers every 5 years. Annual statewide surveys at the top 9 wintering shorebird sites in Florida could census 50% of the total shorebird winter population (Sprandel et al. 1997). Volunteers could be used to annually monitor rooftop colonies of least terns to determine the presence or absence of historical colonies and to identify new colonies (Hovis and Gore 2000).

Exclusion or direct control of predators may be required at nesting sites of shorebirds, such as the snowy plover, where predation is a problem (Deblinger et al. 1992). Non-intrusive census techniques need to be developed for breeding shorebird or seabird colonies where predators can follow observers and destroy a major colony, particularly early in incubation (Safina and Burger 1983). Most rooftop shorebird colonies would benefit from limiting disturbance, improving drainage, fencing edges, and providing additional shade and shelter for chicks (O'Meara and Gore 1988, Coburn et al. 2001). Most skimmer eggs on rooftops crack because of inadequate cushioning by the gravel substrate, so the addition of extra gravel might be beneficial (Bolte 1999, Coburn et al. 2001).

The proper placement and management of dredge-material islands may provide roosting, breeding, or feeding habitats for shorebirds, gulls, terns, and black skimmers (Parnell et al. 1986). Spoil islands should be designed and maintained by the agencies responsible for dredging harbors and waterways to encourage nesting and loafing by birds. Dredge-material islands in the Keys suffer from lack of sufficient maintenance because of competing needs for beach nourishment (Erwin et al. 1995). Annual removal of vegetative ground cover at these sites may be required to maintain their suitability for target avian taxa. On sites where vegetation encroachment is a problem, vegetation control can be used to maintain ≈4% vegetative cover (Burger 1984). Vegetation control may attract nesting Wilson's plovers and least, roseate, royal, sandwich, and Caspian terns to spoil islands. Beach nourishment projects do not necessarily damage benthic communities (Marsh and Turbeville 1982) and might be used to create or maintain suitable shorebird habitat.

Important shorebird sites that are susceptible to disturbance should be candidates for posting, fencing, or other restrictions to keep pedestrians, vehicles, and pets out (Melvin et al. 1991). Based on historical patterns of shorebird use, a small portion of the beachfront or tip could be closed to protect roosting areas (Pfister et al. 1992). Because the sensitivity of birds to disturbance varies widely among colonies, buffer-zone sizes should, whenever practical, be determined for individual colonies based upon observed flushing distances. Buffer zones may be 50 m from the mean high-tide mark (Helmers 1992), 100 m in sign-posted royal tern colonies (Erwin 1989), or ≥175 m outside of colonies (Rodgers and Smith 1995). A buffer zone of ≈100 m would minimize disturbance to most species of wading birds and shorebirds while foraging and loafing in Florida (Rodgers and Smith 1997). Buffer zones of ≈180 m for wading birds, 140 m for gulls and terns, and 100 m for plovers and sandpipers would minimize their disturbance by personal watercraft and outboard-powered boats at foraging and loafing sites (Rodgers and Schwikert 2002). In areas where beach driving is allowed, driving could be restricted to certain areas or seasons, or higher beach driving fees could help pay for staff to enforce current regulations (Primack 1980, Cox et al. 1994). At important sites without existing staff, patrols by FWC officers might be the most effective means of ensuring that shorebirds remain undisturbed. Volunteers and salaried wardens have been effective elsewhere in ensuring that beach users understand closed areas (Melvin et al. 1991), and they may be a useful alternative in Florida wherever traditional law enforcement officers are not available. Posting or closure of all royal tern and most other seabird colonies before the start of breeding activity would reduce the likelihood of any pre-laying site abandonment caused by human disturbance. Pedestrians and vehicles can be deterred from entering colonies by delineating the colony with string or wire strung between fence posts set 6–30 m apart (O'Meara and Gore 1988).

There needs to be a balance between providing viewing opportunities and minimizing disturbance to shorebird and seabird congregations. A direct educational effort could teach citizens to avoid disturbing sites that are heavily used by shorebirds and to keep pets leashed. Educational programs could be designed based on U.S. Fish and Wildlife Service programs for piping plovers (e.g., Beers 1991) or the Western Hemisphere Shorebird Reserve Network (WHSRN) Shorebird Education Project (Wetlands for the Americas 1993). Parks and wildlife refuges offer excellent opportunities for education and viewing. The impact of disturbance in wildlife refuges may be counteracted with guided tours and low-disturbance zones where people stay in their cars (Klein et al. 1995). Sites with information kiosks and trained staff could inform large numbers of people about shorebird and sea turtle biology, and on how to minimize disturbances. Posters or pamphlets at marinas can be used to inform boaters who might visit offshore shorebird sites. Ideally, education efforts should include research into the problem, an appraisal of community concern, a plan for setting up the educational program, and an evaluation of its effectiveness (Blanchard and Nettleship 1991).

Reviewers of U.S. Coast Guard Area Contingency Plans and the FWC's Oil Sensitivity Atlas should be aware of important winter shorebird, winter seabird, and wading bird sites, and these sites should be incorporated into plans. Particularly important sites are Tampa Bay and, due to shipping near the Florida Keys, Florida Bay (Townsend 1990). The potential for impacts to coastal wildlife would be reduced by changes in navigation standards that would minimize oil spills, such as implementing vessel-free zones, improving traffic separation schemes, enhancing pilot training, and redesigning vessels and navigational equipment. Survival of oiled birds would probably increase if wildlife rehabilitators were provided instructions on handling and caring for oiled shorebirds, specifically means to avoid cramps to the birds' legs and to maintain their salt balance (Burridge and Kane 1985, Kasprzyk and Harrington 1989). The plan for emergency response to spills of hazardous materials (Bird Emergency Aid and Kare Sanctuary, Inc. 1991) would be improved if it included contingencies for wintering shorebird or seabird sites that are most susceptible to pollutant impacts. For sites currently monitored for pollutants (Long et al. 1991, O'Connor 1992), research should be conducted on the biological effects of the pollutants. Tampa Bay is part of the National Estuary Program, and management plans are being developed that include seagrass restoration and monitoring and reducing pollutants (Greening and Eckenrod 1995).

Privately owned habitat important for shorebirds can receive short-term protection through designation as a Critical Wildlife Area (Robson 1991), if the boundaries are firm and landowners are willing, or long-term protection through conservation easements or public land acquisition. However, ranking of shorebird nesting areas according to their need for protection is pointless, primarily due to the dynamic nature of breeding colonies in terms of number of nests and species composition (Hovis and Gore 2000). Normal colony establishment and abandonment patterns should be studied to understand how public acquisition would affect a given colony. Sites with federally threatened piping or snowy plovers may receive additional protection under Section 7 of the Endangered Species Act (Sidle et al. 1991).

Because Cooper's hawks exhibit high nest-site fidelity, increased emphasis should be placed on locating and protecting nesting habitat. Because the sharp-shinned hawk, merlin, and peregrine falcon feed on migrating songbirds and shorebirds in Florida, they would benefit from efforts to conserve coastal habitats important to their prey species. Recent delisting of the *anatum* subspecies of the peregrine falcon may mean that Florida will play a role in regulating falconry harvest. Two recognized subspecies of the peregrine falcon, and individuals of uncertain taxonomic affinity from reintroduced established populations, may occur in Florida during migration and during the winter. Other possibly beneficial conservation efforts include monitoring of migrating and wintering hawks, and determination of source populations for peregrine falcons wintering in Florida.

Tidal Marsh Habitat Description

Tidal or salt marsh habitat is an expanse of grasses, rushes, and sedges along low wave-energy coastlines and river mouths. Black needlerush (*Juncus roemarianus*), smooth cordgrass (*Spartina alterniflora*), or sawgrass (*Cladium jamaicense*) often form dense, uniform stands, depending on tide levels and slight changes in elevation. In the high tidal marsh above mean high water, a mosaic of plant species may be found besides black needlerush: glasswort (*Salicornia* spp.), saltwort (*Batis maritima*), salt grass (*Distichlis spicata*), soft rush (*Juncus effusus*), salt myrtle (*Baccharis halimifolia*), and marsh elder. Dense stands of sawgrass often occur in the upper reaches of river mouths where estuarine tidal marsh grades into freshwater marsh (Florida Natural Areas Inventory 1990, Montague and Wiegert 1990). Flood frequency and soil salinity primarily determine the types and productivity of tidal marsh vegetation, with smooth cordgrass occupying the deepest water (Eleuterius and Eleuterius 1979, Stout 1984). Soils are usually very poorly drained muck or sandy clay loams with high organic content. Dead, decaying marsh plants and detritus from upland runoff or ocean currents are trapped by the dense stems and roots of living plants and accumulate to form peat deposits that may build land (Florida Natural Areas Inventory 1990).

Tidal marsh habitat covers an estimated 170,000 ha of Florida (Montague and Wiegert 1990), which is second in acreage only to Louisiana (Durako et al. 1985). The coverage of tidal marshes in different regions of Florida is ≈50% on the Gulf Coast north of Tampa Bay and westerly to Alabama, 20% in South Florida, 10% along the Indian River Lagoon from Volusia to Martin County, and 20% along the Atlantic Coast north of Marineland (Montague and Wiegert 1990). The northern Atlantic Coast tidal marshes mostly consist of large expanses of smooth cordgrass that are flooded twice daily by the highest tides in the state. The Indian River Lagoon tidal marshes were once mainly above mean high sea level and consisted primarily of black needlerush, but most of these marshes have been diked and semipermanently flooded to control salt marsh mosquitoes (*Aedes taeniorhynchus* and *A. sollicitans*) (Bidlingmayer 1982; Montague et al. 1984, 1987). In South Florida, especially south of Homestead in Dade County, tidal marshes consist of a narrow fringe of smooth cordgrass seaward of some red mangrove (*Rhizophora mangle*) forests and a strip of black needlerush and high-marsh plants landward of the white mangrove (*Laguncularia racemosa*) zone (Schomer and Drew 1982). Tidal marshes in the northwestern Gulf Coast north of Tampa Bay and westerly to Alabama, especially the extensive ones in the Big Bend region, are irregularly flooded by a combination of lunar and wind-blown tides and a seasonal rise in sea level (Montague and Wiegert 1990). About 60% of this area consists of monospecific stands of black needlerush, with a variety of monospecific or mixed stands of high marsh plants occurring landward; smooth cordgrass mostly fringes the tidal creeks (Kruczynski 1982, Woods et al. 1982).

Tidal Marsh Wildlife Communities

Vertebrate taxa that predominately utilize tidal marsh habitat include 8 mammal, 11 avian, and 6 reptile taxa with biological scores ≥17. High-ranking mammals include rodents and minks, whereas reptiles consist of salt marsh snakes and diamondback terrapins. High-ranking birds are rails, seaside sparrows, and marsh wrens. Many target taxa could be included under both tidal marsh and tidal swamp habitats, and some taxa also use coastal grasslands and other uplands. Although we are not considering marine fish and molluscs in this conservation plan, we must mention that at least 72% of Florida's 89 commercial species of finfish and shellfish and 74% of 84 recreational species are estuarine-dependent (Durako et al. 1985).

Tidal marshes have very high rates of net primary production because of the nutrient and energy subsidy supplied by tidal action, and tidal marshes are important in sediment stabilization, storm protection, pollutant filtration, and wildlife production (Durako et al. 1985). The terrestrial food web is based upon grazing arthropods and passerine birds (Wiegert and Freeman 1989), but marine organisms use the marsh for food and cover during tidal inundation. The terrestrial habitat provided by the stems and leaves of marsh plants has the highest species richness of animals, including >500 species of insects (McCoy

1977). The many grazing insects provide food for predatory insects and arachnids, and insectivorous migrant and resident birds, such as marsh wrens, seaside sparrows, clapper rails (*Rallus longirostris*), and black rails (*Laterallus jamaicensis*).

The high net primary productivity and high density of plant stems in tidal marshes provide abundant food and cover for both resident and transient animal species that are able to tolerate or avoid the rigorous diurnal changes in salinity, drainage, and temperature (Durako et al. 1985, Montague and Wiegert 1990). The few vertebrate species that have adapted to these conditions may have high population densities, but overall species richness is relatively low in tidal marsh. Transient vertebrates that feed in tidal marsh are the raccoon, marsh rabbit (*Sylvilagus palustris*), cotton rat, cotton mouse, bobcat *(Lynx rufus floridanus*), river otter, and mink. Tidal creeks are the main access corridors for estuarine fish, shellfish, and mammals (e.g., the Florida manatee), and they are major foraging sites for egrets, herons, wood storks, and roseate spoonbills (*Ajaia ajaja)*. Raccoons and rice rats (*Oryzomys palustris*) may be significant egg predators of marsh-nesting birds; rice rats nest in smooth cordgrass and black needlerush in the vicinity of marsh wren and seaside sparrow nests (Kale 1965, Post 1981). Most species of amphibians and reptiles are only transients because of saltwater intolerance or inability to cope with the tides, but 5 subspecies of the diamondback terrapin and 3 subspecies of the salt marsh snake reside in tidal marshes or swamps. Most transient mammals, reptiles, and amphibians live at higher elevations along the tidal marsh fringes, where they retreat to adjacent freshwater marshes, hydric hammocks, or flatwoods during incoming tides.

The black rail is a permanent resident in high tidal marshes dominated by black needlerush along the northern Gulf Coast, in freshwater marshes of cordgrass (*Spartina* spp.) along the St. Johns River, and on Merritt Island in marshes dominated by salt grass (Runde and Wamer 1996). The high marsh areas favored by the black rail are typically saturated to the surface by ground water but are rarely inundated by surface water. Nests are constructed over moist soil in dense herbaceous vegetation ≤ 1 m tall, preferably near hyper-saline patches of bare sand (Legare and Eddleman 2001).

Common loons from Canada, Minnesota, and the Great Lakes winter along the Florida coast up to a few kilometers offshore, especially in the western Panhandle (Clapp et al. 1982, McIntyre 1986). In the eastern Panhandle, loon densities are greatest between Apalachee Bay and St. George Sound, a rich estuarine habitat with many shoals and reefs (Jodice 1991).

Six subspecies of the seaside sparrow once resided in Florida, and a seventh subspecies, the northern seaside sparrow (*Ammodramus m. maritimus*), winters along Florida's Atlantic Coast. Optimal seaside sparrow habitat on the Atlantic Coast consists of the extensive tidal marshes of smooth cordgrass and, in Duval County, patches of black needlerush that occur behind barrier islands. Optimal Gulf Coast habitat for the seaside sparrow is the mixture of dense stands of cordgrass and black needlerush and scattered stands of salt grass that front the Gulf from Port Richey northward to Apalachee Bay, and in the bays behind the barrier islands westward to Escambia Bay (Kale 1996*c*).

The dusky seaside sparrow formerly lived in tidal marshes on northern Merritt Island and 40 km of coastline in Brevard County (Howell 1932), but it is now extinct despite habitat restoration (Leenhouts and Baker 1982) and captive breeding efforts. The Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) lives in the vicinity of ENP and is listed as endangered. The Smyrna seaside sparrow (*A. m. pelonota*) on the northeastern coast of Florida (Baker and Kale 1978) may be synonymous with MacGillivray's seaside sparrow (*A. m. macgillivraii*), and the Wakulla seaside sparrow (*A. m. juncicola*) on the upper Gulf Coast (Stevenson et al. 1978) may be synonymous with Scott's seaside sparrow (*A. m. peninsulae*) (Kale 1996*c*). MacGillivray's seaside sparrow once ranged into Volusia County, but it now ranges only as far south as Duval County (Kale 1983). Scott's seaside sparrow once nested in tidal marshes as far south as upper Tampa Bay, but it now ranges from Port Richey in Pasco County northward into Apalachee Bay, and sporadically farther west to Choctawhatchee Bay in Walton County (Kale 1996*c*). The population at the latter locality may be intermediate between the Scott's and the Louisiana seaside sparrows (*A. m. fisheri*) (Kale 1983), the latter of which breeds in tidal marshes from Santa Rosa County westward into Texas (Kale 1996*c*). The Atlantic Coast and Gulf Coast seaside sparrows appear to be 2 phylogenetically distinct groups based on comparisons of mitochondrial DNA (Avise and Nelson 1989). The relationship is unknown for the Cape Sable seaside sparrow, which is isolated by 300 km from its nearest conspecific, Scott's seaside sparrow (Avise and Nelson 1989).

In Florida, Marian's marsh wren (*Cistothorus palustris marianae*) breeds in tidal marshes dominated by black needlerush from Pasco to Escambia County, whereas Worthington's marsh wren (*C. p. griseus*) breeds in tidal marshes dominated by smooth cordgrass in Nassau and Duval counties (Kale 1996*b*), although it once ranged as far south as Volusia County (Nicholson 1950). Marsh wrens prefer the taller marsh vegetation growing along tidal creeks (Kale 1996*b*).

Three highly ranked rodent taxa primarily inhabit tidal marshes: insular cotton rat (*Sigmodon hispidus insulicola*), Florida or Duke's salt marsh vole (*Microtus pennsylvanicus dukecampbelli*), and Key rice rat (*Oryzomys argentatus*). The insular cotton rat inhabits tidal marsh, freshwater marsh, fields, flatwoods, and maritime hammock margins on Sanibel, Captiva, Pine, and Little Pine islands in Lee County (Layne 1974). The Florida salt marsh vole is a Pleistocene relict that is known only from the type locality at Island Field Marsh along the shore of

Waccasassa Bay in Levy County (Woods et al. 1982). It appears to prefer patches of salt grass and areas near patches of black needlerush. One individual was trapped in 1988 (Woods 1992), and 5 males were trapped in 1996 at the type locality (T. J. Doonan, unpubl. data). Voles may be difficult to trap because of the cyclical nature of their populations and competition for limited resources and space with cotton rats, rice rats, and cotton mice, whose relative abundances appear to fluctuate dramatically (Woods 1988). Extensive suitable habitat remains in the area, but tidal inundation by several tropical storms and hurricanes during the past decade in this region might have affected this taxon. Woods (1992) suggested that a systematic search for additional populations be undertaken, but trapping at other localities has proven fruitless (T. J. Doonan, unpubl. data).

Spitzer and Lazell (1978) described the Lower Keys population of rice rats described as a separate species, the Key or silver rice rat. Humphrey and Setzer (1989) could not distinguish it from other specimens at either the subspecies or species level, and thus assigned it to the marsh rice rat (*Oryzomys palustris natator*). However, Humphrey and Setzer (1989) suggested that an examination of a larger sample of adult males might result in designation of it as a separate subspecies based on colorimetry of the pelage, or from karyotypic or electrophoretic studies. According to Whitaker and Hamilton (1998), Humphrey and Setzer's (1989) analysis had errors in methodology that rendered their conclusions suspect. Because no consensus has been reached on the status of the various taxa of *Oryzomys* (Humphrey and Setzer 1989, Goodyear 1991, Humphrey 1992*g*, Wilson and Reeder 1992, Whitaker and Hamilton 1998, Mitchell 2000), we are following Whitaker and Hamilton (1998) because their interpretation sets apart the island populations, which are most likely to be distinct, and groups the inland forms that are likely intergrading. Their interpretation also preserves *O. argentatus* as a species, which may be important, regardless of biological reality, because it conforms to the current status given on the FWC's list of endangered species. Future analysis of genetic and morphological differences will probably identify different taxa than used here. The Key rice rat is known from 12 islands in the Lower Keys but is apparently absent between Little Pine Key and Key Largo (Goodyear 1987, Mitchell 2000). The Key rice rat uses the interface between upland and marine habitats, including tidal swamp (both buttonwood transition zones and mangrove forests), tidal marsh, coastal grassland, and occasionally freshwater marsh (Goodyear 1987, Mitchell 2000). Limited radiotelemetry data indicate that the more upland buttonwood forest is mostly used for nesting, although foraging occurs here when other habitats flood. Tidal marshes are used for both nesting (in grass tussocks) and foraging, and the edges of mangrove forests are occasionally used for foraging. Primary foraging areas are swales in tidal marsh dominated by saltwort, a major part of the diet of Key rice rats. A male Key rice rat that was radio tracked for 2 months had a 22.8-ha home range (minimum convex polygon), which is much larger than that of other rice rats studied (Spitzer 1983). Fluctuating tide levels made this large home range necessary (Spitzer 1983).

The Lower Keys marsh rabbit described by Lazell (1984) was not a taxon ranked by Millsap et al. (1990). It is state and federally endangered and has apparently been extirpated from several localities (Wolfe 1992). Although these rabbits prefer areas of transitional tidal marsh 1–3 m above sea level that are dominated by thick grasses and shrubs, dispersing subadults travel through mangroves, rockland hammocks, and grassy disturbed areas (Forys and Humphrey 1996, 1999). Lazell (1989) thought its taxonomic status should be reevaluated with additional specimens because it might be a distinct species, and the observed geographic variation might warrant separation into 2 subspecies.

During high tides, diamondback terrapins are able to forage aquatically in the upper reaches of tidal marshes (Tucker et al. 1995). Florida has 5 recognized subspecies of the diamondback terrapin, including 3 endemic subspecies. Mitochondrial DNA variability among the various terrapin subspecies is unusually low, but a distinct "break" in 1 restriction site polymorphism exists between populations north and south of Cape Canaveral, which is approximately the dividing line between Carolina (*centrata*) and Florida East Coast (*tequesta*) terrapins (Lamb and Avise 1992). Ecological studies have been conducted in Florida on the Carolina subspecies (Butler 2000), the Florida East Coast subspecies (Seigel 1980, 1984), the mangrove subspecies (Wood 1994, Miller et al. *in press*), and the ornate subspecies (Boykin, 1999).

The Atlantic salt marsh snake (*Nerodia clarkii taeniata*) is state and federally threatened, and it has the highest biological score of any reptile taxon. It apparently once ranged as far south as Indian River County, but phenotypically distinctive (i.e., striped) individuals are now confined to tidal marshes and swamps of northern Volusia County near New Smyrna Beach, with specimens farther south apparently being intergrades with the mangrove salt marsh (Kochman and Christman 1992). The taxonomic validity of *clarkii* subspecies has been challenged, however (Dunson 1979, Hebrard and Lee 1981). The Atlantic subspecies could be a relict population of past hybridization between the Gulf salt marsh snake (*N. c. clarkii*) and the mangrove salt marsh snake, whose intergrades along the Gulf Coast appear strikingly similar to the Atlantic salt marsh snake (Kochman and Christman 1992). Lawson et al. (1991) reported differences among 3 allozyme loci that supported the existence of a salt marsh group of *Nerodia*, but subsequent research funded by the FWC found no diagnostic allozyme alleles and no significant partitioning of allozyme variation between *N. clarkii* and *N. fasciata* (Karl et al. 2001). The existence of *N. clarkii* was also not supported by mtDNA analysis, and *taeniata* could not be differentiated from *compressicauda* (Karl et al. 2001).

Threats to Tidal Marsh Habitat or Wildlife

Tidal marshes are often used as dumping grounds for dredged spoil, domestic and industrial solid wastes, and liquid industrial wastes near cities, such as Jacksonville and Tampa (Montague and Wiegert 1990). Tidal marshes in urban areas are sometimes bulkheaded and filled for construction sites. Tidal marshes may be impacted by offshore pollution from oil or chemical spills, litter jettisoned by shipping traffic, and nearby upland development. Human activities in the marsh or in the water basin upstream from the marsh can alter freshwater flow into the marsh, and thus affect wildlife communities. The horizontal distribution of salinities affects plant and some wildlife species, and it can be altered by changes in the frequency, duration, timing, and area of flooding of tidal marsh, such as result from marsh channelization (Durako et al. 1985). Freshwater stream flow through tidal marshes tends to increase with increased urban and agricultural development of a water basin because of more surface runoff, but dam building, irrigation farming, and some large-scale industrial development tend to decrease stream flow (Durako et al. 1985). Of the 117,892 ha of tidal marsh mapped by Kautz et al. (1993), 60.0% occurs in conservation areas (Cox et al. 1994).

The greatest human impact on tidal marshes has been that associated with mosquito control efforts. Parallel-grid ditching of tidal marshes during the 1930s had minimal impacts on tidal marsh communities and mosquito populations (Provost 1977), unlike spraying of tidal marshes near cities with DDT, which began in the 1940s. By the 1950s, most of the spraying was discontinued because of the development of DDT-resistant strains of mosquitoes and negative side effects on fish and wildlife (Montague and Wiegert 1990). Spraying was replaced by impounding water in high tidal marshes during summer to break the life cycle of salt marsh mosquitoes (Clements and Rogers 1964) and sandflies (*Culicoides* spp.). By 1972, a total of 14,090 ha of tidal marshes along the Indian River had been impounded because of the impetus of space travel and increasing tourism. Brevard County tidal marshes accounted for 74% of the impounded area, and only 5% of the tidal marshes remained intact (Montague and Wiegert 1990). Semipermanent flooding after impoundment kills many salt marsh plants and replaces them with freshwater emergent vegetation, such as cattails (*Typha* spp.), or submergent vegetation (Bidlingmayer 1982). Dredging and filling of tidal marshes occurred until the 1970s, when governmental policies against wetland destruction stopped most of these activities.

A future potential threat to tidal marshes and their inhabitants is that the world's increasing temperature rise (the greenhouse effect) may cause the sea level to rise faster than the marsh vegetation can compensate. On Florida's west coast, tidal marsh vegetation is replacing coastal forest as trees, primarily cabbage palms, are prevented from regenerating due to saltwater exposure from a rise in sea level (Williams et al. 1999).

Wildlife, such as seaside sparrows and marsh wrens, are vulnerable to local extirpation by hurricanes or other severe storms that cause tides to inundate all the marsh vegetation. Invasion of tidal marsh habitat by woody vegetation, or prolonged impoundment of marshes for waterfowl or mariculture, will cause seaside sparrows and marsh wrens to abandon sites (Kale 1996*b*, *c*). MacGillivray's seaside sparrow no longer ranges as far south along the Atlantic Coast because of invasion of their tidal marsh habitat by mangroves, which began in the 1920s (Nicholson 1928, 1946, 1950), and heavy spraying of DDT for mosquito control in the late 1940s (Austin 1968). Impoundment was apparently the primary reason for extirpation of the dusky seaside sparrow on Merritt Island (Kale 1996*a*). The original range of the Cape Sable seaside sparrow has been constricted by vegetative changes in its coastal grassland habitat resulting from a 1935 hurricane, which apparently eliminated its habitat and population from Cape Sable (Werner 1983, Pimm et al. 1996). Instead of occupying sparse coastal grasslands like at Cape Sable, present populations prefer short-hydroperiod freshwater prairies in ENP and Big Cypress National Preserve (Bass and Kushlan 1982, Pimm et al. 1996, Lockwood et al. 1997). Saltwater intrusion, ORV use, and altered hydrologic conditions have led to hardwood invasion of Cape Sable seaside sparrow habitat (Kushlan et al. 1982). The sparrow's reproductive potential is limited by changes in the vegetative composition of marl prairies resulting from long-term hydrologic changes and fire (Pimm et al. 1996, Nott et al. 1998), and from summer rains that limit the breeding season by flooding nests (Lockwood et al. 1997). Population numbers of this short-lived habitat specialist declined nearly 50% between 1992 and 1996 (Curnutt et al. 1998). Restoration of hydrological conditions in the Everglades to their original patterns is necessary to maintain suitable breeding conditions for this species, especially since individuals generally remain within 1 km of their breeding grounds and do not move among populations (Lockwood et al. 2001) .

Population viability analysis indicates that the Lower Keys marsh rabbit will go extinct during the next 20–30 years if current mortality rates persist (Forys 1995). It once ranged throughout the Lower Keys but is now limited to 41 subpopulations occurring in 3 distinct metapopulations: Saddlebunch, Boca Chica, and Big Pine (Forys and Humphrey 1999). The main source of mortality is predation by house cats. Because marsh rabbits apparently rely on dense ground cover, particularly in the mid- and high marsh, they may be threatened by exotic vegetation or human activities—ORV use, mowing, and trash dumping—that impact the ground cover (Forys 1995). Marsh rabbits live in a highly fragmented mosaic of native and disturbed patches; the marsh transition zone they occupy lies between uplands and protected wetlands, and it is under pressure from developers (Williams 1991, Forys and Humphrey 1996).

In the early 1900s, many diamondback terrapin populations declined, particularly in northeastern states, due to heavy exploitation for food, but the popularity of terrapins declined after World War I (Carr 1952, Pritchard 1979), and some populations gradually recovered (Coker 1951). Coastal development may be detrimental to some terrapin populations (Hurd et al. 1979, Roosenburg 1991, Mann 1995, Wood 1997), but the major threat to terrapin populations nowadays is probably drowning in crab traps (Bishop 1983, Mann 1995, Roosenburg et al. 1997, Wood 1997) and possibly in shrimp trawl nets. Raccoons, fish crows (*Corvus ossifragus*), and other predators often eat terrapin eggs (Burger 1977, Roosenburg 1992, Goodwin 1994, Butler 2000). Terrapins are philopatric to nesting sites, and waterfront development and construction of bulkheads and seawalls have eliminated entire nesting beaches or crowded terrapins into restricted, suboptimal nesting areas (Seigel 1980, Roosenburg 1991).

Tidal Marsh Conservation and Management Strategies

Current governmental policy against wetland destruction now protects most tidal marshes. In tidal marsh and other wetlands that have been impounded for mosquito control, staggered drawdowns can control water levels, restrict emergent vegetation, increase invertebrate production, and provide habitat for wintering shorebirds and waterfowl (Rundle and Fredrickson 1981, Clarke et al. 1984, Brush et al. 1986, Eldridge 1992, Helmers 1992, Rehfisch 1994). Options for managing impounded tidal marshes are (1) eliminating impoundments, (2) creating vestigial impoundments, (3) using leaky impoundments, (4) permanent flooding, (5) seasonal flooding, (6) seasonal flooding with added potholes, and (7) intensively managing for waterfowl foods (Montague et al. 1985). Prescribed fire can prevent tidal freshwater marshes from being invaded by woody species and can increase preferred wildlife food plants in some brackish marshes (Chabreck 1981, Chabreck et al. 1989). Cover burns are conducted in marshes when several centimeters of water are present to prevent damage to plant roots (Nyman and Chabreck 1995). Cover burns conducted every 1 to 5 years in fall and winter in tidal marshes promotes the growth of three-square (*Scirpus americanus*), a preferred waterfowl food, over saltmeadow cordgrass (*Spartina patens*) (Chabreck 1981), and at burning this time of year avoids destroying nests and killing young wildlife (Nyman and Chabreck 1995).

Mosquito control impoundments are secondarily managed for waterfowl and other wildlife at Merritt Island (Leenhouts 1983, Montague et al. 1985), Ding Darling, and Hobe Sound NWRs. The water in impounded marshes has lower salinity than estuarine water and thus provides habitat for alligators and certain fish (especially freshwater species), and dike-using waterfowl, wading birds, and upland mammals (Montague et al. 1985). Dikes and roads also provide access to persons interested in fishing, hunting, and viewing wildlife, but estuarine fish and shellfish are precluded from using these former tidal marshes (Montague et al. 1985).

Tidal marshes become unsuitable for seaside sparrows and marsh wrens when they are invaded by too many trees and shrubs due to climatological changes (permitting the northward migration of mangroves) or drainage, or when they are impounded for mosquito control or waterfowl management. Periodic fires are essential to maintain suitable seaside sparrow habitat by inhibiting invasion of hardwood species and preventing buildup of dead plant material (Werner 1975). Most Cape Sable sparrow habitat is protected in ENP and Big Cypress National Preserve, but aggressive control of exotic species and prudent use of fire management need to be continued to maintain suitable habitat (Curnutt 1996).

Kale (1996*c*) recommended that the present listing status of the endemic populations of seaside sparrows be maintained and that Florida populations of the MacGillivray's and Louisiana seaside sparrows, plus the Choctawhatchee Bay population, be designated as species of special concern. Although MacGillivray's seaside sparrow and Worthington's marsh wren populations north of the St. Johns River appear to be stable, they should be regularly monitored because these taxa inexplicably disappeared in the 1970s from seemingly suitable habitat between Matanzas Inlet and the St. Johns River (Kale 1996*b,c*). Habitat suitable for seaside sparrows is protected in conservation lands along 40% of the northeastern coast (Matanzas Inlet to Amelia Island), 25% of the central Gulf Coast (Tampa Bay to Pepperfish Key, Dixie County), and only 10% of the Panhandle Coast (St. Joseph Peninsula to Pensacola), so habitat conservation efforts should be considered for subspecies and populations living in these areas (Cox et al. 1994).

Much of the northern Gulf Coast range of black rails is protected in publicly owned refuges or WMAs. Much of the black rail habitat in the St. Johns River Valley is also publicly owned; however, substantial areas are in private ownership and used for cattle range. The St. Johns River Valley population of black rails may be susceptible to extended droughts and mosquito control activities (Runde and Wamer 1996). Black rails would benefit from habitat management practices, such as water-level manipulations or fire, that maintain dense stands of perennial emergent vegetation over shallow water or moist soils (Runde and Wamer 1996).

Local populations of Lower Keys marsh rabbits are socially isolated, although subadults may move between habitat patches. Rabbits would benefit from conservation efforts that prevent further fragmentation and destruction of existing upper-marsh habitat, and maintain native habitats (hammocks, mangroves, transition zone) between marsh areas to serve as corridors for dispersing rabbits (Forys and Humphrey 1996). However, the most effective management strategy to decrease the risk of extinction in all 3 metapopulations would be to develop a plan to reduce populations of feral and pet cats on public (66% of habitat) and private lands (Forys and Humphrey 1999). Rabbit populations need to be monitored, which might be economically and efficiently accomplished by counting fecal pellets (Forys and Humphrey 1997).

Tidal marshes and swamps along the Halifax and Indian rivers in Volusia County from 5 km north of Ponce de Leon Inlet southward to Oak Hill need to be protected to preserve the Atlantic salt marsh snake, and population surveys of this area need to be conducted (Kochman and Christman 1992). Surveys are also needed to ascertain the extent of the striped *taeniata* phenotype in tidal marshes in northern Volusia and southern Flagler counties and on barrier islands south of Volusia County. Wetland alteration through draining, diking, and impounding has probably promoted hybridization with the adjacent freshwater Florida water snake (*Nerodia fasciata pictiventris*).

In 1996, the FWC established a personal possession limit of 2 diamondback terrapins and prohibited commercial trade. An effort should be made to determine the extent of terrapin mortality from crab trapping and means of reducing this mortality.

Tidal Swamp Habitat Description

Tidal swamps occur in Florida along relatively flat coastal areas with low wave energy. They are characteristically dense, low (up to 25 m tall under ideal conditions, however) forests composed of red mangrove, black mangrove (*Avicennia germinans*), white mangrove, and buttonwood that occasionally occur in zones determined by varying water depths. Red mangroves have a complex network of "prop" roots and typically inhabit the deepest water. Black mangroves have shallow "cable" roots and an extensive carpet of pneumatophores (i.e., short, vertical, aerating branches), and they usually inhabit the intermediate zone. White mangroves, with their dense root mats, and buttonwood inhabit the highest elevations. Other plant species associated with tidal swamps are salt grass, black needlerush, spikerush, glasswort, smooth cordgrass, sea purslane, saltwort, and sea oxeye. The anaerobic soils range from sand to mud and are usually always saturated with brackish water, and the soils are inundated with standing water at high tides. A surface layer of peat composed of detritus is usually present in older tidal swamps (Odum and McIvor 1990).

The size and extent of tidal swamps are determined by climate, salinity, tidal fluctuation, terrestrial nutrient runoff, substrate, and wave energy (Odum et al. 1982). Mangroves require an average annual water temperature $\geq$19^{o}C (Waisel 1972), and they cannot tolerate rapid temperature fluctuations of >10^{o}C or freezing temperatures for more than a few hours (Odum and McIvor 1990). The most extensive tidal swamps, including red and white mangroves, occur south of Cedar Key along the Gulf Coast and south of the Ponce de Leon Inlet on the Atlantic Coast at approximately 29^{o} 10' N latitude (Rehm 1976, Teas 1977). Black mangroves occur in the form of semipermanent shrubs as far north as portions of the northern Gulf Coast and at 30^{o} N latitude on the Atlantic Coast (Savage 1972) because they can resprout from their roots following severe freeze damage (Sherrod and McMillan 1985). In 1982, the National Wetlands Inventory estimated that mangrove forests covered 272,725 ha (Lewis et al. 1985), whereas the Coastal Coordinating Council (1974) estimated the coverage at 189,725 ha ± 15%. The four southern counties of Dade, Collier, Monroe, and Lee contained 90% of the mangrove area (Coastal Coordinating Council 1974), with the most luxuriant growth occurring in the Ten Thousand Islands area of Collier County (Florida Natural Areas Inventory 1990).

A classification of tidal swamps based on hydrologic flushing includes (1) overwash swamps on islands that undergo frequent tidal inundation, (2) narrow fringe swamps along waterways, (3) riverine swamps on floodplains, (4) basin swamps in depressions that are slightly inland, (5) hammock swamps that are similar to basin swamps but at a slightly higher elevation, and (6) scrub swamps growing on hard substrates such as limestone marl (Lugo and Snedaker 1974). A simpler version of this classification system has 3 major mangrove community types: riverine forests, fringe forests, and basin forests (Cintron et al. 1985, Lugo et al. 1990). Tidal marshes are often found along the inland boundary of tidal swamps, and tidal swamps may occur adjacent to shell mounds, coastal berms, maritime hammocks, and other coastal communities (Florida Natural Areas Inventory 1990).

Tidal Swamp Wildlife Communities

Tidal swamp is the primary habitat of 3 reptile taxa and 8 avian taxa with biological scores $\geq$17 (Appendix A). Tidal swamps provide valuable habitat for 220 fish species, 24 amphibian and reptile species, 18 mammal species, and 181 bird species—18 wading birds, 25 shorebirds, 29 floating and diving water birds, 20 birds of prey, and 71 arboreal birds (Odum et al. 1982). Tidal swamps are important nursery areas for many recreational and commercial fishes and invertebrates (Heald and Odum 1970, Lewis et al. 1985). Many of the larger vertebrate species are not restricted to tidal swamps but instead visit them seasonally or opportunistically. Tidal swamps provide the primary nesting or foraging habitat for several high-ranking avian taxa: Florida prairie warbler (*Dendroica discolor paludicola*), Cuban yellow warbler (*Dendroica petechia gundlachi*), gray kingbird, black-whiskered vireo. Other avian species that will nest in mangroves are the white-crowned pigeon, bald eagle (Shea and Robertson 1979), swallow-tailed kite (Meyer and Collopy 1995), short-tailed hawk (Millsap et al. 1989), and snail kite (Dreitz and Duberstein 2001). Many wading bird species nest and roost in mangroves, including several target taxa: reddish egret (*Egretta rufescens*), roseate spoonbill, yellow-crowned night heron, and wood stork (Ogden 1996). Mangroves are also the primary habitat for the mangrove diamondback terrapin (*Malaclemys terrapin rhizophorarum*) and mangrove salt marsh snake (*Nerodia clarkii compressicauda*), and red mangrove leaves are the top browse species for Key deer (Klimstra and Dooley 1990). Other high-ranking taxa that may partially utilize tidal swamps are the manatee, black bear, Everglades mink, Big Cypress fox squirrel, peregrine falcon, Atlantic ridley, crocodile, and indigo snake. Many neotropical migratory birds seasonally utilize this highly productive habitat to help fuel their long-distance migrations (Day et al. 1989).

The major nutrient inputs for mangroves probably come from upland, terrestrial sources (Carter et al. 1973) and localized sources like wading bird rookeries (Onuf et al. 1977). The amount of tidal flushing affects the productivity of a particular mangrove ecosystem (Twilley et al. 1986). Mangrove roots entrap sediments, serve to recycle nutrients from upland areas and from tidal import, and provide areas of substrate attachment and shelter for many marine and estuarine organisms. The continuous fall of mangrove litter produces up to 80% of the total organic material available in the aquatic food web (Odum 1970, Lugo et al. 1980, Benner et al. 1986, Camilleri and Ribi 1986, Snedaker 1989).

The short-tailed hawk was included in the interior dry prairie section, but in South Florida, it often forages along the ecotone between tidal marsh and tidal swamp, and it roosts in mangroves (Millsap et al. 1989). The short-tailed hawk winters primarily southward of Lake Okeechobee, particularly in ENP (Ogden 1974). Boot Key is an important foraging and roosting site for migrating raptors (Brashear 1998).

The white-crowned pigeon nests on mangrove islands free of raccoons and human disturbance (Strong et al. 1991). Many of the nesting keys are within ENP, in the Upper Keys, or in national wildlife refuges in the Lower Keys, which are protected from human disturbance by restricted public access (Bancroft 1996).

The narrow, mangrove-lined shores of the Everglades Coast provide habitat for wintering shorebirds. The most common wintering shorebird in the Everglades is the western sandpiper (*Calidris mauri*). Important sites in the Everglades for highly ranked wintering shorebirds are Lake Ingraham, Tigertail Beach, and Cape Romano for Wilson's plovers, and Snake Bight Channel for marbled godwits (Sprandel 1996, Sprandel et al. 1997).

Two-thirds of Florida's 350–400 breeding pairs of reddish egrets occur in Florida Bay and the Keys, where they nest in red or black mangroves, Brazilian pepper, or other vegetation on mangrove keys and on dredged-material islands located near suitable foraging habitat and free from terrestrial predators. The reddish egret is the rarest heron in Florida and the rest of the United States, despite an apparently sustained population increase in Florida since the 1930s and reoccupation of nearly all of its former range since the days of plume hunting, when its population may have been 10 times larger (Paul 1996). Over 90% (≈1,000 pairs) of Florida's population of roseate spoonbills are found in Florida Bay, where they primarily nest on coastal islands in red or black mangroves, sometimes in loose colonies with reddish egrets. These spoonbills primarily forage in the fringing mangroves, the marine-estuarine ecotone, and the freshwater Everglades (Bjork and Powell 1996). In the Tampa Bay area, spoonbills primarily nest in Brazilian pepper and black mangroves on a spoil island, and in red mangroves on natural islands (R. Paul, unpubl. data, from Bjork and Powell 1996).

In Florida, the black-whiskered vireo primarily lives in tidal swamps but also inhabits adjacent tropical hammocks and other hardwood forests. The black-whiskered vireo breeds throughout the Florida Keys and along the coastline of the peninsula irregularly northward to the Anclote Keys, Pasco County, in the west and New Smyrna Beach, Volusia County, in the east. The species has been reported as far inland as Tallahassee in Leon County and Royal Palm Hammock in ENP, and it has been reported as far west as Pensacola (Merritt and Owre 1996).

The Cuban yellow warbler and Florida prairie warbler are the only 2 warbler species among fewer than 10 passerine species that breed regularly in mangrove habitats (Robertson 1955, Odum et al. 1982, Robertson and Kushlan 1984). The Cuban yellow warbler almost exclusively inhabits red and black mangrove forests (Robertson 1978), preferring red mangroves fronting on relatively deep water, such as the channels and moats that border some small islands. However, it also uses stands of tree-sized black mangroves on some Florida Bay islands (J. Prather, pers. commun. to Hoffman 1996). Since the species was discovered near Key West in 1941, it has spread through the Lower Keys, Florida Bay, Biscayne Bay north to Virginia Key (Robertson 1978), and into the Ten Thousand Islands area (Hoffman 1996). The Florida prairie warbler presently breeds in a narrow strip extending from the southern Keys northward to northern Pasco County on the Gulf Coast, and to Brevard and probably Flagler County on the Atlantic Coast (Webber 1996). It nests almost exclusively in mangroves and occasionally in oak hammocks adjacent to mangroves (Stevenson and Anderson 1994).

Mangrove terrapins in the Keys spend much of their time buried in mud covered by very shallow water in the interior of mangrove islands (Wood 1994). The terrapin population in Florida Bay is morphologically distinct from the population in the Keys and occurs at higher densities (Wood 1994). The mangrove terrapin is relatively sedentary, like other subspecies that have been studied, and individuals never or seldom move between islands (Wood 1994, Miller et al. *in press*). Information is lacking on the nesting habitat and reproductive success of mangrove terrapin population (Wood 1994, Miller et al. *in press*).

The mangrove salt marsh snake is closely associated with red mangroves, and its geographic range approximates that of this plant (Lawson et al. 1991). Gene flow between populations of the freshwater *Nerodia fasciata* and saltwater *N. clarkii* primarily occurs when habitats are disturbed by human destruction or hurricanes (Lawson et al. 1991). No intrinsic barriers to the production of viable, fertile hybrids exist, but ecological adaptations usually keep them separate. A recent genetics study indicates that *N. clarkii* is not distinct from *N. fasciata*, but significant differentiation among populations of the mangrove subspecies was found in areas with (i.e., Tampa Bay and Sarasota) and without (i.e., Lower Keys) high levels of habitat modification (Karl et al. 2001).

Most crocodiles in Florida live in tidal swamps as far north as southern Biscayne Bay in Dade County on the Atlantic Coast and Sanibel Island on the Gulf Coast (Moler 1992*a*). Crocodiles have been mostly eliminated south of Key Largo, and breeding is restricted to North Key Largo, some islands in Florida Bay, and along the coast from southern Biscayne Bay (Turkey Point) westward to Cape Sable (Moler 1992*a*). Crocodile reproduction has increased in recent years (Brandt et al. 1995).

Threats to Tidal Swamp Habitat or Wildlife

Established mangrove ecosystems are probably steady-state cyclical or catastrophic climax communities that undergo succession in response to external perturbations: intrusions of freezing temperatures, hurricanes, periodic droughts, or fire (Lugo 1980). In 1962 and during the late 1970s and early 1980s, freezing weather caused widespread but uneven mortality of all mangrove species as far south as Naples on the Gulf Coast and West Palm Beach on the Atlantic Coast (Odum and McIvor 1990).

Tidal swamps can be devastated by hurricanes, but the area occupied is too large to be heavily damaged by a single storm. In 1935, a strong hurricane with wind velocities up to 320 km/hr caused severe damage to mature mangrove forests around Flamingo and Cape Sable, and it destroyed >90% of the epiphytes in tidal swamps (Palmer 1944). In 1960, Hurricane Donna destroyed large areas of the Everglades' mangrove forests (Craighead and Gilbert 1962). In 1992, Hurricane Andrew destroyed ≥75% of the mangroves in areas of ENP, but the fringing forests of low (<3 m tall) red mangroves along waterways and the basin forests of dwarf mangroves suffered much less damage (Smith et al. 1994). Tall mangrove forests suffered the most damage, with red and black mangroves in the 20–25 cm DBH class and white mangroves in the 15–20 cm DBH class suffering the greatest initial mortality (mortality was reduced for trees >30 cm DBH) (Smith et al. 1994). Black mangroves suffered significantly less mortality than red or white mangroves; however, delayed mortality occurred, especially in white mangroves, large black mangroves, and the smallest trees of all 3 species. In areas where Brazilian pepper was mixed in with mangroves, this exotic invasive species recovered faster than the surviving mangroves. On Elliott and Old Rhodes keys, severe mangrove destruction resulted from an intense north-to-south storm surge (Smith et al. 1994).

The rate of the rising sea level has apparently been 10–15 cm per century for the past few centuries (Aubrey and Emery 1983), and it may accelerate in the near future to ≥1 m per century due to global warming or groundwater withdrawal (Hoffman 1984). Mangroves will probably be able to keep pace with relatively high rates of sea level rise, or even expand their coverage if sedimentation rates are high, although their coverage may decrease in places where a steep terrestrial gradient prevents inland expansion (Odum and McIvor 1990). A rapid sea level rise resulting from global warming could potentially lead to extensive erosion of mangrove islands and shores.

The exact amount of mangrove habitat destroyed by humans in Florida is unknown but has been conservatively estimated at ≈3–5% overall, with higher losses in certain localities: Tampa Bay, near Sarasota, around Marco Island, in the Florida Keys, and along the lower Atlantic Coast (Odum et al. 1982, Odum and McIvor 1990). Lewis et al. (1985) estimated that 23% of Florida's mangrove habitat has been lost. Approximately 4,453 ha of mangroves were estimated lost between 1943 and 1970 in Collier, Monroe, and Dade counties (Birnhak and Crowder 1974), and an estimated 9,522 ha of tidal swamps and marshes have been lost to dredge-and-fill activities (Lindall and Saloman 1977). Tidal swamps have mostly been destroyed through diking and flooding, ditching for mosquito control, and dredging and filling (Florida Natural Areas Inventory 1990). Any activity that results in long-term flooding of mangrove prop roots and pneumatophores will cause mass mortality (Odum and Johannnes 1975). Of the 221,221 ha of tidal swamp mapped by Kautz et al. (1993), 78.9% is contained in conservation areas (Cox et al. 1994).

Mangroves are susceptible to damage from herbicides, oil spills, high concentrations of suspended solids, and permanent flooding of their aerial roots (Odum et al. 1982). The red mangrove is particularly sensitive to herbicide damage (Teas and Kelly 1975). Human activities in adjacent upland areas that affect the quantity, quality, and timing of the input of fresh water have destroyed some tidal swamps by changing estuarine salinity and creating chemical pollution (Odum and Johannes 1975), often allowing the invasion of non-mangrove species (Florida Natural Areas Inventory 1990). Changes in freshwater flow can permit Australian pine and Brazilian pepper to invade mangrove communities (Anonymous 1999). Causeways and undersized culverts can damage mangroves by restricting tidal circulation; thereby lowering salinities enough that freshwater vegetation can invade (Odum and McIvor 1990). In contrast, saltwater intrusion and reduced freshwater flow have allowed the inland expansion of mangrove forests in many areas of South Florida during the past 50 years (Reark 1975, Teas 1979, Ball 1980).

The greatly reduced freshwater discharge into Florida Bay (Smith et al. 1989, Walters et al. 1992) has increased the salinity, altered the estuarine ecosystem, decreased the secondary productivity, and affected many wildlife populations, such as foraging wading birds (Browder 1985, Tilmant et al. 1989). Eutrophication, algal blooms, increased turbidity, and an abundance of pathogens in Florida Bay have contributed to mass mortality of sponges, sea grass beds, and nursery habitats (Fourqurean and Robblee 1999). The recent dieoff of mangroves in the interiors of some islands in Florida Bay may be attributable to hypersaline conditions resulting from reduced freshwater inflow from upstream water management and drought (Bjork and Powell 1996).

In 1985, Florida adopted specific legislation to protect tidal swamps (Florida Natural Areas Inventory 1990), but extensive areas of mangrove forests were cleared prior to regulations or after forests were killed by freezing weather. The age of wholesale dredge-and-fill seems to be over (Frayer and Hefner 1991), but the widespread practice of waterfront mangrove trimming and other piecemeal damage continues. Many waterfront homeowners cut the mangroves between their property and the water, and the state's ability to stop outright destruction of mangroves is dependent upon the vagaries of court's decisions. Under the Mangrove Trimming and Preservation Act, a permit from FDEP is required to cut mangroves, but the Mangrove Protection Rule passed in 1995 allows homeowners with <46 m of waterfront in a mangrove riparian fringe ≤15 m wide to trim all their mangroves that are <3.0 m tall to a minimum height of 1.8 m without a permit. If the waterfront is longer, only 65% of the mangroves may be trimmed without a permit. A professional mangrove trimmer can trim mangroves 3.0–7.3 m tall without a permit, but mangroves taller than 7.3 m can be trimmed only with a permit. In Sarasota Bay, 33.8% of the 927 mangrove stands were trimmed to some extent, and in 39.3% of the trimmed stands, the cut portion covered more than 66% of the area of the stand (Estevez 1992). The recovery potential of mangrove species to pruning is highest for the white mangrove and lowest for the red mangrove (Snedaker 1982). Habitat fragmentation of the linear mangrove habitat due to urban sprawl may help account for increased population differentiation of the mangrove salt marsh snake near Tampa Bay and Sarasota (Karl et al. 2001).

Mangrove trimming reduces the amount of habitat useful to Florida prairie warblers. In 4 Southwest Florida aquatic preserves, the Florida prairie warbler was not observed at any time of the year in any of the 3 trimmed study sites (Beever 1989). On Raccoon Key in the Lower Keys, the Cuban yellow warbler was apparently absent from areas where the red mangrove fringe had been devastated by feral rhesus macaques (*Macaca mulatta*) (Hoffman 1996). Many mangrove-dependent bird species will not roost overnight or nest in canopies lower than 2–3 m, and rookeries that have been cut are abandoned (Anonymous 1999). Freezing temperatures that killed mangroves apparently reduced the black-whiskered vireo population along the Gulf Coast (R. Paul, pers. commun. to Merritt and Owre 1996). Small, insectivorous passerines are at greatest ecological risk from mosquito control, and Tiebout and Brugger (1995) estimated that a population of the black-whiskered vireo exposed to one application of fenthion (an organophosphate commonly sprayed for mosquito control) could potentially suffer 42% mortality.

Brood parasitism by cowbirds (*Molothrus* spp.) is a major threat to the Cuban yellow warbler (Cruz et al. 1985), Florida prairie warbler (Nolan 1978, Webber 1996), and black-whiskered vireo (Atherton and Atherton 1988, Wiley 1988, Post et al. 1990). South Florida is currently being colonized by the brown-headed cowbird (*Molothrus ater*) moving southward in the peninsula, and by the shiny cowbird from the West Indies (Hoffman and Woolfenden 1986, Post et al. 1993).

Coastal wading bird rookeries are lost when islands are connected to adjacent land by filling and no longer provide isolation from terrestrial predators. Expansion of raccoons onto additional mangrove keys could represent a serious threat to breeding populations of the white-crowned pigeon (Allen 1942, Strong et al. 1991). Raccoon distributions on mangrove keys may be partially limited by the frequency of large hurricanes. Human activity on the mainline Keys could increase and accelerate the dispersal of raccoon populations into the heart of the pigeon's nesting range (Bancroft 1996).

Extensive foraging areas for wading birds have been lost in Sarasota Bay, Boca Ciega Bay, the Florida Keys, and elsewhere as channels have been dredged, or flats filled and bulkheaded. The permanent loss of intertidal flats due to dredging and filling—particularly near Sarasota, Bradenton, St. Petersburg and Clearwater—is probably the greatest single obstacle to the recovery from plume hunting of significant populations of reddish egrets on the Gulf Coast (Paul 1996). Spoonbill populations nesting in eastern Florida Bay declined from 1955 to1985 because of a decrease in foraging habitat in the Upper Keys due primarily to commercial and residential development (Bjork and Powell 1996). Roseate spoonbill reproductive success is apparently sensitive to hydropatterns on their foraging grounds (Bjork and Powell 1994). In the Keys, nest densities of the great white heron (*Ardea herodias*) were highest on islands 2–10 ha in size, which also attracted nesting black skimmers, gulls, and terns. These small estuarine islands are vulnerable to erosion and boating disturbances (Erwin et al. 1995).

Despite official protection, staffing at most refuges and sanctuaries is inadequate. Boaters, campers, and their pets may disturb wading bird colonies and cause nesting failures. This has been observed in the Lower Keys, Estero Bay, Clearwater Harbor, and St. Joseph Sound (Paul 1996). Evidence of changes related to human disturbance occurred at a major spoonbill colony on a Florida Bay island, where nesting numbers declined sharply concurrent with increased boating activity that caused repeated flushing of nesting birds (Bjork and Powell 1996). A no-access zone 33 m wide was posted around the island and patrolling increased, and nesting numbers more than doubled the following season (Bjork and Powell 1994).

Tidal Swamp Conservation and Management Strategies

The best management practice is to preserve tidal swamps and the adjacent ecosystems that affect them (Odum et al. 1982). The mangrove forests of southwestern Florida are highly dependent on the ecological health of the Everglades and Big Cypress Swamp (Odum et al. 1982). Where mangroves must be destroyed, the losses should be ameliorated through mitigation or modified development that places canals and seawalls as far inland as possible (Voss 1969, Tabb and Heald 1973).

The most important factors for successful restoration and creation of tidal marsh and swamp habitats are (1) correct elevations for the target plant species, (2) adequate drainage provided by gradual slopes and sufficient tidal connections, (3) appropriate site selection to avoid wave damage, (4) appropriate plant materials, and (5) protection from human impacts (Lewis 1990). Mangroves can be planted in suitable areas where they did not previously exist or were destroyed (Pulver 1976). The mitigation practice of transplanting mangroves is widespread in Florida, and several private firms specialize in it (Odum and McIvor 1990). The black mangrove is easier to transplant as a seedling than the red mangrove, with properly designed plantings having a 75–90% success rate (Teas 1977). Other advantages of the black mangrove are (1) rapid establishment of its pneumatophore system, (2) an underground root system better adapted to holding sediments, (3) cold tolerance, and (4) better tolerance of "artificial" substrates such as dredge spoil (Teas 1977). A new technique allows the planting of red mangroves in sites where significant tidal action, wave activity, or upland runoff previously prevented successful rooting by young red mangroves (Riley 1995/1996). This encased planting method uses a PVC pipe to protect the mangrove seedling until it is about 3 years old.

Mangrove-nesting Cuban yellow and Florida prairie warblers are relatively secure from direct human disruption because most suitable mangrove stands are at least partially protected within ENP, Biscayne National Park, state aquatic preserves, and NWRs in the Lower Keys. About 113,000 ha of mangroves were protected as of 1981 (Odum et al. 1982), and studies by the Tampa Bay National Estuary Program may help restore some mangroves in Tampa Bay (Hoppe et al. 1993). Greater restrictions on mangrove cutting and ditching, diking, or spraying for mosquito control would probably benefit the 2 warbler species and the black-whiskered vireo (Merritt and Owre 1996, Webber 1996). Reliable means, perhaps biochemical, should be devised to discriminate between the two races of prairie warbler in winter so that the winter habitat needs of the Florida prairie warbler can be identified. The Florida Keys population is not strongly isolated, but it is sufficiently differentiated to suggest reduced genetic exchange with populations in Puerto Rico and Jamaica (Zwartjes 2001). If systematic surveys confirm that Florida prairie warbler populations are declining, their listing status should be changed (Webber 1996).

Cowbird populations in South Florida should be monitored, and if they become numerous, intensive investigations of nest parasitism rates should be undertaken at a variety of sites. The ongoing study by J. W. Prather and A. Cruz on the breeding success of the Cuban yellow warbler, Florida prairie warbler, black-whiskered vireo, and other potential cowbird hosts in the Keys and Everglades should provide valuable baseline data for determining the effects of cowbird parasitism (Hoffman 1996). Extensive control of cowbirds using mangrove forests is probably not feasible because of logistical problems, but local control may be an option (Post et al. 1990). Research should be conducted to determine whether human-created openings, including those made by trimming, increase the likelihood that cowbirds will enter mangrove forests and parasitize warblers, as has been found elsewhere (Brittingham and Temple 1983). The key to conserving these species may be maintaining mangrove habitat in blocks undissected by roads, power lines, and other strips of habitat attractive to cowbirds (Webber 1996).

Most of the known breeding sites of the reddish egret are protected within the boundaries of Everglades and Biscayne national parks, and at Merritt Island, Ding Darling, Pinellas, Key West, and Great White Heron NWRs. Other breeding sites are in sanctuaries maintained by the National Audubon Society, where terrestrial predators are annually trapped and removed on the Gulf Coast. Wetland regulations somewhat protect foraging areas for wading birds on private lands. Channel dredging has resulted in the creation of hundreds of islands in Florida, some of which have been occupied by large mixed-species bird colonies (Paul 1996). Two of the most important nesting sites for the reddish egret in Florida are spoil islands at Alafia Bank (Tampa Bay) and Haulover (Merritt Island), and spoil islands near Vero Beach, Merritt Island, Sarasota, and Clearwater are also used (Toland 1991, Paul 1996). Reddish egrets have also exploited new foraging areas along the shores of dredged-material islands, large diked disposal areas, large shallow mosquito-control impoundments along the Atlantic Coast, and shallow flats constructed as part of coastal habitat mitigation projects (Paul 1996). For many waterbirds nesting in coastal estuaries, such as in Florida Bay, maintaining numerous small islands (<20 ha in size) may be more beneficial than maintaining larger islands or reserves (Erwin et al. 1995).

Increased staffing at refuges and sanctuaries would allow more comprehensive monitoring and patrolling of coastal wading bird colonies and increased educational activities. Increased survey efforts are needed to locate additional nesting sites, initiate protective measures, and update population assessments. Comprehensive plans for community developments should include sufficient setbacks to protect the habitat and hydrological function of tidal creeks. Special land-use planning provisions should address heronry protection, including the establishment of buffer zones around island colonies of 100–125 m where watercraft access is prohibited (Erwin 1989, Rodgers and Smith 1995).

We need a better understanding of the ecological processes that permitted Florida Bay's estuaries to once support huge populations of wading birds. Restoration of water quality and natural hydropatterns may be impossible in Florida Bay because of extensive water demands by South Florida's urban areas, alteration of historic drainage patterns, and water pollution by agricultural fertilizers and pesticides. The mangrove ecotones and mouths of tidal creeks need protection because they are often the primary foraging areas for wading birds. Newly discovered wading bird colonies should be protected and monitored, and important colonies should be included in the Wading Bird Protection Initiative (Douglass et al. 1993, Sewell et al. 1995). Monitoring of mercury concentration in spoonbill nestlings should be continued, particularly in northeastern Florida Bay colonies where concentrations are at levels warranting further investigation (Bjork and Powell 1996).

Key rice rat populations are unstable, and large contiguous expanses of habitat, particularly tidal swamps adjacent to transitional uplands, need to be preserved to sustain long-term viability of populations (Mitchell 2000). Wherever possible, normal drainage patterns should be restored in areas that have been filled (Mitchell 2000). It is important to periodically monitor all known populations and to try to identify new populations (Forys et al. 1996, Mitchell 2000).

Most documented adult mortality of the American crocodile occurs along U.S. Highway 1 adjacent to 3 pairs of usually submerged culverts. Replacing the culverts with bridges or box culverts with sufficient clearance for swimming crocodiles could prevent most of the highway mortality (Moler 1992*a*). An educational campaign is needed to inform South Florida residents about the population status and biology of the crocodile and to encourage tolerance of its existence (Moler 1992*a*).

Conservation Tasks

Seventy-two tasks have been identified for lizards, snakes, turtles, rodents, mink, shorebirds, seabirds, wading birds, seaside sparrows, marsh wrens, mangrove-nesting songbirds, neotropical migrant songbirds, and migrant raptors utilizing coastal habitats. Eleven conservation tasks specifically target beach mice, 10 tasks target various species of wading birds, 10 tasks target shorebirds, 5 tasks target the many species of declining neotropical migrant birds, and 4 tasks target the bald eagle, seaside sparrow, or coastal arboreal songbirds (Appendix B).

We have not identified any conservation tasks for sea turtles or the manatee because a great deal of research has already been conducted on these species, and annual population monitoring programs are already in place. Until 1999, manatees and sea turtles were under the jurisdiction of the Florida Department of Environmental Protection, but the FWC's Bureau of Protected Species Management is now responsible for implementing management activities for the protection of these marine species. Manatee protection plans have been approved by the FWC for 5 of 13 key counties. The Sea Turtle Section is responsible for (1) recovery program planning, management, and administration; (2) coordination of research and management activities; (3) habitat protection; and (4) education. Additional or more effective means to reduce manatee and sea turtle mortality need to be found.

Numerous geographically isolated subspecies of widespread taxa have been described from tidal marshes and coastal grasslands in Florida, but the extent of differentiation of these populations from parent populations is unclear for some taxa. Six tasks address the need for systematic reviews of various taxa (Appendix B). Conservation programs for these taxa should focus first on highly differentiated populations.

Important habitat areas for coastal strand, tidal marsh, and coastal grassland target taxa are only generally known, and much existing information has not been synthesized and compiled. Accordingly, important habitat areas for target tidal marsh and grassland vertebrates—mink, beach mice, seaside sparrows, marsh wrens, rails, diamondback terrapins, and salt marsh snakes—have not been identified, and surveys are needed. Eighteen-tasks identify the need for distributional and population surveys of coastal wildlife taxa, and 3 tasks call for the development of effective survey techniques for certain bird species (Appendix B).

Eleven population-monitoring tasks have been identified, plus 13 tasks to study various aspects of the life history, ecology, and population biology of coastal taxa. Only 3 tasks are related to public education regarding coastal taxa or habitats. Five tasks are related to habitat protection needs, and 13 tasks address species conservation or management needs (Appendix B).

LITERATURE CITED

Able, K. P. 1972. Fall migration in coastal Louisiana and the evolution of migration patterns in the Gulf region. Wilson Bulletin 84:231–242.

Abrahamson, W. G. 1984. Post-fire recovery of Florida Lake Wales Ridge vegetation. American Journal of Botany 71:9–21.

Abrahamson, W. G., and D. C. Hartnett. 1990. Pine flatwoods and dry prairies. Pages 103–149 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Abrahamson, W. G., A. F. Johnson, J. N. Layne, and P. A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: an example of the southern Lake Wales Ridge. Florida Scientist 47:209–250.

Adams, S. R. 1978. Population studies and ecology of a native population of *Peromyscus gossypinus* and an introduced population of *Peromyscus floridanus* on Buck Island, Florida. M.A. Thesis, University of South Florida, Tampa, Florida, USA.

Ager, L. A., C. Mesing, and M. Hill. 1985. Fishery study, Apalachicola River Maintenance Dredging Disposal Site Evaluation Program. Florida Game and Fresh Water Fish Commission Report, prepared for the U.S. Army Corps of Engineers, Mobile District.

Alexander, T. R. 1967. A tropical hammock on the Miami (Florida) limestone—a twenty-five year study. Ecology 48:863–867.

Alexander, T. R., and A. G. Crook. 1984. Recent vegetational changes in South Florida. Pages 199–210 *in* P. J. Gleason, editor. Environments of South Florida: present and past II. Miami Geological Society, Coral Gables, Florida, USA.

Alexander, T. R., and J. D. Dickson. 1970. Vegetational changes in the National Key Deer Refuge. Quarterly Journal of the Florida Academy of Science 33:81–89.

Alexander, T. R., and J. D. Dickson, III. 1972. Vegetational changes in the National Key Deer Refuge II. Quarterly Journal of the Florida Academy of Science 35:85–96.

Allen, C. R., S. Demarais, and R. S. Lutz. 1997*a*. Effects of red imported fire ants on recruitment of white-tailed deer fawns. Journal of Wildlife Management 61:911–916.

Allen, C. R., E. A. Forys, K. G. Rice, and D. P. Wojcik. 2001. Effects of fire ants (Hymenoptera: Formicidae) on hatchling turtles and prevalence of fire ants on sea turtle nesting beaches in Florida. Florida Entomologist 84:250–253.

Allen, C. R., R. S. Lutz, and S. Demarais. 1997*b*. Red imported fire ant impacts on northern bobwhite populations. Ecological Applications 5:632–638.

Allen, C. R., K. G. Rice, D. P. Wojcik, and H. F. Percival. 1997*c*. Effect of red imported fire ant envenomization on neonatal American alligators. Journal of Herpetology 31:318–321.

Allen, C. R., R. Scott, and S. Demarais. 1998. Ecological effects of the invasive nonindigenous ant, *Solenopsis invicta*, on native vertebrates: the wheels on the bus. Transactions of the North American Wildlife and Natural Resources Conference 63:56–65.

Allen, R. P. 1942. The roseate spoonbill. Dover, New York, New York, USA.

Anderson, R. A., and H. M. Tiebout III. 1993. The effects of timber management practices on the lizards of xeric pineland habitats: an investigation of the Florida sand pine scrub. Final report submitted to The Nature Conservancy, Washington, D.C., USA.

Andres, B. A. 1991. Migration of sharp-shinned hawks in the Dry Tortugas, Florida. Wilson Bulletin 103: 493–497.

Angermeier, P. L., and M. R. Winston. 1997. Assessing conservation value of stream communities: a comparison of approaches based on centres of density and species richness. Freshwater Biology 37:699–710.

Anonymous. 1996. The landscape manual. Dade County Department of Planning, Development, and Regulation, Miami, Florida, USA.

Anonymous. 1999. South Florida multiple-species recovery plan. Prepared for the U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia, USA.

Ashley, E. P., and J. T. Robinson. 1996. Road mortality of amphibians, reptiles, and other wildlife on the Long Point Causeway, Lake Erie, Ontario. Canadian Field-Naturalist 110:403–412.

Ashton, R. E., Jr. 1992. Flatwoods salamander, *Ambystoma cingulatum* (Cope). Pages 39–43 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Ashton, R. E., Jr., and P. S. Ashton. 1977. Investigation into the natural history of *Pseudacris ornata* in north central Florida: preliminary report. Herpetological Review 8(3, Supplement):1 (abstract).

Atherton, L. S., and B. H. Atherton. 1988. Florida region. American Birds 42:60–63.

Aubrey, D. G., and K. O. Emery. 1983. Eigeanalysis of recent U.S. sea levels. Shelf Research 2:21–33.

Auffenberg, W. 1982. Florida environments and their herpetofaunas. Part III: herpetogeography. Florida State Museum, Florida Herpetologist No. 4.

Auffenberg, W., and R. Franz. 1982. The status and distribution of the gopher tortoise (*Gopherus polyphemus*). Pages 95–126 *in* R. B. Bury, editor. North American tortoises: conservation and ecology. U.S. Fish and Wildlife Service Wildlife Research Report No. 12.

Auffenberg, W., and J. B. Iverson. 1979. Demography of terrestrial turtles. Pages 541–569 *in* M. Harless and H. Morlock, editors. Turtles: perspectives and research. John Wiley and Sons, New York, New York, USA.

Auffenberg, W., and W. M. Milstead. 1965. Reptiles in the Quaternary of North America. Pages 557–568 *in* H. E. Wright, Jr. and D. G. Frey, editors. The Quaternary of the United States. Princeton University Press, Princeton, New Jersey, USA.

Austin, O. L., Jr. 1968. Smyrna seaside sparrow. Pages 835–838 *in* O. L. Austin, Jr., editor. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. Smithsonian Institution Bulletin No. 237, Part 2, U.S. National Museum, Washington, D.C., USA.

Auth, D. L. 1989. Amphibian and reptilian density in Florida counties. Gainesville Herpetological Society Newsletter 5(8):7–14.

Auth, D. L., and C. Scott. 1996. Geographic distribution: *Diadophis punctatus acricus* (Key ringneck snake). Herpetological Review 27:33.

Avery, G. N., and L. L. Loope. 1980. Endemic taxa in the flora of South Florida. South Florida Research Center Report T-558, Everglades National Park, Homestead, Florida, USA.

Avise, J. C., and W. S. Nelson. 1989. Molecular genetic relationships of the extinct dusky seaside sparrow. Science 243:646–648.

Babbitt, K. J., and G. W. Tanner. 2000. Use of temporary wetlands by anurans in a hydrologically modified landscape. Wetlands 20:313–322.

Bacchus, S. T. 1995. Groundwater levels are critical to the success of prescribed burns. Pages 117–133 *in* S. I. Cerulean and R. T. Engstrom, editors. Fire in wetlands: a management perspective. Proceedings of the Tall Timbers Fire Ecology Conference No. 19, Tall Timbers Research Station, Tallahassee, Florida, USA.

Bailey, R. M., H. E. Winn, and C. L. Smith. 1954. Fishes from the Escambia River, Alabama and Florida, with ecologic and taxonomic notes. Proceedings of the Academy of Natural Sciences of Philadelphia 106:109–164.

Baker, J. L., and H. W. Kale II. 1978. Smyrna seaside sparrow. Pages 115–116 *in* H. W. Kale II, editor. Rare and endangered biota of Florida. Volume 2. Birds. University Presses of Florida, Gainesville, Florida, USA.

Ball, M. C. 1980. Patterns of secondary succession in a mangrove forest in South Florida. Oecologia 44:226–235.

Bancroft, G. T. 1993. Florida Bay: jewel in jeopardy. Coastal Currents 1(2):1–2.

Bancroft, G. T. 1996. White-crowned pigeon, *Columba leucocephala*. Pages 258–266 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Bancroft, G. T., and R. Bowman. 1994. Temporal patterns in diet of nestling white-crowned pigeons: implications for conservation of frugivorous columbids. Auk 111:842–850.

Bancroft, G. T., R. Bowman, and R. J. Sawicki. 2000. Rainfall, fruiting phenology, and the nesting season and white-crowned pigeons in the Upper Florida Keys. Auk 117:416–426.

Bancroft, G. T., A. M. Strong, and M. Carrington. 1995. Deforestation and its effects on forest-nesting birds in the Florida Keys. Conservation Biology 9:835–844.

Bangs, O. 1898. The land mammals of peninsular Florida and the coastal region of Georgia. Boston Society of Natural History Proceedings 28:157–235.

Barbour, D. B., and S. R. Humphrey. 1982. Status and habitat of the Key Largo woodrat and cotton mouse (*Neotoma floridana smalli* and *Peromyscus gossypinus allapaticola*). Journal of Mammalogy 63:144–148.

Barbour, R., and G. M. Allen. 1922. The white-tailed deer of eastern United States. Journal of Mammalogy 3:65–78.

Bass, D. G., and D. T. Cox. 1985. River habitat and fishery resources of Florida. Pages 121–174 *in* W. Seaman, Jr., editor. Florida aquatic habitat and fishery resources. Florida Chapter of the American Fisheries Society, Kissimmee, Florida, USA.

Bass, O. L., Jr., and J. A. Kushlan. 1982. Status of the Cape Sable sparrow. South Florida Research Center Report T-672, Everglades National Park, Homestead, Florida, USA.

Bechtold, W. A., and H. A. Knight. 1982. Florida's forests. U.S. Forest Service, Southeastern Forest Experiment Station Resources Bulletin SE-62, Asheville, North Carolina, USA.

Beck, W. M., Jr. 1965. The streams of Florida. Bulletin Florida State Museum, Biological Sciences Series 10:91–126.

Beers, B. A. 1991. The Atlantic Coast piping plover lesson plans. U.S. Fish and Wildlife Service, Concord, New Hampshire, USA.

Beever, J. W., III. 1989. The effects of fringe red mangrove trimming for view in the Southwest Florida Aquatic Preserves No. 5. Punta Gorda, Florida, USA.

Bellis, V. J. 1995. Ecology of maritime forests of the southern Atlantic Coast: a community profile. U.S. Department of the Interior, National Biological Service Biological Report 30.

Below, T. H. 1996. American oystercatcher, *Haematopus palliatus*. Pages 230–235 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Belwood, J. J. 1981. Wagner's mastiff bat, *Eumops glaucinus floridanus*, (Molossidae) in southern Florida. Journal of Mammalogy 62:411–413.

Belwood, J. J. 1992. Florida mastiff bat, *Eumops glaucinus floridanus*. Pages 216–223 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Benke, A. C., T. C. van Arsdall, Jr., D. M. Gillespie, and F. K. Parrish. 1984. Invertebrate productivity in a subtropical blackwater river: the importance of habitat and life history. Ecological Monographs 54:25–63.

Benke, A. C., R. L. Henry, III, D. M. Gillespie, and R. J. Hunter. 1985. Importance of snag habitat for animal production in southeastern streams. Fisheries 10:8–13.

Benner, R., E. R. Peele, and R. E. Hodson. 1986. Microbial utilization of dissolved organic matter from leaves of the red mangrove, *Rhizophora mangle*, in the fresh creek estuary, Bahamas. Estuarine Coastal Shelf Science 23:607–619.

Benson, R. F., J. A. Saraceno, D. R. Lowell, and D. W. Brett. 1994. Selenium levels in the Palm River and Mackay Bay region of Tampa Bay. Florida Scientist 57:177–185

Bentzien, M. M. 1987. Agency draft recovery plan for five rockland plant species. U.S. Fish and Wildlife Service, Atlanta, Georgia, USA.

Bernardino, F. S., Jr., and G. H. Dalrymple. 1992. Seasonal activity and road mortality of the snakes of the Pa-hay-okee wetlands of Everglades National Park, USA. Biological Conservation 62:71–75.

Bidlingmayer, W. L. 1982. Surveying salt marsh mosquito impoundments of central Florida. Journal of the Florida Anti-Mosquito Association 53:4–7.

Bird Emergency Aid and Kare Sanctuary, Inc. 1991. Florida coastal pollutant spill wildlife rescue and rehabilitation contingency plan. Florida Department of Natural Resources, Tallahassee, Florida, USA.

Birnhak, B. I., and J. P. Crowder. 1974. An evaluation of the extent of vegetative habitat alteration in South Florida, 1943–1970. South Florida Environmental Project Ecological Report No. DI-SFEP-74-22, U.S. Department of the Interior Bureau of Sport Fisheries and Wildlife, Atlanta, Georgia, USA.

Bishop, J. M. 1983. Incidental capture of diamondback terrapins by crab traps. Estuaries 6:426–430.

Bjork, R., and G. V. N. Powell. 1994. Relationships between hydrologic conditions and quality and quantity of foraging habitat for roseate spoonbills and other wading birds in the C-111 basin. Final Report to the South Florida Research Center, Everglades National Park, Homestead, Florida, USA.

Bjork, R., and G. V. N. Powell. 1996. Roseate spoonbill, *Ajaia ajaja*. Pages 295–308 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Blanchard, K. A., and D. N. Nettleship. 1991. Education and seabird conservation; a conceptual framework. Pages 616–632 *in* D. R. McCullough and R. H. Barrett, editors. Wildlife 2001: populations. Elsevier Applied Science, New York, New York, USA.

Blasing, T. J., D. W. Stahle, and D. N. Duvick. 1988. Tree ring-based reconstruction of annual precipitation in the south-central United States from 1750 to 1980. Water Resources Research 24:163–171.

Blaustein, A. R., and D. B. Wake. 1990. Declining amphibian populations: a global phenomenon? Trends in Ecology and Evolution 5:203–204.

Blaustein, A. R., D. B. Wake, and W. P. Sousa. 1994. Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinction. Conservation Biology 8:60–71.

Boecklen, W. J., and D. Simberloff. 1986. Area-based extinction models in conservation. Pages 247–276 *in* D. K. Elliott, editor. Dynamics of extinction. Wiley & Sons, New York, New York, USA.

Blus, L. J., and R. M. Prouty. 1979. Organochlorine pollutants and population status of least terns in South Carolina. Wilson Bulletin 91:62–71.

Bogert, C. M., and R. B. Cowles. 1947. Moisture loss in relation to habitat selection in some Florida reptiles. American Museum Novitates 1358:1–34.

Bogan, T., T. J. O'Shea, and L. Ellison. 1996. Diversity and conservation of bats in North America. University of Michigan School of Natural Resources, Endangered Species Update 13(4 & 5):1–4, 14.

Bolte, H. A. 1999. An evaluation of management techniques to increase the reproductive success of roof-nesting black skimmers (*Rynchops niger*) in northwest Florida. M.S. Thesis, Tennessee Technological University, Cookeville, Tennessee, USA.

Bowen, W. W. 1968. Variation and evolution of Gulf coast populations of beach mice, *Peromyscus polionotus*. Bulletin of the Florida State Museum, Biological Sciences Series 12:1–91.

Boyce, D. A. 1985. Merlins and the behavior of wintering shorebirds. Journal of Raptor Research 19:95–96.

Boyer, W. D. 1990. Growing-season burns for control of hardwoods in longleaf pine stands. U.S. Department of Agriculture Forest Service Research Paper SO-256, Southern Forest Experiment Station, New Orleans, Louisiana, USA.

Boykin, C. S. 1999. The ecology of the ornate diamondback terrapin (*Malaclemys terrapin macrospilota*) at Tarpon Key, Pinellas National Wildlife Refuge. Abstract in G. L. Heinrich and P. A. Meylan, coordinators. A second symposium on the status and conservation of Florida turtles and the 1999 annual meeting of the Gopher Tortoise Council, 8–11 October 1999, Eckerd College, St. Petersburg, Florida, USA.

Branch, L. C., and D. G. Hokit. 2000. A comparison of scrub herpetofauna on two Central Florida ridges. Florida Scientist 63:108–117.

Branch, L. C., D. G. Hokit, B. M. Stith, B. W. Bowen, and A. Clark. 1997. Aspects of landscape dynamics on endemic scrub lizards: an assessment with molecular genetics and GIS modeling. Final Report to the Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Brandt, L. A., F. J. Mazzotti, J. R. Wilcox, P. D. Barker, Jr., and J. Wasilewski. 1995. Status of the American crocodile (*Crocodylus acutus*) at a power plant site in Florida, USA. Herpetological Natural History 3:29–36.

Brandt, L. A., K. L. Montgomery, A. W. Saunders, and F. J. Mazzotti. 1993. Life history notes: *Gopherus polyphemus* (gopher tortoise). Burrows. Herpetological Review 24:149.

Brashear, C. B. 1998. Autumn raptor migration through the Florida Keys. M.S. Thesis, Florida International University, Miami, Florida, USA.

Brashear, C. B., and P. K. Stoddard. 2001. Autumn raptor migration through the Florida Keys with special focus on the peregrine falcon. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Breininger, D. R. 1989. A new population estimate for the Florida scrub jay on Merritt Island National Wildlife Refuge. Florida Field Naturalist 17:25–31.

Breininger, D. R., P. A. Schmalzer, and C. R. Hinkle. 1994. Gopher tortoise (*Gopherus polyphemus*) densities in coastal scrub and slash pine flatwoods in Florida. Journal of Herpetology 28:60–65.

Breininger, D. R, A. Schmalzer, D. A. Rydine, and C. R. Hinkle. 1988. Burrow and habitat relationships of the gopher tortoise in coastal scrub and slash pine flatwoods on Merritt Island, Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Report, Tallahassee, Florida, USA.

Brenner, J. 1991. Southern oscillation anomalies and their relationship to wildfire activity in Florida. International Journal of Wildland Fire 1:73–78.

Bridges, E. L. 1998. Vegetation mapping and natural community types of Kissimmee Prairie State Preserve. *In* Kissimmee Prairie State Preserve unit management plan. Florida Department of Environmental Protection, Tallahassee, Florida, USA.

Briese, L. A., and M. H. Smith. 1973. Competition between *Mus musculus* and *Peromyscus polionotus*. Journal of Mammalogy 54:968–969.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31–35.

Brockway, D. G., and K. W. Outcalt. 2000. Restoring longleaf pine–wiregrass ecosystems: low-rate hexasinone application enhances effects of prescribed fire. Page 131 (abstract) *in* W. K. Moser and C. F. Moser, editors. Fire and forest ecology: innovative silviculture and vegetation management. Proceedings of the Tall Timbers Fire Ecology Conference No. 21, Tall Timbers Research Station, Tallahassee, Florida, USA.

Brooks, H. K. 1981. Physiographic divisions. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida, USA.

Browder, J. 1985. Relationship between pink shrimp production on the Tortugas grounds and water flow patterns in the Florida Everglades. Bulletin of Marine Science 37:839–856.

Brown, L. N., and R. L. Williams. 1971. The Key Largo woodrat (*Neotoma floridana snail* [sic]) and cotton mouse (*Peromyscus gossypinus allapaticola*) on Lignum Vitae Key, Florida. Florida Naturalist 44:95–96.

Brush, T., R. A. Lent, T. Hruby, B. A. Harrington, R. M. Marshall, and W. G. Montgomery. 1986. Habitat use by salt marsh birds and response to open marsh water management. Colonial Waterbirds 9:189–195.

Bryan, D. C. 1996. Limpkin, *Aramys guarauna*. Pages 485–496 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Buchanan, J. B., S. G. Herman, and T. M. Johnson. 1986. Success rates of the peregrine falcon (*Falco peregrinus*) hunting dunlin (*Calidris alpina*) during winter. Journal of Raptor Research 20:130–131.

Buchanan, K. S. 1999. Restoration of sandhill vegetation on abandoned agricultural land. M.S. Thesis, University of Central Florida, Orlando, Florida, USA.

Buhlmann, K. A., C. A. Payne, J. C. Mitchell, and R. B. Glasgow. 1988. Forestry operations and terrestrial salamanders: techniques in a study of the Cow Knob salamanders, *Plethodon punctatus*. Pages 38–44 in R. C. Szaro, K. E. Severson, and D. R. Patton, technical coordinators. Proceedings of the symposium on the management of amphibians, reptiles, and small mammals in North America. U.S. Forest Service General Technical Report RM-166.

Bullock, J. F., Jr., and W. A. Wall. 1995. Proactive endangered species management: a partnership paradigm. Transactions of the North American Wildlife and Natural Resources Conference 60:439–446.

Bureau of Economic and Business Research. 1999. Florida statistical abstract 1999. University of Florida, Gainesville, Florida, USA.

Burger, J. 1977. Determinants of hatching success in the diamondback terrapin, *Malaclemys terrapin*. American Midland Naturalist 97:444–464.

Burger, J. 1981. The effect of human activity on birds at a coastal bay. Biological Conservation 21:231–244.

Burger, J. 1984. Colony stability in least terns. Condor 86:61–67.

Burger, J, and M. Gochfeld. 1991. Human activity influence and diurnal and nocturnal foraging of sanderlings (*Calidris alba*). Condor 93:259–265.

Burke, R. L. 1989. Florida gopher tortoise relocation: overview and case study. Biological Conservation 48:295–309.

Burke, V. J., and J. W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina bay. Conservation Biology 9:1365–1369.

Burridge, J., and M. Kane, editors. 1985. Rehabilitating oiled sea birds. American Petroleum Institute, Washington, D.C., USA.

Buskirk, W. H. 1980. Influence of meteorological patterns and trans-Gulf migration on the calendars of latitudinal migrants. Pages 485–491 *in* A. Keast and E. S. Morton, editors. Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Washington, D.C., USA.

Butler, J. A. 2000. Status and distribution of the Carolina diamondback terrapin, *Malaclemys terrapin centrata*, in Duval County. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Butterfield, B. P., W. E. Meshaka, Jr., and C. Guyer. 1997. Nonindigenous amphibians and reptiles. Pages 123–138 *in* D. Simberloff, D. C. Schmitz, and T. C. Brown, editors. Strangers in paradise. Impact and management of nonindigenous species in Florida. Island Press, Covelo, California, USA.

Callahan, J. L., C. Barnett, and J. W. H. Cates. 1990. Palmetto prairie creation on phosphate-mined lands in central Florida. Restoration and Management Notes 8:94–95.

Camilleri, J. C., and G. Ribi. 1986. Leaching of dissolved organic carbon (DOC) from dead leaves, formation of flakes of DOC, and feeding on flakes by crustaceans in mangroves. Marine Biology (Berlin) 91:337–344.

Campbell, H. W. 1992. Short-tailed snake, *Stilosoma extenuatum* Brown. Pages 150–153 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Campbell, H. W., and S. P. Christman. 1982. The herpetofaunal components of Florida sandhill and sand pine scrub associations. Pages 163–171 *in* N. J. Scott, Jr., editor. Herpetological communities. U.S. Fish and Wildlife Service Wildlife Research Report No. 13.

Campbell, H. W., and P. E. Moler. 1992. Rim rock crowned snake, *Tantilla oolitica* Telford. Pages 158–161 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Cantillo, A. Y., T. P. O'Connor, and G. G. Lauenstein. 1993. South Florida environmental quality. NOAA Technical Memorandum NOS ORCA 75, Silver Spring, Maryland, USA.

Carlson, P. C., G. W. Tanner, J. M. Wood, and S. R. Humphrey. 1993. Fire in Key deer habitat improves browse, prevents succession, and preserves endemic herbs. Journal of Wildlife Management 57:914–928.

Carr, A. F., Jr. 1940. A contribution to the herpetology of Florida. University of Florida Publication, Biological Sciences Series 3:1–118.

Carr, A. F., Jr. 1952. Handbook of turtles. Comstock, Ithaca, New York, USA.

Carroll, C. R., and G. K. Meffe. 1994. Management to meet conservation goals: general principles. Pages 307–337 *in* G. K. Meffe and C. R. Carroll, editors. Principles of conservation biology. Sinauer, Sunderland, Massachusetts, USA.

Carter, M. R., L. A. Burns, T. R. Cavinder, K. R. Dugger, P. L. Fore, D. B. Hicks, H. L. Revells, and T. W. Schmidt. 1973. Ecosystems analysis of the Big Cypress Swamp and estuaries. U.S. Environmental Protection Agency Region IV, Atlanta, Georgia, USA.

Chabreck, R. H. 1981. Effect of burn date on regrowth of *Scirpus olneyi* and *Spartina patens*. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 35:201–210.

Chabreck, R. H., T. Joanen, and S. L. Paulus. 1989. Southern coastal marshes. Pages 249–277 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Chaplin, S. J., R. A. Gerrard, H. M. Watson, L. L. Master, and S. R. Flack. 2000. The geography of imperilment: targeting conservation toward critical biodiversity areas. Pages 159–199 *in* B. A. Stein, L. S. Katner, and J. S. Adams, editors. Precious heritage: the status of biodiversity in the United States. Oxford University Press, New York, New York, USA.

Chase, C. A., and J. A. Gore. 1989. Snowy plover breeding distribution. Florida Game and Fresh Water Fish Commission Final Report, Tallahassee, Florida, USA.

Chen, E., J. F. Gerber. 1990. Climate. Pages 11–34 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Christman, S. P. 1970. The possible evolutionary history of two Florida skinks. Quarterly Journal of the Florida Academy of Science 33:291–293.

Christman, S. P. 1988. Endemism in Florida's interior sand pine scrub. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Report, Tallahassee, Florida, USA.

Christman, S. P. 1992*a*. Bluetail mole skink, *Eumeces egregius lividus* Mount. Pages 117–122 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Christman, S. P. 1992*b*. Florida Keys mole skink, *Eumeces egregius egregius* (Baird). Pages 178–180 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Christman, S. P. 1992*c*. Many-lined salamander, *Stereochilus marginatus* (Hallowell). Pages 58–61 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Christman, S. P. 1992*d*. Sand skink, *Neoseps reynoldsi* Stejneger. Pages 135–140 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Christman, S. P., and W. S. Judd. 1990. Notes on plants endemic to Florida scrub. Florida Scientist 53:52–73.

Christman, S. P., H. I. Kochman, H. W. Campbell, C. R. Smith, and W. S. Lippincott, Jr. 1979. Successional changes in community structures: amphibians and reptiles in Florida sand pine scrub. Unpublished manuscript, U.S. Fish and Wildlife Service, National Fish and Wildlife Laboratory, Gainesville, Florida, USA.

Christman, S. P., and D. B. Means. 1992. Striped newt, *Notophthalmus perstriatus* (Bishop). Pages 62–65 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Christman, S. P., and P. E. Moler. 1992. Big Pine Key ringneck snake, *Diadophis punctatus acricus* Paulson. Pages 146–149 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Churcher, P. B., and J. H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology, London 212:439–455.

Cintron, G., A. E. Lugo, and R. Martinez. 1985. Structural and functional properties of mangrove forests. Pages 53–66 in W. G. Darcy and M. D. Correa, editors. The botany and natural history of Panama. Monograph of Systematic Botany, Volume 10, Missouri Botanical Gardens, St. Louis, Missouri, USA.

Clapp, R. B., R. C. Banks, D. Morgan-Jacobs, and W. A. Hoffman. 1982. Marine birds of the southeastern United States and Gulf of Mexico. Part I. Gaviiformes through Pelecaniformes. U.S. Fish and Wildlife Service Office of Biological Services FWS/OBS-82/01, Washington, D.C., USA.

Clapp, R. B., and P. A. Buckley. 1984. Status and conservation of seabirds in the southeastern United States. Pages 135–155 *in* J. P. Croxall, P. G. H. Evans, and R. W. Schreiber, editors. Status and conservation of the world's seabirds. ICBP Technical Publication No. 2.

Clark, D. R., Jr. 1981. Bats and environmental contaminants: a review. U.S. Fish and Wildlife Service Special Scientific Report—Wildlife 235.

Clark, R. 1986. Hurricane Kate, November 15–23, 1985. Florida Department of Natural Resources, Beaches Shores Post-Storm Report No. 86-1.

Clark, A. M., B. W. Bowen, and L. C. Branch. 1999. Effects of natural habitat fragmentation on an endemic scrub lizard (*Sceloporus woodi*): an historical perspective based on mitochondrial DNA gene genealogy. Molecular Ecology 8:1093–1104.

Clarke, J. A., B. A. Harrington, T. Hruby, and F. E. Wadderman. 1984. The effect of ditching for mosquito control on salt marsh use by birds in Rowley, Massachusetts. Journal of Field Ornithology 55:160–180.

Clawson, R. G., B. G. Lockaby, and R. H. Jones. 1997. Amphibian responses to helicopter harvesting in forested floodplains of low order, blackwater streams. Forest Ecology and Management 90:225–235.

Clements, B. W., Jr., and A. J. Rogers. 1964. Studies of impounding for the control of salt marsh mosquitos in Florida, 1958–1963. Mosquito News 24:265–276.

Clewell, A. F. 1971. The vegetation of the Apalachicola National Forest: an ecological perspective. Final Report to U.S. Forest Service, Atlanta, Georgia, USA.

Clewell, A. F. 1977. Geobotany of the Apalachicola River region. Florida Marine Research Publication No. 26:6–15.

Clewell, A. F. 1986. Natural setting and vegetation of the Florida Panhandle. COESAM/PDEI-86/001, Contract No. DACW01-77-C-0104, U.S. Army Corps of Engineers, Mobile, Alabama, USA.

Clewell, A. F. 1989. Natural history of wiregrass (*Aristida stricta* Michx. Gramineae). Natural Areas Journal 9:223–233.

Coastal Coordinating Council. 1974. Florida coastal zone management atlas. Coastal Coordinating Council, Tallahassee, Florida, USA.

Coburn, L. M., D. T. Cobb, and J. A. Gore. 2001. Management opportunities and techniques for roof- and ground-nesting black skimmers. Wildlife Society Bulletin 29:342–348.

Coker, R. W. 1951. The diamond-back terrapin in North Carolina. Pages 219–230 *in* H. F. Taylor, editor. Survey of marine fisheries in North Carolina. University of North Carolina Press, Chapel Hill, North Carolina, USA.

Conley, W. J., and B. A. Hoffman. 1987. Nesting activity of sea turtles in Florida, 1979□1985. Florida Scientist 50:201–210.

Connor, E. G., and E. D. McCoy. 1979. The statistics and biology of the species-area relationship. American Naturalist 113:791–833.

Cooper, R. W. 1973. Fire and sand pine. Pages 207–212 *in* Proceedings of the sand pine symposium. Southeastern Forest Experiment Station, U.S. Forest Service General Technical Report No. SE-2.

Coultas, C. L., A. F. Clewell, and E. M. Taylor, Jr. 1979. An aberrant toposequence of soils through a titi swamp. American Journal of Soil Science 43:377–383.

Cox, J. 1987. The breeding bird survey in Florida: 1969–1983. Florida Field Naturalist 15:29–56.

Cox, J. 1988. The influence of forest size on transient and resident bird species occupying maritime hammocks of northeast Florida. Florida Field Naturalist 16:25–34.

Cox, J., D. Inkley, and R. Kautz. 1987. Ecology and habitat protection needs of gopher tortoise (*Gopherus polyphemus*) populations found on lands slated for large-scale development in Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 4, Tallahassee, Florida, USA.

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and Fresh Water Fish Commission Office of Environmental Services, Tallahassee, Florida, USA.

Cox, J. A. 1984. Distribution, habitat, and social organization of the Florida scrub jay, with a discussion of the evolution of cooperative breeding in New World jays. Dissertation, University of Florida, Gainesville, Florida, USA.

Craighead, F. C., Sr. 1971. The trees of South Florida. Volume 1. The natural environments and their succession. University of Miami Press, Coral Gables, Florida, USA.

Craighead, F. C., Sr. 1974. Hammocks of South Florida. Pages 53–60 *in* P. J. Gleason, editor. Environments of South Florida: present and past. Miami Geological Society Memoirs No. 2, Miami, Florida, USA.

Craighead, F. C., Sr., and V. C. Gilbert. 1962. The effects of Hurricane Donna on the vegetation of southern Florida. Quarterly Journal of the Florida Academy of Science 25:1–28.

Crain, D. A., A. B. Bolten, and K. A. Bjorndal. 1995. Effects of beach nourishment on sea turtles: review and research initiatives. Restoration Ecology 3:95–104.

Cruz. A., T. Manolis, and J. W. Wiley. 1985. The shiny cowbird: a brood parasite expanding its range in the Caribbean region. Pages 607–620 *in* P. A. Buckley, M. S. Foster, E. S. Morton, R. S. Ridgely, and F. G. Buckley, editors. Neotropical ornithology. Ornithological Monographs No. 36.

Curnutt, J. L. 1996. Cape Sable seaside sparrow, *Ammodramus maritima mirabilis*. Pages 137–143 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Curnutt, J. L., A. L. Mayer, T. M. Brooks, L. Manne, O. L. Bass, Jr., D. M. Fleming, M. P. Nott, and S. L. Pimm. 1998. Population dynamics of the endangered Cape Sable seaside sparrow. Animal Conservation 1:11–21.

Dahm, C. N., K. W. Cummins, H. M. Valett, and R. L. Coleman. 1995. An ecosystem view of the restoration of the Kissimmee River. Restoration Ecology 3:225–238.

Davis, J. H. 1943. The natural features of southern Florida. Florida Geological Survey Bulletin No. 25.

Davis, J. H., Jr. 1967. General map of the natural vegetation of Florida. Institute of Food and Agricultural Sciences Circular S-178, Agricultural Experiment Station, University of Florida, Gainesville, Florida, USA.

Day, J. W., Jr., C. A. S. Hall, W. M. Kemp, and A. Yanez-Arancibia. 1989. Estuarine ecology. John Wiley & Sons, New York, New York, USA.

Deblinger, R. D., J. J. Vaske, and D. W. Rimmer. 1992. An evaluation of different predator exclosures used to protect Atlantic Coast piping plover nests. Wildlife Society Bulletin 20:274–279.

DeGraaf, R. M., and D. D. Rudis. 1990. Herpetofaunal species composition and relative abundance among three New England forest types. Forest Ecology and Management 32:155–165.

Delany, M. F. 1991. Florida grasshopper sparrow habitat management needs. Florida Game and Fresh Water Fish Commission Final Performance Report Study No. 7513, Tallahassee, Florida, USA.

Delany, M. F. 1996. Florida grasshopper sparrow, *Ammodramus savannarum floridanus*. Pages 128–136 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Delany, M. F. 1997. Florida's prairie. Endangered Species Bulletin 22(4):14–15.

Delany, M. F., and J. A. Cox. 1986. Florida grasshopper sparrow breeding distribution and abundance in 1984. Florida Field Naturalist 14:100–104.

Delany, M. F., J. T Giesel, and D. A. Brazeau. 2000. Genetic variability among populations of the Florida grasshopper sparrrow. Journal of Wildlife Management 64:631–636.

Delany, M. F., and S. B. Linda. 1994. Characteristics of occupied and abandoned Florida grasshopper sparrow territories. Florida Field Naturalist 22:106–109.

Delany, M. F., C. T. Moore, and D. R. Progulske, Jr. 1995. Territory size and movements of Florida grasshopper sparrows. Journal of Field Ornithology 66:305–309.

Delany, M. F., H. M. Stevenson, and R. McCracken. 1985. Distribution, abundance, and habitat of the Florida grasshopper sparrow. Journal of Wildlife Management 49:626–631.

Delany, M. F., P. B. Walsh, B. Pranty, and D. W. Perkins. 1999. A previously unknown population of Florida grasshopper sparrows on Avon Park Air Force Range. Florida Field Naturalist 27:52–56.

Delis, P. R., H. R. Mushinsky, and E. D. McCoy. 1996. Decline of some west-central Florida anuran populations in response to habitat degradation. Biodiversity and Conservation 5:1579–1595.

Delroy, L. B., E. J. Radbone, A. C. Robinson, and M. Hewett. 1986. The breeding and reestablishment of the brush-tailed bettong, *Bettongia penicillata*, in South Australia. Australian Journal of Wildlife Research 13:387–396.

deMaynadier, P. G., and M. L. Hunter, Jr. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. Biological Conservation 12:340–352.

DeSelm, H. R., and N. Murdock. 1993. Grass-dominated communities. Pages 87–141 *in* W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States: upland terrestrial communities. John Wiley & Sons, New York, New York, USA.

Deyrup, M. A. 1989. Arthropods endemic to Florida scrub. Florida Scientist 52:254–271.

Diamond, J. M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biological Conservation 7:129–146.

Dickinson, V. M. 1995. Red imported fire ant predation on crested caracara nestlings in south Texas. Wilson Bulletin 107:761–762.

Diemer, J. E. 1986. The ecology and management of the gopher tortoise in the southeastern United States. Herpetologica 42:125–133.

Diemer, J. E. 1989. An overview of gopher tortoise relocation. Pages 1–6 *in* J. E. Diemer et al., editors. Proceedings gopher tortoise relocation symposium. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 5, Tallahassee, Florida, USA.

Diemer, J. E. 1992. Gopher tortoise, *Gopherus polyphemus* (Daudin). Pages 123–127 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Diemer, J. E., D. R. Jackson, J. L. Landers, J. N. Layne, and D. A. Wood, editors. 1989. Proceedings gopher tortoise relocation symposium. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 5, Tallahassee, Florida, USA.

Diemer, J. E., and P. E. Moler. 1982. Gopher tortoise response to site preparation in northern Florida. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Agencies 36:634–637.

Diemer Berish, J. E., L. D. Wendland, and C. A. Gates. 2000. Distribution and prevalence of upper respiratory tract disease in gopher tortoises in Florida. Journal of Herpetology 34:5– 12.

DiSilvestro, R. 1997. What's killing the Key deer? National Wildlife 35(2):16–23.

Dobson, A. P. 1988. Restoring island ecosystems: the potential of parasites to control introduced mammals. Conservation Biology 2:31–39.

Dodd, C. K., Jr. 1991. Drift fence-associated sampling bias of amphibians at a Florida sandhills temporary pond. Journal of Herpetology 25:296–301.

Dodd, C. K., Jr. 1992*a*. Biological diversity of a temporary pond herpetofauna in North Florida sandhills. Biodiversity and Conservation 1:125–142.

Dodd, C. K., Jr. 1992*b*. Loggerhead sea turtle, Caretta caretta (Linnaeus). Pages 128–134 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Dodd, C. K., Jr. 1993. The cost of living in an unpredictable environment: the ecology of striped newts *Notophthalmus perstriatus* during a prolonged drought. Copeia 1993:605–614.

Dodd, C. K., Jr. 1994. The effects of drought on population structure, activity, and orientation of toads (*Bufo quercicus* and *B. terrestris*) at a temporary pond. Ethology Ecology & Evolution 6:331–349.

Dodd, C. K., Jr. 1996. Use of terrestrial habitats by amphibians in the sandhill uplands of north-central Florida. Alytes 14:42–52.

Dodd, C. K., Jr. 1998. *Desmognathus auriculatus* at Devil's Millhopper State Geological Site, Alachua County, Florida. Florida Scientist 61:38–45.

Dodd, C. K., Jr., and B. S. Cade. 1998. Movement patterns and the conservation of amphibians breeding in small, temporary wetlands. Conservation Biology 12:331–339.

Dodd, C. K., Jr., and B. G. Charest. 1988. The herpetofaunal community of temporary ponds in north Florida sandhills: species composition, temporal use, and management implications. Pages 87–97 *in* R. C. Szaro, K. E. Severson, and D. R. Patton, technical coordinators. Proceedings of the symposium on the management of reptiles, amphibians, and small mammals in North America. U.S. Forest Service General Technical Report RM-166.

Dodd, C. K., Jr., and L. V. LaClaire. 1995. Biogeography and status of the striped newt (*Notophthalmus perstriatus*) in Georgia, USA. Herpetological Natural History 3:37–46.

Doren, R. F., W. J. Platt, and L. D. Whiteaker. 1993. Density and size structure of slash pine stands in the Everglades region of South Florida. Forest Ecology and Management 59:295–311.

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.

Douglass, N. J. 1993. The Florida Game and Fresh Water Fish Commission response to the 1993 Tampa Bay oil spill. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program, Tallahassee, Florida, USA.

Douglass, N. J., M. S. Robson, and L. Pennington. 1993. The Wading Bird Protection Initiative: a conservation initiative. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:320–327.

Doyle, L. J., D. C. Sharma, A. C. Hine, O. H. Pilkey, Jr., W. J. Neal, O. H. Pilkey, Sr., D. Martin, and D. F. Belknap. 1984. Living with the West Florida shore. Duke University Press, Durham, North Carolina, USA.

Dreitz, V. J., and J. A. Duberstein. 2001. Use of red mangrove for nesting by snail kites in Florida. Florida Field Naturalist 29:49–50.

Drummond, F. 1989. Factors affecting road mortality of Key deer. M.S. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Duellman, W. E., and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin of the Florida State Museum, Biological Sciences Series 3:181–324.

Duever, L. C. 1984. Natural communities of Florida's rocklands. Palmetto 4:8–11.

Duever, M. J., J. E. Carlson, J. F. Meeder, L. C. Duever, L. H. Gunderson, L. A. Riopelle, T. R. Alexander, R. F. Myers, and D. P. Spangler. 1979. Resource inventory and analysis of the Big Cypress National Preserve. Volume 1. Natural resources. Final Report to the U.S. National Park Service. Center for Wetlands, University of Florida, Gainesville, and National Audubon Society, Naples, Florida, USA.

Duncan, R. A. 1994. Bird migration weather and fallout. Private printing, Gulf Breeze, Florida.

Dunson, W. A. 1979. Occurrence of partially striped forms of the mangrove water snake *Nerodia fasciata compressicauda* and comments on the status of *N. f. taeniata*. Florida Scientist 42:102–112.

Dunson, W. A. 1992. Striped mud turtle, lower Keys population, *Kinosternon baurii* (Garman). Pages 105–110 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Dunson, W. A., and F. Mazzotti. 1989. Salinity as a limiting factor in the distribution of reptiles in Florida Bay: a theory for the estuarine origin of marine snakes and turtles. Bulletin of Marine Science 44:229–244.

Durako, M. J., J. A. Browder, W. L. Kruczynski, C. B. Subrahmanyam, and R. E. Turner. 1985. Salt marsh habitat and fishery resources of Florida. Pages 189–280 *in* W. Seaman, Jr., editor. Florida aquatic habitat and fishery resources. Florida Chapter of the American Fisheries Society, Kissimmee, Florida, USA.

Dutoit, C. H. 1979. The carrying capacity of the Ichetucknee Springs and River. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Edmiston, H. L., and H. A. Tuck. 1987. Resource inventory of the Apalachicola River and Bay drainage basin. Florida Game and Fresh Water Fish Commission Office of Environmental Services, Apalachicola, Florida, USA.

Ehrhart, L. M. 1978. Pallid beach mouse. Pages 8–9 *in* J. N. Layne, editor. Rare and endangered biota of Florida. Volume 1. Mammals. University Presses of Florida, Gainesville, Florida, USA.

Ehrhart, L. M., and B. E. Witherington. 1992. Green turtle, *Chelonia mydas* (Linnaeus). Pages 90–94 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Eisenberg, J. 1983. The gopher tortoise as a keystone species. Proceedings of the Annual Meeting of the Gopher Tortoise Council 4:1–4.

Eldridge, J. 1992. Management of habitat for breeding and migrating shorebirds in the Midwest. U.S. Fish and Wildlife Service Fish and Wildlife Leaflet 13, Washington, D.C., USA.

Eleuterius, L. N., and C. K. Eleuterius. 1979. Tide levels and salt marsh zonation. Bulletin of Marine Science 29:394–400.

Enderson, J. H., J. Larrabee, Z. Jones, C. Peper, and C. Lepisto. 1995. Behavior of peregrines in winter in south Texas. Journal of Raptor Research 29:93–98.

Enge, K. M. 1998*a*. Herpetofaunal drift-fence survey of steephead ravines in the Apalachicola and Ochlockonee river drainages. Florida Game and Fresh Water Fish Commission Final Performance Report, Tallahassee, Florida, USA.

Enge, K. M. 1998*b*. Herpetofaunal survey of an upland hardwood forest in Gadsden County, Florida. Florida Scientist 61:144–159.

Enge, K. M. 2002. Herpetofaunal drift-fence survey of two seepage bogs in Okaloosa County, Florida. Florida Scientist 65:67–82.

Enge, K. M. 2002. Herpetofaunal drift-fence survey of steephead ravines and seepage slopes in the western Panhandle. Florida Fish and Wildlife Conservation Commission Final Performance Report, Tallahassee, Florida, USA.

Enge, K. M., M. 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, USA.

Enge, K. M., R. L. Cailteux, and J. J. Nordhaus. 1996*a*. Geographic distribution: *Graptemys barbouri* (Barbour's map turtle). Herpetological Review 27:150–151.

Enge, K. M., D. T. Cobb, G. L. Sprandel, and D. L. Francis. 1996*b*. Wildlife captures in a pipeline trench in Gadsden County, Florida. Florida Scientist 59:1–11.

Enge, K. M., and C. K. Dodd, Jr. 1992. An indexed bibliography of the herpetofauna of Florida. Florida Game and Fresh Water Fish Commission Technical Report No. 11, Tallahassee, Florida, USA.

Enge, K. M, and N. J. Douglass. 2000. Easement Documentation Report (Volume II: vertebrate surveys) for Fisheating Creek Ecosystem—Phase I, Glades County, Florida. Prepared for the Conservation and Recreational Lands Program and the Division of State Lands, Florida Department of Environmental Protection. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Enge, K. M, and W. R. Marion. 1986. Effects of clearcutting and site preparation on herpetofauna of a North Florida flatwoods. Forest Ecology and Management 12:177–192.

Enge, K. M, and K. N. Wood. 1998. Herpetofaunal surveys of the Big Bend Wildlife Management Area, Taylor County, Florida. Florida Scientist 61:61–87.

Enge, K. M, and K. N. Wood. 1999–2000. A herpetofaunal survey of Chassahowitzka Wildlife Management Area, Hernando County, Florida. Herpetological Natural History 7:117–144.

Enge, K. M , and K. N. Wood. 2001. Herpetofauna of Chinsegut Nature Center, Hernando County, Florida. Florida Scientist 64:283–305.

Environmental Protection Agency. 1994. The quality of our nation's water: 1992. EPA 841-S-94-002, EPA Office of Water, Washington, D.C., USA.

Erwin, K. L. 1990. Freshwater marsh creation and restoration in the Southeast. Pages 233–265 *in* J. A. Kushler and M. E. Kentula, editors. Wetland creation and restoration of coastal plain wetlands in Florida: the status of the science. Island Press, Washington, D.C., USA.

Erwin, K. L., and G. R. Best. 1985. Marsh development in a central Florida phosphate surface-mined reclaimed wetland. Wetlands 5:155–166.

Erwin, R. M. 1989. Responses to human intruders by birds nesting in colonies: experimental results and management guidelines. Colonial Waterbirds 12:104–108.

Erwin, R. M., J. S. Hatfield, and T. J. Wilmers. 1995. The value and vulnerability of small estuarine islands for conserving metapopulations of breeding waterbirds. Biological Conservation 71:187–191.

Estevez, E. D. 1992. Tidal wetlands. Chapter 6 *in* Framework for action; Sarasota Bay National Estuary Program. U.S. Environmental Protection Agency, Sarasota, Florida, USA.

Ewel, K. C. 1988. Florida's freshwater swamps: ecological relationships and management issues. ENFO (Environmental Information Center of the Florida Conservation Foundation) Report (January):1–9.

Ewel, K. C. 1990. Swamps. Pages 282–323 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Ewel, K. C. 1995. Fire in cypress swamps in the southeastern United States. Pages 111–116 *in* S. I. Cerulean and R. T. Engstrom, editors. Fire in wetlands: a management perspective. Proceedings of the Tall Timbers Fire Ecology Conference No. 19, Tall Timbers Research Station, Tallahassee, Florida, USA.

Ewel, K. C., and W. J. Mitsch. 1978. The effects of fire on species composition in cypress dome ecosystems. Florida Scientist 41:25–31.

Ewel, K. C., and H. T. Odum, editors. 1984. Cypress swamps. University Presses of Florida, Gainesville, Florida, USA.

Ewert, M. A., and D. R. Jackson. 1994. Nesting ecology of the alligator snapping turtle (*Macroclemys temminckii*) along the lower Apalachicola River, Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Report, Tallahassee, Florida, USA.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management 61:603–610.

Fahrig, L., J. Pedlar, S. Pope, P. Taylor, and J. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177–182.

Felley, J. D. 1992. Medium–low-gradient streams of the Gulf Coastal Plain. Pages 233–269 *in* C. T. Hackney, S. M. Adams, and W. H. Martin, editors. Biodiversity of the southeastern United States: aquatic communities. John Wiley & Sons, New York, New York, USA.

Fergus, C. 1993. Scrub: learning to love it. Audubon Magazine 95(3):100–104.

Fernald, E. A., and E. D. Purdum, editors. 1992. Atlas of Florida. University Press of Florida, Gainesville, Florida, USA.

Fernald, R. T. 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. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 6, Tallahassee, Florida, USA.

Ferris, D. K., M. J. Killion, K. P. Ferris, W. E. Grant, and S. B. Vinson. 1998. Influence of relative abundance of red imported fire ants (*Solenopsis invicta*) on small mammal captures. Southwestern Naturalist 43:97–100.

Finch, G. 2000. Critter crossings: Linking habitats and reducing roadkill. U.S. Department of Transportation, Federal Highway Administration Publication No. FHWA-EP-00-004, Washington, D.C., USA.

Fisk, E. J. 1978. Roof-nesting terns, skimmers, and plovers in Florida. Florida Field Naturalist 6:1–8.

Fitzgerald, B. M., and B. J. Karl. 1979. Foods of feral house cats (*Felis catus* L.) In forest of the Orongorongo Valley, Wellington, New Zealand. Journal of Zoology 6:107–126.

Fitzgerald, S. A., and G. W. Tanner. 1992. Avian community response to fire and mechanical shrub control in South Florida. Journal of Range Management 45:396–400.

Fitzgerald, S. A., J. M. Wood, and G. W. Tanner. 1995. Small mammal and plant responses to the rehabilitation of a dry prairie grassland association using fire and roller chopping applied in two seasons. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Report, Tallahassee, Florida, USA.

Fitzpatrick, J. W., G. E. Woolfenden, and M. T. Kopeny. 1991. Ecology and development-related habitat requirements of the Florida scrub jay (*Aphelocoma coerulescens coerulescens*). Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 8, Tallahassee, Florida, USA.

Flickinger, E. L., and K. A. King. 1972. Some effects of aldrin-treated rice on Gulf Coast wildlife. Journal of Wildlife Management 36:706–727.

Florida Department of Agriculture and Consumer Services. 1994. Florida agriculture facts, 1994 release. Bureau of Informational Services, Tallahassee, Florida, USA.

Florida Department of Environmental Protection. 1997. Biological assessment of the effectiveness of forestry best management practices. Division of Administration and Technical Services, Bureau of Laboratories, Tallahassee, Florida, USA.

Florida Department of Natural Resources. 1988. Survey of pollutant transfers. Unpublished report, Florida Department of Natural Resources, Tallahassee, Florida, USA.

Florida Fish and Wildlife Conservation Commission. 2001. Impacts of feral and free-ranging domestic cats on wildlife in Florida. Tallahassee, Florida, USA.

Florida Game and Fresh Water Fish Commission. 1976*a*. Cross Florida barge canal restudy report: wildlife study. Volume II. Section IV: existing environmental setting. Department of the Army Corps of Engineers, Jacksonville, Florida, USA.

Florida Game and Fresh Water Fish Commission. 1976*b*. Cross Florida barge canal restudy report: wildlife study. Volume II. Department of the Army Corps of Engineers, Jacksonville, Florida, USA.

Florida Game and Fresh Water Fish Commission. 1988. Guidelines for gopher tortoise relocations. Tallahassee, Florida, USA.

Florida Game and Fresh Water Fish Commission. 1994. Agency strategic plan for the Florida Game and Fresh Water Fish Commission 1995–1998. Tallahassee, Florida, USA.

Florida Natural Areas Inventory. 1990. Guide to the natural communities of Florida. Florida Natural Areas Inventory and Florida Department of Natural Resources, Tallahassee, Florida, USA.

Folk, M. J., and W. D. Klimstra. 1991. Urbanization and domestication of the Key deer (*Odocoileus virginianus clavium*). Florida Field Naturalist 19:1–9.

Folkerts, G. W. 1982. The Gulf Coast pitcher plant bogs. American Scientist 70:260–267.

Folkerts, G. W. 1991. A preliminary classification of pitcher plant habitats in the southeastern United States. Journal of the Alabama Academy of Science 62:199–225.

Fontenot, L. W., G. P. Noblet, and S. G. Platt. 1994. Rotenone hazards to amphibians and reptiles. Herpetological Review 25:150–153, 156.

Foose, D. W. 1983. Selected flow characteristics of Florida streams and canals. U.S. Geological Survey Water Resources Investigative Report 83-4107.

Forys, E. A. 1995. Metapopulations of marsh rabbits: a population viability analysis for the Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*). Dissertation, University of Florida, Gainesville, Florida, USA.

Forys, E. A., and C. R. Allen. 1999. Biological invasions and deletions: community change in South Florida. Biological Conservation 87:341–347.

Forys, E. A., P. A. Frank, and R. S. Kautz. 1996. Recovery actions for the Lower Keys marsh rabbit, silver rice rat, and Stock Island tree snail. U.S. Fish and Wildlife Service/Florida Game and Fresh Water Fish Commission Cooperative Agreement Final Report, Tallahassee, Florida, USA.

Forys, E. A., and S. R. Humphrey. 1996. Home range and movements of the Lower Keys marsh rabbit in a highly fragmented habitat. Journal of Mammalogy 77:1042–1048.

Forys, E. A., and S. R. Humphrey. 1997. Comparison of 2 methods to estimate density of an endangered lagomorph. Journal of Wildlife Management 61:86–92.

Forys, E. A., and S. R. Humphrey. 1999. Use of population viability analysis to evaluate management options for the endangered Lower Keys marsh rabbit. Journal of Wildlife Management 63:251–260.

Foster, M. L., and S. R. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin 23:93–100.

Fourqurean, J. W., and M. B. Robblee. 1999. Florida Bay: a history of recent ecological changes. Estuaries 2:345–357.

Frank, P. A. 1996. Ecology and conservation of the Anastasia Island beach mouse (*Peromyscus polionotus phasma*). Dissertation, University of Florida, Gainesville, Florida, USA.

Frank, P. A. 1997. First record of *Artibeus jamaicensis* Leach (1821) from the United States. Florida Scientist 60:37–39.

Frank, P. A., and S. R. Humphrey. 1996. Populations, habitat requirements, and management of the endemic Anastasia Island beach mouse (*Peromyscus polionotus phasma*), emphasizing the potential threat of exotic house mice (*Mus musculus*). Florida Game and Fresh Water Fish Commission Final Report, Tallahassee, Florida, USA.

Frankel, O. H., and M. E. Soulé. 1981. Conservation and evolution. Cambridge University Press, Cambridge, Massachusetts, USA.

Franklin, I. R. 1980. Evolutionary change in small populations. Pages 135–149 *in* M. E. Soulé and B. A. Wilcox, editors. Conservation biology: an evolutionary-ecological perspective. Sinauer, Sunderland, Massachusetts, USA.

Franz, R. 1988. The Florida gopher frog and the Florida pine snake as burrow associates of the gopher tortoise in northern Florida. Proceedings of the Annual Meeting of the Gopher Tortoise Council 5:16–20.

Franz, R. 1995. Habitat use, movements and home range in two species of ratsnakes (genus *Elaphe*) in a north Florida sandhill. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Report, Tallahassee, Florida, USA.

Franz, R., R. E. Ashton, and W. W. Timmerman. 1995. Behavior and movements of certain small sandhill amphibians and reptiles in response to drift fences. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Report, Tallahassee, Florida, USA.

Franz, R., J. Bauer, and T. Morris. 1994. Review of biologically significant caves and their faunas in Florida and south Georgia. Brimleyana No. 20:1–109.

Franz, R., C. K. Dodd, Jr., and C. Jones. 1988. Life history notes: *Rana areolata aesopus* (Florida gopher frog). Movement. Herpetological Review 19:33.

Franz, R., and L. L. Smith. 1999. Distribution of the striped newt and Florida gopher frog in peninsular Florida. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Frayer, W. E., and J. M. Hefner. 1991. Florida wetlands: status and trends, 1970s to 1980s. U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia, USA.

Freed, P. S., and K. Neitman. 1988. Notes on predation on the endangered Houston toad, *Bufo houstonensis*. Texas Journal of Science 40:454–456.

Freeman, J. R. 1958. Burrowing in the salamanders *Pseudobranchus striatus* and *Siren lacertina*. Herpetologica 44:18–24.

Fry, D. M. 1992. Point-source and non-point-source problems affecting seabirds populations. Pages 547–562 *in* D. R. McCullough and R. H. Barrett, editors. Wildlife 2001: populations. Elsevier Applied Science, New York, New York, USA.

Funderburg, J. B., and D. S. Lee. 1968. The amphibian and reptile fauna of pocket gopher (*Geomys*) mounds in central Florida. Journal of Herpetology 1:99–100.

Gaddy, L. L., and T. L. Kohlsaat. 1987. Recreational impact on the vegetation, avifauna, and herpetofauna of four South Carolina barrier islands. Natural Areas Journal 7:55–64.

Gann, G. 1995. Guidelines for rockland hammock creation in Dade County. Tillandsia (June):2–3.

Gauthreaux, S. A. Jr. 1971. A radar and direct visual study of passerine spring migration in southern Louisiana. Auk 88:343–365.

Gauthreaux, S. A. Jr. 1972. Behavioral responses of migrating birds to daylight and darkness: a radar and direct visual study. Wilson Bulletin 84:136–148

Gauthreaux, S. A. Jr ., J. Cely, C. Hunter. 1992. Minutes of Partners in Flight, Santee State Park, South Carolina, USA, November 19–20, 1991.

Gentry, J. B., and M. H. Smith. 1968. Food habits and burrow associates of *Peromyscus polionotus*. Journal of Mammalogy 49:562–565.

Gentry, R. C. 1974. Hurricanes in South Florida. Pages 73–81 *in* P. J. Gleason, editor. Environments of South Florida: present and past. Miami Geological Society Memoirs No. 2, Miami, Florida, USA.

Gibbons, J. W., and P. W. Stangel, coordinators. 1999. Conserving amphibians and reptiles in the new millenium. Proceedings of the Partners in Amphibian and Reptile Conservation (PARC) conference, June 1999, Atlanta, Georgia. Savannah River Ecology Laboratory HerpOutreach Publication No. 2, Aiken, South Carolina, USA.

Gibbs, J. P. 1998. Amphibian movements in response to forest edges, roads, and streambeds in southern New England. Journal of Wildlife Management 62:584–589.

Gilbert, C. R. 1987. Zoogeography of the freshwater fish fauna of southern Georgia and peninsular Florida. Brimleyana No. 13:25–54.

Gilbert, C. R., editor. 1992. Rare and endangered biota of Florida. Volume II. Fishes. University Press of Florida, Gainesville, Florida, USA.

Glitzenstein, J. S., W. J. Platt, and D. R. Streng. 1995. Effects of fire regime and habitat on tree dynamics in North Florida longleaf pine savannas. Ecological Monographs 65:441–476.

Godley, J. S. 1992. Gopher frog, *Rana capito* Le Conte. Pages 15–19 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Goodwin, C. C. 1994. Aspects of nesting ecology of the diamondback terrapin (*Malaclemys terrapin*) in Rhode Island. M.S. Thesis, University of Rhode Island, South Kingstown, Rhode Island, USA.

Goodyear, N. C. 1985. Results of a study of Key Largo woodrats and cotton mice: Phase I, spring and summer 1985. Unpublished report to the U.S. Fish and Wildlife Service, Jacksonville, Florida, USA.

Goodyear, N. C. 1987. Distribution and habitat of the silver rice rat, *Oryzomys argentatus*. Journal of Mammalogy 68:692–695.

Goodyear, N. C. 1991. Taxonomic status of the silver rice rat, *Oryzomys argentatus*. Journal of Mammalogy 72:723–730.

Gore, J. A. 1991. Distribution and abundance of nesting least terns and black skimmers in northwest Florida. Florida Field Naturalist 19:65–72.

Gore, J. A, and M. J. Kinnison. 1993. Hatching success in roof and ground colonies of least terns. Condor 93:759–762.

Gore, J. A, B. A. Millsap, and J. A. Feiertag. 1991. Coastal wildlife conservation initiative. Florida Game and Fresh Water Fish Commission Nongame Wildlife Section Annual Performance Report, Tallahassee, Florida, USA.

Gore, J. A, and T. L. Schaefer. 1993. Distribution and conservation of the Santa Rosa beach mouse. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:378–385.

Greenberg, C. H. 1993. Effect of high-intensity wildfire and silvicultural treatments on biotic communities of sand pine scrub. Dissertation, University of Florida, Gainesville, Florida, USA.

Greenberg, C. H. *In press*. Chaos and continuity: the role of isolated, ephemeral wetlands on amphibian populations in xeric sandhills. *In* W. E. Meshaka, Jr., and K. J. Babbitt, editors. Status and conservation of Florida amphibians and reptiles. Krieger Press, Boca Raton, Florida, USA.

Greenberg, C. H., D. G. Neary, and L. D. Harris. 1994. Effect of high-intensity wildfire and silvicultural treatments on reptile communities in sand-pine scrub. Conservation Biology 8:1047–1057.

Greening, H., and R. Eckenrod. 1995. Watershed management in Tampa Bay: a progress report May, 1994. Florida Scientist 58:117–121

Griffith, B., J. M. Scott, J. W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477–480.

Gunderson, L. H. 1994. Vegetation of the Everglades: determinants of community composition. Pages 323–340 *in* S. M. Davis and J. C. Ogden, editors. Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida, USA.

Hagan, J. M., III, and D. W. Johnston. 1992. Introduction. Pages 1–3 *in* Ecology and conservation on Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C., USA.

Haig, S. M., and L. W. Oring. 1987. The piping plover. Pages 509–518 *in* R. L. Di Silvestro, editor. Audubon wildlife report. National Audubon Society, Academic Press, New York, New York, USA.

Hardin, J. W., W. D. Klimstra, and N. J. Silvy. 1984. White-tailed population and habitats: Florida Keys. Pages 381–390 *in* L. K. Hall, editor. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

Harper, R. M. 1921. Geography of central Florida. Pages 71–307 *in* 13th Annual Report of the Florida Geological Survey.

Harper, R. M. 1927. Natural resources of southern Florida. Pages 27–206 *in* 18th Annual Report of the Florida Geological Survey.

Harrington, B. A., J. P. Myers, and J. S. Grear. 1989. Coastal refueling sites for global bird migrants. Pages 4293–4307 *in* O. T. Magoon, H. Converse, D. Miner, L. T. Tobin, and D. Clark, editors. Coastal Zone '89. Proceedings of the Sixth Symposium on Coastal and Ocean Management, Omni Hotel, Charleston, South Carolina, July 11–14, 1989. American Society of Civil Engineers, Salem, Massachusetts, USA.

Harris, L. D., and R. Mulholland. 1983. Southeastern bottomland ecosystems as wildlife habitat. Pages 63–73 *in* D. M. Flinchum, G. B. Doolittle, and K. R. Munson, editors. Appraisal of Florida's wetland hardwood resource. School of Forest Resources and Conservation, University of Florida, Gainesville, Florida, USA.

Harris, L. D., and C. R. Vickers. 1984. Some faunal community characteristics of cypress ponds and the changes induced by perturbations. Pages 171–185 *in* K. C. Ewel and H. T. Odum, editors. Cypress swamps. University Presses of Florida, Gainesville, Florida, USA.

Harrison, S. 1994. Metapopulations and conservation. Pages 111–128 *in* P. J. Edwards, R. M. May, and N. R. Webb, editors. Large-scale ecology and conservation biology. Blackwell Scientific, Oxford, United Kingdom.

Harshberger, J. W. 1914. The vegetation of South Florida south of 27 degrees 30 minutes north, exclusive of the Florida Keys. Transactions of the Wagner Free Institute of Science of Philadelphia Volume VII, Part 3:51–189; also Phytogeographic map of South Florida dated 1913.

Hart, R., and J. R. Newman. 1995. The importance of isolated wetlands to fish and wildlife in Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Report, Tallahassee, Florida, USA.

Hartman, B. 1992. Major terrestrial and wetland habitats. Pages xvii–xxviii *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Hartmann, T. 1988. Season summary. League of Florida Herpetological Societies Newsletter (October):19–20.

Hays, H., and R. W. Risebrough. 1972. Pollutant concentrations in abnormal young terns from Long Island Sound. Auk 89:19–35.

Heald, E. J., and W. E. Odum. 1970. The contribution of mangrove swamps to Florida fisheries. Proceedings of the Gulf and Caribbean Fisheries Institute 22:130–135.

Hedges, S. 1996. Landmark acquisition to save 47,000 acres of dry prairie habitat. The Nature Conservancy Florida Chapter News (Summer):1–2.

Hellman, R. E., and S. R. Telford, Jr. 1956. Notes on a large number of red-bellied mudsnakes, *Farancia a. abacura*, from northcentral Florida. Copeia 1956:257–258.

Helmers, D. L. 1992. Shorebird management manual. Western Hemisphere Shorebird Reserve Network, Manomet, Massachusetts, USA.

Henwood, T., W. Stuntz, and N. Thompson. 1992. Evaluation of U.S. turtle protective measures under existing TED regulations, including estimates of shrimp trawler related turtle mortality in the wider Caribbean. NOAA Technical Memorandum NMFS-SEFSC-303.

Hebrard, J. J., and R. C. Lee. 1981. A large collection of brackish water snakes from the central Atlantic Coast of Florida. Copeia 1981:886–889.

Herbst, L. H., and P. A. Klein. 1995. Green turtle fibropapillomatosis: challenges to assessing the role of environmental cofactors. Environmental Health Perspectives 103 (Supplement 4):27–30.

Hill, E. A. 1989. Population dynamics, habitat, and distribution of the Alabama beach mouse. M.S. Thesis, Auburn University, Auburn, Alabama, USA.

Hilmon, J. B., C. E. Lewis, and J. E. Bethune. 1963. Highlights of recent results of range research in southern Florida. Society of American Foresters Proceedings 1962:73–76.

Hilsenbeck, R. 1996. Kissimmee Prairie acquisition. Florida Department of Environmental Protection Resource Management Notes 8(3):58–60.

Hobbs, R. J., and A. J. M. Hopkins. 1991. The role of conservation corridors in a changing climate. Pages 281–290 *in* D. A. Saunders and C. B. Hobbs, editors. Nature conservation 2: the role of corridors. Surrey Beatty, Chipping Norton, New South Wales, Australia.

Hoehn, T. 1998. Rare and imperiled fish species of Florida: a watershed perspective. Florida Game and Fresh Water Fish Commission Office of Environmental Services, Tallahassee, Florida, USA.

Hoehn, T. 2001. The Apalachicola River today. Florida Wildlife 55(3):12.

Hoffman, D. J. 1990. Embryotoxicity and teratogenicity of environmental contaminants to bird eggs. Review of Environmental Contamination and Toxicology 115:40–89.

Hoffman, J. S. 1984. Estimates of future sea level rise. *In* M. C. Barth and J. G. Titus, editors. Greenhouse effect and sea level rise. Van Nostrand-Reinhold, New York, New York, USA.

Hoffman, M. L., and M. W. Collopy. 1988. Historical status of the American kestrel (*Falco sparverius paulus*) in Florida. Wilson Bulletin 100:91–107.

Hoffman, W. 1996. Cuban yellow warbler, *Dendroica petechia gundlachi*. Pages 375–380 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Hoffman, W., and G. E. Woolfenden. 1986. A fledgling brown-headed cowbird specimen from Pinellas County. Florida Field Naturalist 14:18–20.

Hoffmeister, J. E. 1974. Land from the sea, the geologic story of South Florida. University of Miami Press, Coral Gables, Florida, USA.

Hofstetter, R. H. 1984. The effect of fire on the pineland and sawgrass communities of southern Florida. Pages 465–476 *in* P. J. Gleason, editor. Environments of South Florida: present and past II. Miami Geological Society, Coral Gables, Florida, USA.

Hokit, D. G., B. M. Stith, and L. C. Branch. 1999. Effects of landscape structure in Florida scrub: a population perspective. Ecological Applications 9:124–134.

Holler, N. R., D. W. Mason, R. M. Dawson, T. Simons, and M. C. Wooten. 1989. Reestablishment of the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*) on Gulf Islands National Seashore. Conservation Biology 3:397–404.

Holliman, D. C. 1983. Status and habitat of Alabama Gulf coast beach mice *Peromyscus polionotus ammobates* and *P. p. trissyllepsis*. Northeast Gulf Science 6:121–129.

Hooper, M. D. 1971. The size and surroundings of nature reserves. Pages 555–561 *in* E. Duffy and A. S. Watt, editors. The scientific management of animal and plant communities for conservation. Blackwell Scientific Publications, London, United Kingdom.

Hoppe, M. K., V. Parsons, and S. Treat. 1993. Tampa Bay status and trends. Tampa Bay National Estuary Program, St. Petersburg, Florida, USA.

Horvitz, C. C. 1994. Hammocks and hurricanes: a surprisingly diverse array of non-indigenous plants threaten the natural regeneration of hardwood hammocks after hurricanes. Box 3.7a *in* D. C. Schmitz and T. C. Brown, editors. An assessment of invasive non-indigenous species in Florida's public lands. Technical Report No. TSS-94-100, Florida Department of Environmental Protection, Tallahassee, Florida, USA.

Horvitz, C. C., S. McMann, and A. Freedman. 1995. Exotics and hurricane damage in three hardwood hammocks in Dade County parks, Florida. Journal of Coastal Research (Special Hurricane Andrew Issue) 18:145–148.

Horvitz, C. C., J. B. Pascarella, S. McMann, A. Freedman, and R. H. Hofstetter. 1998. Functional roles of invasive non-indigenous plants in hurricane-affected subtropical hardwood forests. Ecological Applications 8:947–974.

Hough, W. A. 1973. Fuel and weather influence wildfires in sand pine forests. U.S. Forest Service Research Paper SE-106.

Hovis, J. A., and J. A. Gore. 2000. Nesting shorebird survey. Florida Fish and Wildlife Conservation Commission Final Performance Report, Tallahassee, Florida, USA.

Hovis, J. A., and M. S. Robson. 1989. Breeding status and distribution of the least tern in the Florida Keys. Florida Field Naturalist 17:61–66.

Howe, M. A., R. B. Clapp, and J. S. Weske. 1978. Marine and coastal birds. MESA New York Bight Atlas Monograph No. 31. New York Sea Grant Institute, Albany, New York, USA.

Howell, A. H. 1932. Florida bird life. Coward-McCann, New York, New York, USA.

Howell, A. H. 1939. Descriptions of five new mammals from Florida. Journal of Mammalogy 20:363–365.

Hubbard, H. G. 1894. The insect guests of the Florida land tortoise. Insect Life 6:302–315.

Huffman, J. M., and S. W. Blanchard. 1991. Changes in woody vegetation in Florida dry prairie and wetlands during a period of fire exclusion, and after dry-growing-season fire. Pages 75–83 *in* S. C. Nodvin and T. A. Waldrop, eds. Fire and the environment: ecological and cultural perspectives. Proceedings of an international symposium. U.S. Forest Service General Technical Report SE-69, Southeastern Experiment Station, Asheville, North Carolina, USA.

Huffman, J. M., and W. S. Judd. 1998. Vascular flora of Myakka River State Park, Sarasota and Manatee counties. Castanea 63(1):25–50.

Hughes, R. H. 1975. The native vegetation in South Florida related to month of burning. U.S. Forest Service Southeastern Forest Experiment Station Research Note SE-222.

Humphrey, S. R. 1981. Goff's pocket gopher (*Goemys pinetis goffi*) is extinct. Florida Scientist 44:250–252.

Humphrey, S. R. 1988*a*. Density estimates of the Key Largo woodrat and cotton mouse (*Neotoma floridana smalli* and *Peromyscus gossypinus allapaticola*), using the nested grid approach. Journal of Mammalogy 69:524–531.

Humphrey, S. R. 1988*b*. The habitat conservation plan. Conservation Biology 2:240–244.

Humphrey, S. R. 1992*a*. Anastasia Island beach mouse, *Peromyscus polionotus phasma*. Pages 94–101 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*b*. Anastasia Island population of cotton mouse, *Peromyscus gossypinus gossypinus* (in part). Pages 41–46 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*c* Chadwick Beach cotton mouse, *Peromyscus gossypinus restrictus*. Pages 24–28 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*d* Goff's pocket gopher, *Geomys pinetis goffi*. Pages 11–18 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*e*. Key Largo cotton mouse, *Peromyscus gossypinus allapaticola*. Pages 110–118 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*f*. Key Largo woodrat, *Neotoma floridana smalli*. Pages 119–130 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*g*. Lower Keys population of rice rat, *Oryzomys palustris natator* (in part). Pages 300–309 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R. 1992*h*. Pallid beach mouse, *Peromyscus polionotus decoloratus*. Pages 19–23 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R., editor. 1992*i*. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R., and D. B. Barbour. 1981. Status and habitat of three subspecies of *Peromyscus polionotus* in Florida. Journal of Mammalogy 62:840–844.

Humphrey, S. R., and B. Bell. 1986. The Key deer population is declining. Wildlife Society Bulletin 14:261–265.

Humphrey, S. R, J. F. Eisenberg, and R. L. 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. A. Frank. 1992. Anastasia Island beach mouse, *Peromyscus polionotus phasma*. Pages 94–101 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Humphrey, S. R., W. H. Kern, Jr., and M. E. Ludlow. 1987. Status survey of seven Florida mammals. Unpublished final report to the U.S. Fish and Wildlife Service, Jacksonville, Florida, USA.

Humphrey, S. R., W. H. Kern, Jr., and M. E. Ludlow. 1988. The Anastasia Island cotton mouse (Rodentia: *Peromyscus gossypinus anastasae*) may be extinct. Florida Scientist 51:150–155.

Humphrey, S. R., and J. L. Morrison. 2000. Habitat associations, reproduction, and foraging ecology of Audubon's crested caracara in south-central Florida. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Humphrey, S. R., and H. W. Setzer. 1989. Geographic variation and taxonomic revision of rice rats (*Oryzomys palustris* and *O. argentatus*) of the United States. Journal of Mammalogy 70:557–570.

Humphrey, S. R., and T. L. Zinn. 1982. Seasonal habitat use by river otters and Everglades mink in Florida. Journal of Wildlife Management 46:375–381.

Hunter, W. C. 1996. Natural resource management priorities in the humid Southeast: an emphasis on nongame bird conservation through public-private partnerships. U.S. Fish and Wildlife Service Internal Publication, Atlanta, Georgia, USA.

Iverson, J. B. 1978. Variation in striped mud turtles, *Kinosternon baurii* (Reptilia, Testudines, Kinosternidae). Journal of Herpetology 12:136–142.

Iverson, J. B., and C. R. Etchberger. 1989. The distributions of the turtles of Florida. Florida Scientist 52:119–144.

Jackson, D. R. 1995. Systematics of the *Pseudemys concinna-floridana* complex (Testudines: Emydidae): an alternative interpretation. Chelonian Conservation and Biology 1:329–333.

Jackson, D. R., and E. G. Milstrey. 1989. The fauna of gopher tortoise burrows. Pages 86–98 *in* J. E. Diemer et al., editors. Proceedings gopher tortoise relocation symposium. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 5, Tallahassee, Florida, USA.

Jackson, J. B. C., J. D. Cubit, B. D. Keller, V. Batista, K. Burns, H. M. Caffey, R. L. Caldwell, S. D. Garrity, C. D. Getter, C. Gonzalez, H. M. Guzman, K. W. Kaufmann, A. H. Knap, S. C. Levings, M. J. Marshall, R. Steger, R. C. Thompson, and E. Weil. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243:37–44.

Jackson, J. F. 1973. Distribution and population phenetics of the Florida scrub lizard, *Sceloporus woodi*. Copeia 1973:746–761.

Jacobson, B. N. 1974. Effects of drinking water on habitat utilization by Key deer. M.S. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Jacobson, E. R. 1994. Diseases in wild populations of turtles and tortoises in Florida. A symposium on the status and conservation of Florida turtles, 2–3 April 1994, Eckerd College, St. Petersburg, Florida, USA. (abstract)

James, F. C., D. A. Wiedenfeld, and C. E. McCulloch. 1992. Trends in breeding populations of warblers: declines in the southern highlands and increases in the lowlands. Pages 43–56 *in* J. M. Hagan III and D. W. Johnston, editors. Symposium on the ecology and conservation of neotropical migrant landbirds, 6–9 December 1989, Manomet Bird Observatory, Manomet, Massachusetts, USA.

Jetter, W., and L. D. Harris. 1976. The effects of perturbation on cypress dome animal communities. Pages 577–653 *in* H. T. Odum, K. C. Ewel, J. W. Ordway, and M. K. Johnston, editors. Cypress wetlands for water management, recycling, and conservation. Third annual report. Center for Wetlands, University of Florida, Gainesville, Florida, USA.

Jodice, P. G. R. 1991. Surveying wintering loons from the air. University of Michigan School of Natural Resources, Endangered Species Update 9(7):9.

Johnson, A. F. 1982. Some demographic characteristics of the Florida rosemary, *Ceratiola ericoides* Michx. American Midland Naturalist 108:170–174.

Johnson, A. F., and M. G. Barbour. 1990. Dunes and maritime forests. Pages 429–480 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Johnson, A. F., and J. W. Muller. 1992*a*. An assessment of Florida's remaining coastal upland natural communities: panhandle. Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Johnson, A. F., and J. W. Muller. 1992*b*. An assessment of Florida's remaining coastal upland natural communities: southeast Florida. Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Johnson, A. F., and J. W. Muller. 1992*c*. An assessment of Florida's remaining coastal upland natural communities: southwest Florida. Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Johnson, S. A., A. L. Bass, B. Libert, M. Marshall, and D. Fulk. 1999. Kemp's ridley (*Lepidochelys kempi*) nesting in Florida. Florida Scientist 62:194–204.

Joiner, N. D., and J. Godwin. 1992*a*. Aquatic and terrestrial wildlife surveys for the Lake Panasoffkee watershed. Fourth quarterly report. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program, Tallahassee, Florida, USA. Prepared for SWIM Department, Southwest Florida Water Management District, Contract No. 89093.

Joiner, N. D., and J. Godwin. 1992*b*. Aquatic and terrestrial wildlife surveys for the Rainbow River watershed. Fourth quarterly report. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program, Tallahassee, Florida, USA. Prepared for SWIM Department, Southwest Florida Water Management District, Contract No. 89093.

Joly, P., and A. Morand. 1997. Amphibian diversity and land–water ecotones. Pages 161–182 *in* J.-P. Bravard and R. Juge, editors. Biodiversity in land–water ecotones. Man and biosphere series. Volume 18. United Nations Educational, Scientific and Cultural Organization, Paris, France.

Jones, C. A. 1990. Microhabitat use by *Podomys floridanus* in the high pine lands of Putnam County, Florida. Dissertation, University of Florida, Gainesville, Florida, USA.

Jones, C. A. 1992. Review of the effects of fire on *Peromyscus* and *Podomys*. Florida Scientist 55:75–84.

Jones, C., and R. Franz. 1990. Use of gopher tortoise burrows by Florida mice (*Podomys floridanus*) in Putnam County, Florida. Florida Scientist 18:45–51.

Jurek, R. M. 1994. A bibliography of feral, stray, and free-ranging domestic cats in relation to wildlife conservation. California Department of Fish and Game, Nongame Bird and Mammal Program Report 94-5.

Kale, H. W., II. 1965. Ecology and bioenergetics of the long-billed marsh wren, *Telmatodytes palustris griseus*, in Georgia salt marshes. Nuttall Ornithological Club Publication No. 5.

Kale, H. W., II. 1983. Distribution, habitat, and status of breeding seaside sparrows in Florida. Pages 41–48 *in* T. L. Quay, J. B. Funderburg, Jr., D. S. Lee, E. F. Potter, and C. S. Robbins, editors. The seaside sparrow, its biology and management. Occasional Paper of the North Carolina Biological Survey 1983–5, Raleigh, North Carolina, USA.

Kale, H. W., II. 1996*a*. Dusky seaside sparrow, *Ammodramus maritimus nigrescens*. Pages 7–12 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Kale, H. W., II. 1996*b*. Marsh wrens, *Cistothorus palustris*; Marian's marsh wren, *C. p. marianae*; Worthington's marsh wren, *C. p. griseus*. Pages 602–607 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Kale, H. W., II. 1996*c*. Seaside sparrows, *Ammodramus maritimus*; MacGillivray's seaside sparrow, *A. m. macgillivraii*; Scott's seaside sparrow, *A. m. peninsulae*; Louisiana seaside sparrow. *A. m. fisheri*. Pages 608–615 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Kalisz, P. J., and E. L. Stone. 1984*a*. The longleaf pine islands of the Ocala National Forest, Florida: a soil study. Ecology 65:1743–1754.

Kalisz, P. J., and E. L. Stone. 1984*b*. Soil mixing by scarab beetles and pocket gophers in north-central Florida. Soil Science Society of America Journal 48:169–172.

Kalmbacher, R. S., and F. G. Martin. 1984. Chopping and tebuthiuron effects on saw-palmetto. Soil and Crop Science Society of Florida Proceedings 43:86–89.

Kantola, A. T. 1986. Fox squirrel home range and mast crops in Florida. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Kantola, A. T. 1992. Sherman's fox squirrel, *Sciurus niger shermani*. Pages 234–241 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Kantola, A. T., and S. R. Humphrey. 1990. Habitat use by Sherman's fox squirrel (*Sciurus niger shermani*) in Florida. Journal of Mammalogy 71:411–419.

Karl, S. A., H. R. Mushinsky, and K. P. Jansen. 2001. Ecological genetics of the threatened saltmarsh snake, *Nerodia clarkii*. Final Report to the Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Karl, S. A., and D. S. Wilson. 2001. Phylogeography and systematics of the mud turtle, *Kinosternon baurii*. Copeia 2001:797–801.

Karr, J. R. 1990. Viable populations, reserve size, and federal land management: a critique. Conservation Biology 4:127–134.

Kasprzyk, M. J., and B. A. Harrington. 1989. Shorebird field manual. Manomet Bird Observatory, Manomet, Massachusetts, USA.

Kautz, R. S. 1998. Land use and land cover trends in Florida 1936–1995. Florida Scientist 61:171–187.

Kautz, R. S., and J. A. Cox. 2001. Strategic habitats for biodiversity conservation in Florida. Conservation Biology 15:55–77.

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.

Kenner, W. E. 1975. Seasonal variation of streamflow in Florida. Bureau of Geology Map Series No. 31 (updated), Florida Department of Natural Resources, Tallahassee, Florida, USA.

Kent, D. M., and E. Snell. 1994. Vertebrates associated with gopher tortoise burrows in Orange County, Florida. Florida Field Naturalist 22:8–10.

Kerlinger, P. 1989. Flight strategies of migrating hawks. University of Chicago Press, Chicago, Illinois, USA.

Kerlinger, P. 1995. How birds migrate. Stackpole Books, Mechanisburg, Pennsylvania, USA.

Kirchhoff, M. 1995. Florida Bay partnerships. Everglades Connection 4(2):1–3.

Kirkman, L. K. 1995. Impacts of fire and hydrological regimes on vegetation in depression wetlands of southeastern USA. Pages 10–20 *in* S. I. Cerulean and R. T. Engstrom, editors. Fire in wetlands: a management perspective. Proceedings of the Tall Timbers Fire Ecology Conference No. 19, Tall Timbers Research Station, Tallahassee, Florida, USA.

Klein, M. L., S. R. Humphrey, and H. F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9:1454–1465.

Klimstra, W. D. 1992. Key deer, *Odocoileus virginianus clavium*. Pages 201–215 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Klimstra, W. D., and A. L. Dooley. 1990. Foods of the Key deer. Florida Scientist 53:264–273.

Klimstra, W. D., J. W. Hardin, N. J. Silvy, B. N. Jacobson, and V. A. Terpening. 1974. Key deer investigations final report. Period of study: December 1967–June 1973. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois, USA.

Klukas, R. W. 1973. Control burn activities in Everglades National Park. Proceedings of the Tall Timbers Fire Ecology Conference 12:397–425.

Klukas, R. W., J. C. Ogden, T. Hines, W. B. Robertson, Jr., J. A. Kushlan, and H. W. Campbell. 1979. American crocodile recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia, USA.

Knizley, E. J. 1997. Gopher tortoise (*Gopherus polyphemus*) relocation project: monitoring the tortoise population and associate species of the tortoise burrow. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Kochman, H. I., and S. P. Christman. 1992. Atlantic salt marsh snake, *Nerodia clarkii taeniata* (Cope). Pages 111–116 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Koebel, J. W., Jr. 1995. An historical perspective on the Kissimmee River restoration project. Restoration Ecology 3:149–159.

Komarek, E. V., Sr. 1968. Lightning and lightning fires as ecological forces. Proceedings of the Tall Timbers Fire Ecology Conference 8:169–197.

Kruczynski, W. L. 1982. Salt marshes of the northeastern Gulf of Mexico. Pages 71–87 *in* R. R. Lewis III, editor. Creation and restoration of coastal plant communities. CRC Press, Boca Raton, Florida, USA.

Kruer, C. R. 1992. An assessment of Florida's remaining coastal upland natural communities: Florida Keys. Prepared for Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Kruer, C. R., T. Armstrong, and P. Braisted. 1998. Invasive exotic vegetation mapping in the Florida Keys. Report and 122-MB CD prepared for the Florida Keys Invasive Exotics Task Force, Summerlin Key, Florida, USA.

Krysko, K. L., and J. Decker. 1996. Geographic distribution: *Tantilla oolitica* (rim rock crowned snake). Herpetological Review 27:215.

Krysko, K. L., and C. Hurt. 1998. Geographic distribution: *Lampropeltis calligaster occipitolineata* (South Florida mole kingsnake). Herpetological Review 29:177.

Kunz, T. H., and E. D. Pierson. 1994. Bats of the world: an introduction. Pages 1–46 *in* R. M. Nowak. Walker's bats of the world. John Hopkins University Press, Baltimore, Maryland, USA.

Kushlan, J. A. 1990. Freshwater marshes. Pages 324–363 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Kushlan, J. A., O. L. Bass, Jr., L. L. Loope, W. B. Robertson, Jr., P. C. Rosendahl, and D. L. Taylor. 1982. Cape Sable sparrow management plan. South Florida Research Center Report M-660, Everglades National Park, Homestead, Florida, USA.

Kushlan, J. A., and F. J. Mazzotti. 1989. Historic and present distribution of the American crocodile in Florida. Journal of Herpetology 23:1–7.

Laan, R., and B. Verboom. 1990. Effects of pool size and isolation on amphibian communities. Biological Conservation 54:251–262.

LaClaire, L. V. 1992. Ecology of temporary ponds in north-central Florida. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

LaClaire, L. V. 1997. Amphibians in peril: resource management in the Southeast. Pages 307–338 in G. W. Benz and D. E. Collins, editors. Aquatic fauna in peril: the southeastern perspective. Special Publication, Southeast Aquatic Research Institute. Lenz Design & Communication, Decatur, Georgia, USA.

LaClaire, L. V., and R. Franz. 1990. Importance of isolated wetlands in upland landscapes. Pages 9–15 *in* M. Kelly, editor. Proceedings of the Second Annual Meeting of the Florida Lake Management Society, Winter Haven, Florida, USA.

Laessle, A. M. 1942. The plant communities of the Welaka area with special reference to correlation between soils and vegetational succession. University of Florida Publication, Biological Sciences Series 4:1–143.

Laessle, A. M. 1958. The origin and successional relationships of sandhill vegetation and sand-pine scrub. Ecological Monographs 28:361–387.

Laessle, A. M. 1968. Relationships of sand pine scrub to former shore lines. Quarterly Journal of the Florida Academy of Science 30:269–286.

Lamb, T., and J. C. Avise. 1992. Molecular and population genetic aspects of mitochondrial DNA variability in the diamondback terrapin, *Malaclemys terrapin*. Journal of Heredity 83:262–269.

Landers, J. L., and J. L. Buckner. 1981. The gopher tortoise: effects of forest management and critical aspects of its ecology. Southlands Experimental Forest Technical Note No. 56.

Landers, J. L., and D. W. Speake. 1980. Management needs of sandhill reptiles on southern Georgia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 34:515–529.

Langton, T. E. S., editor. 1989. Amphibians and roads. ACO Polymer Products, Shefford, United Kingdom.

Larsen, E. M., and S. A. Richardson. 1990. Some effects of a major oil spill on wintering shorebirds at Grays Harbor Washington. Northwestern Naturalist 71:88–92.

Lawson, R., A. J. Meier, P. G. Frank, and P. E. Moler. 1991. Allozyme variation and systematics of the *Nerodia fasciata–Nerodia clarkii* complex of water snakes (Serpentes: Colubridae). Copeia 1991:638–659.

Layne, J. N. 1970. Climbing behavior of *Peromyscus floridanus* and *Peromyscus gossypinus*. Journal of Mammalogy 51:580–591.

Layne, J. N. 1974. The land mammals of South Florida. Pages 386–413 *in* P. Gleason, editor. Environments of South Florida: present and past. Miami Geological Society Memoirs No. 2, Miami, Florida, USA.

Layne, J. N. 1978. Audubon's caracara (*Caracara cheriway auduboni*). Pages 34–36 *in* H. W. Kale II, editor. Rare and endangered biota of Florida. Volume 2. Birds. University Presses of Florida, Gainesville, Florida, USA.

Layne, J. N. 1984. The land mammals of South Florida. Pages 269–296 *in* P. J. Gleason, editor. Environments of South Florida: past and present II. Miami Geological Society, Coral Gables, Florida, USA.

Layne, J. N. 1990. The Florida mouse. Proceedings of the Annual Meeting of the Gopher Tortoise Council 8:1–21.

Layne, J. N. 1992. Florida mouse, *Podomys floridanus*. Pages 250–264 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Layne, J. N. 1996. Caracara, *Caracara plancus*. Pages 197–210 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Layne, J. N., and R. J. Jackson. 1994. Burrow use by the Florida mouse (*Podomys floridanus*) in south-central Florida. American Midland Naturalist 131:17–23.

Layne, J. N., J. A. Stallcup, G. E. Woolfenden, M. N. McCauley, and D. J. Worley. 1977. Fish and wildlife inventory of the seven-county region included in the Central Florida Phosphate Industry Areawide Environmental Impact Study. U.S. Department of Commerce, National Technical Information Service PB-278 456, Volume 1.

Layne, J. N., T. J. Walsh, and P. Meylan. 1986. New records for the mole snake, *Lampropeltis calligaster*, in peninsular Florida. Florida Scientist 49:171–175.

Lazell, J. D., Jr. 1984. A new marsh rabbit (*Sylvilagus palustris*) from Florida's Lower Keys. Journal of Mammalogy 65:26–33.

Lazell, J. D., Jr. 1989. Wildlife of the Florida Keys: a natural history. Island Press, Covelo, California, USA.

Lee, D. S. 1968. Herpetofauna associated with central Florida mammals. Herpetologica 24:83–84.

Lee, D. S. 1969. Moisture toleration: a possible key to dispersal ability in three fossorial lizards. Bulletin of the Maryland Herpetological Society 5:53–56.

Lee, D. S. 1974. Possible role of fire on population density of the Florida scrub lizard, *Sceloporus woodi* Stejneger. Bulletin of the Maryland Herpetological Society 10:20–22.

Leenhouts, W. P. 1983. Marsh and water management plan, Merritt Island National Wildlife Refuge. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge, Titusville, Florida, USA.

Leenhouts, W. P., and J. L. Baker. 1982. Vegetation dynamics in dusky seaside sparrow habitat on Merritt Island National Wildlife Refuge. Wildlife Society Bulletin 10:127–132.

Legare, M. L., and W. R. Eddleman. 2001. Home range size, nest-site selection and nesting success of black rails in Florida. Journal of Field Ornithology 72:170–177.

Lehmkuhl, J. F. 1984. Determining population size and dispersion of minimum viable populations for land management planning and species conservation. Environmental Management 8:167–176.

Leitman, H. M., J. E. Sohm, and M. A. Franklin. 1982. Wetland hydrology and tree distribution of the Apalachicola River flood plain. U.S. Geological Survey Water-Supply Paper No. 2196-A.

Lewis, R. R., III. 1990. Creation and restoration of coastal plain wetlands in Florida. Pages 73–101 *in* J. A. Kushler and M. E. Kentula, editors. Wetland creation and restoration of coastal plain wetlands in Florida: the status of the science. Island Press, Washington, D.C, USA.

Lewis, R. R., III, R. G. Gilmore, Jr., D. W. Crewz, and W. E. Odum. 1985. Mangrove habitat and fishery resources of Florida. Pages 281–336 *in* W. Seaman, Jr., editor. Florida aquatic habitat and fishery resources. Florida Chapter of the American Fisheries Society, Kissimmee, Florida, USA.

Lindall, W. M., Jr., and C. H. Saloman. 1977. Alteration and destruction of estuaries affecting fisheries resources of the Gulf of Mexico. Marine Fisheries Review 39, Paper No. 1262.

Lindeman, P. V. 1999. Surveys of basking map turtles *Graptemys* spp. in three river drainages and the importance of deadwood abundance. Biological Conservation 88:33–42.

Lins, H. F., Jr. 1980. Patterns and trends of land use and land cover on Atlantic and Gulf coast barrier islands. U.S. Geological Survey Professional Paper No. 1156.

Litt, A. R. 1999. Herpetofaunal responses to longleaf pine sandhill restoration treatments on Eglin Air Force Base, Florida. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Litt, A. R., L. Provencher, G. W. Tanner, and R. Franz. 2001. Herpetofaunal responses to restoration treatments of longleaf pine sandhills in Florida. Restoration Ecology 9:462–474.

Lockwood, J. L., K. H. Fenn, J. L. Curnutt, D. Rosenthal, K. L. Balent, and A. L. Mayer. 1997. Life history of the endangered Cape Sable seaside sparrow. Wilson Bulletin 109:720–731.

Lockwood, J. L., K. H. Fenn, J. M. Caudill, D. Okines, O. L. Bass, Jr., J. R. Duncan, and S. L. Pimm. 2001. The implications of Cape Sable seaside sparrow demography for Everglades restoration. Animal Conservation 4:275–281.

Lodé, T. 2000. Effect of a motorway on mortality and isolation of wildlife populations. Ambio 29:163–166.

Long, E. R., R. S. Carr, G. B. Thursby, and D. A. Wolfe. 1995. Sediment toxicity in Tampa Bay: incidence, severity, and spatial distribution. Florida Scientist 58:163–178.

Long, E. R., D. MacDonald, and C. Cairncross. 1991. Status and trends in toxicants and the potential for their biological effects in Tampa Bay, Florida. NOAA Technical Memorandum NOS OMA 58, Seattle, Washington, USA.

Loope, L. L., D. W. Black, S. Black, and G. N. Avery. 1979. Distribution and abundance of flora in limestone rockland pine forests of southeastern Florida. South Florida Research Center Report T-547, Everglades National Park, Homestead, Florida, USA.

Loope, L. L., M. Duever, A. Herndon, J. Snyder, and D. Jansen. 1994. Hurricane impact on uplands and freshwater swamp forest. BioScience 44:238–246.

Loope, L. L., and V. L. Dunevitz. 1981. Impact of fire exclusion and invasion of *Schinus terebinthifolius* on limestone rockland pine forests of southeastern Florida. South Florida Research Center Report T-645, Everglades National Park, Homestead, Florida, USA.

Lopez, R. R., N. J. Silvy, and J. D. Sebesta. 1999. Population estimates of Florida Key deer. Abstract *in* Managing for biodiversity. The Florida Wildlife Society and Natural Areas Association Spring Conference, 31 March–2 April 1999, Orlando, Florida, USA.

Lovich, J. E., and C. J. McCoy. 1992. Review of the *Graptemys pulchra* group (Reptilia: Testudines: Emydidae), with descriptions of two new species. Annals of the Carnegie Museum 61:293–315.

Lowe, J. D. 1994. Winter bird population study 1993. Journal of Field Ornithology, Resident Bird Counts Supplement Volume 65.

Lowery, G. H., Jr. 1945. Trans-Gulf migration of birds and the coastal hiatus. Wilson Bulletin 57:92–121

Lugo, A. E. 1980. Mangrove ecosystems: successional or steady state? Biotropica 12:65–73.

Lugo, A. E. 1995. Fire and wetland management. Pages 1–9 *in* S. I. Cerulean and R. T. Engstrom, editors. Fire in wetlands: a management perspective. Proceedings of the Tall Timbers Fire Ecology Conference No. 19, Tall Timbers Research Station, Tallahassee, Florida, USA.

Lugo, A. E, M. Brinson, and S. Brown, editors. 1990. Forested wetlands. Elsevier, New York, New York, USA.

Lugo, A. E, and S. C. Snedaker. 1974. The ecology of mangroves. Annual Review of Ecology and Systematics 5:39–64.

Lugo, A. E, R. R. Twilley, and C. Patterson-Zucca. 1980. The role of black mangrove forests in the productivity of coastal ecosystems in South Florida. Report to the Corvallis Environmental Research Laboratory, Corvallis, Oregon, USA.

Lund, P. F. 1985. Hawksbill turtle (*Eretmochelys imbricata*) nesting on the east coast of Florida. Journal of Herpetology 19:164–166.

Lydeard, C., and R. L. Mayden. 1995. A diverse and endangered aquatic ecosystem of the Southeast United States. Conservation Biology 9:800–805.

Macdonald, L. A. 1994. Reintroduction of gopher tortoises, *Gopherus polyphemus*, to reclaimed phosphate-mined land. A symposium on the status and conservation of Florida turtles, 2–3 April 1994, Eckerd College, St. Petersburg, Florida, USA. (abstract)

MacVicar, T. K., and S. S. T. Lin. 1984. Historical rainfall activity in central and southern Florida: average, return period estimates and selected extremes. Pages 477–509 *in* P. J. Gleason, editor. Environments of South Florida: present and past II. Miami Geological Society, Coral Gables, Florida, USA.

Mader, H. 1984. Animal habitat isolation by roads and agricultural fields. Biological Conservation 29:81–96.

Maguire, J. 1995. Restoration plan for Dade County's pine rocklands following Hurricane Andrew. Department of Environmental Resources Management, Miami, Florida, USA.

Mann, T. M. 1995. Population surveys for diamondback terrapin (*Malaclemys terrapin*) and Gulf salt marsh snakes (*Nerodia clarkii*) in Mississippi. Mississippi Museum of Natural Science Technical Report No. 37, Jackson, Mississippi, USA.

Marois, K. C., and K. C. Ewel. 1983. Natural and management-related variation in cypress domes. Forest Science 29:627–640.

Marsh, D. M., and T. C. Trenham. 2001. Metapopulation dynamics and amphibian conservation. Conservation Biology 15:40–49.

Marsh, G. A. and D. B. Turbeville. 1982. Some beach nourishment projects do not seem to cause long term damage to marine life. Pages 15–23 *in* L. Tait, editor. Papers presented at annual conference on beach preservation. Florida Shore & Beach Preservation Association, Tallahassee, Florida, USA.

McCoid, M. J., and P. W. Bettoli. 1996. Additional evidence for rotenone hazards to turtles and amphibians. Herpetological Review 27:70–71.

McCoy, E. D. 1977. The diversity of terrestrial arthropods in northwest Florida salt marshes. Dissertation, Florida State University, Tallahassee, Florida, USA.

McGuinness, K. A. 1984. Equations and explanations in the study of species-area curves. Biological Review 59:423–440.

McIntyre, J. W. 1986. Common loon. Pages 679–695 *in* R. L Di Silvestro, editor. Audubon wildlife report. The National Audubon Society, New York, New York, USA.

McLaughlin, G. S. 1997. Upper respiratory tract disease in gopher tortoises, *Gopherus polyphemus*: pathology, immune responses, transmission, and implications for conservation and management. Dissertation, University of Florida, Gainesville, Florida, USA.

McNair, D. B., and J. A. Gore. 2000. Recent breeding of Caspian terns in northwest Florida. Florida Field Naturalist 28:30–32.

McNair, D. B., M. A. McMillian, and K. D. Meyer. 2001. A review of the breeding status of the short-tailed hawk in the Lake Istokpoga region, Highlands County, Florida. Florida Field Naturalist 29:41–46.

McRae, W. A., J. L. Landers, and G. D. Cleveland. 1981. Sexual dimorphism in the gopher tortoise (*Gopherus polyphemus*). Herpetologica 37:46–52.

Mealor, W. T., Jr. 1972. The open range ranch in South Florida and its contemporary successors. Dissertation, University of Georgia, Athens, Georgia, USA.

Means, D. B. 1975. Competitive exclusion along a habitat gradient between two species of salamanders (*Desmognathus*) in northern Florida. Journal of Biogeography 2:253–263.

Means, D. B. 1977. Aspects of the significance to terrestrial vertebrates of the Apalachicola River drainage basin. Florida Marine Research Publication No. 26:37–67.

Means, D. B. 1985*a*. The canyonlands of Florida. Nature Conservancy News (September/October):13–17.

Means, D. B. 1985*b*. Radio-tracking the eastern diamondback rattlesnake. National Geographic Society Research Report 18:529–536.

Means, D. B. 1990. Florida wetlands: seepage bogs. Florida Wildlife 44(5):34–37.

Means, D. B. 1991. Florida's steepheads: unique canyonlands. Florida Wildlife 45(3):25–28.

Means, D. B. 1992*a*. Four-toed salamander, *Hemidactylium scutatum* (Schlegel). Pages 54–57 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Means, D. B. 1992*b*. Georgia blind salamander, *Haideotriton wallacei* Carr. Pages 49–53 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Means, D. B. 1992*c*. Pine Barrens treefrog, *Hyla andersonii* Baird. Pages 20–25 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Means, D. B. 1992*d*. Seal salamander, *Desmognathus monticola* Dunn. Pages 44–48 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Means, D. B. 1997. Wiregrass restoration: probable shading effects in a slash pine plantation. Restoration & Management Notes 15:52–55.

Means, D. B. 1999. The effects of highway mortality on four species of amphibians at a small, temporary pond in northern Florida. Pages 125–128 *in* G. Evink, P. Garrett, and D. Zeigler, editors. Proceedings of the Third International Conference on Wildlife Ecology and Transportation. Florida Department of Transportation FL-ER-TS-99, Tallahassee, Florida, USA.

Means, D. B. 2002. Decline of the southern dusky salamander in the southeastern U.S. Florida Scientist 66(Supplement 1):45–46 (abstract).

Means, D. B., and G. O. Grow. 1985. The endangered longleaf pine community. ENFO (Environmental Information Center of the Florida Conservation Foundation) Report (September):1–12.

Means, D. B., and R. C. Means. *In press*. Effects of sand pine silviculture on pond-breeding amphibians in the Woodville Karst Plain of north Florida. *In* W. E. Meshaka, Jr., and K. J. Babbitt, editors. Status and conservation of Florida amphibians and reptiles. Krieger Press, Boca Raton, Florida, USA.

Means, D. B., and P. E. Moler. 1979. The Pine Barrens treefrog: fire, seepage bogs, and management implications. Pages 77–83 *in* R. R. Odum and L. Landers, editors. Proceedings of the rare and endangered wildlife symposium. Georgia Department of Natural Resources Game and Fish Division Technical Bulletin WL 4, Social Circle, Georgia, USA.

Means, D. B., J. G. Palis, and M. Baggett. 1996. Effects of slash pine silviculture on a Florida population of flatwoods salamander. Conservation Biology 10:426–437.

Meffe, G. K., and C. R. Carroll, editors. 1994. Principles of conservation biology. Sinauer, Sunderland, Massachusetts, USA.

Melvin, S. M., C. R. Griffin, and L. H. MacIvor. 1991. Recovery strategies for piping plovers in managed coastal landscapes. Coastal Management 19:21–34.

Merritt, P. G., and O. T. Owre. 1996. Black-whiskered vireo, *Vireo altiloquus*. Pages 348–352 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Meshaka, W. E., Jr., and J. N. Layne. 2002. Herpetofauna of a long-unburned sandhill habitat in south-central Florida. Florida Scientist 65:35–50.

Meyer, K. D. 1998. Communal roosts of the American swallow-tailed kite in Florida: habitat associations, critical sites, and a technique for monitoring population status. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Report, Tallahassee, Florida, USA.

Meyer, K. D., and M. W. Collopy. 1995. Status, distribution, and habitat requirements of the American swallow-tailed kite (*Elanoides forficatus*) in Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Report, Tallahassee, Florida, USA.

Meyers, J. M. 1983. Status, microhabitat, and management recommendations for *Peromyscus polionotus* on Gulf coast beaches. Unpublished report to the U.S. Fish and Wildlife Service, Atlanta, Georgia, USA.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the State of Florida 1979–1992. Florida Marine Research Publication No. 52.

Meylan, P. A. 1982. The squamate reptiles of the Inglis IA fauna (Irvingtonian: Citrus County, Florida). Bulletin of the Florida State Museum 27:1–85.

Miller, L. A., J. D. Baldwin, B. K. Mealey, G. M. Parks, and M. R. J. Forstner. *In press*. Insights into turtle conservation from observations of the diamondback terrapin *Malaclemys terrapin* in Florida Bay. *In* W. E. Meshaka, Jr., and K. J. Babbitt, editors. Status and conservation of Florida amphibians and reptiles. Krieger Press, Boca Raton, Florida, USA.

Millsap, B. A. 1987. Summer concentrations of American swallow-tailed kites at Lake Okeechobee, Florida, with comments on post-breeding movements. Florida Field Naturalist 15:85–92.

Millsap, B. A. 1995. Wildlife conservation priorities for Florida: the state's perspective. Transactions of the North American Wildlife and Natural Resources Conference 60:466–472.

Millsap, B. A., and C. Bear. 1997. Territory fidelity, mate fidelity, and dispersal in an urban-nesting population of Florida burrowing owls. Journal of Raptor Research 9:91–98.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs No. 111.

Millsap, B. A., and G. L. Holder. 1989. Chadwick Beach cotton mouse survey. Florida Game and Fresh Water Fish Commission Nongame Wildlife Section Final Performance Report, Tallahassee, Florida, USA.

Millsap, B. A., M. S. Robson, and D. E. Runde. 1989. Short-tailed hawk surveys. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Annual Performance Report, Tallahassee, Florida, USA.

Millsap, B. A., M. S. Robson, and B. R. Toland. 1996. Short-tailed hawk, *Buteo brachyurus*. Pages 315–322 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Mitchell, N. C. 2000. Silver rice rat status. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Moler, P. E. 1985*a*. A new species of frog (Ranidae: *Rana*) from northwestern Florida. Copeia 1985:379–383.

Moler, P. E. 1985*b*. Home range and seasonal activity of the eastern indigo snake, *Drymarchon corais couperi*, in northern Florida. Florida Game and Fresh Water Fish Commission Wildlife Research Laboratory, Gainesville, Florida, USA.

Moler, P. E. 1987. Delicate balance: eastern indigo snake (*Drymarchon corais couperi*). Florida Wildlife 41(4):19.

Moler, P. E. 1992*a*. American crocodile, *Crocodylus acutus* Cuvier. Pages 83–89 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E. 1992*b*. Eastern indigo snake, *Drymarchon corais couperi* (Holbrook). Pages 181–186 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E. 1992*c*. Florida bog frog, *Rana okaloosae* Moler. Pages 30–33 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E. 1992*d*. Florida brown snake, Lower Keys population, *Storeria dekayi victa* Hay. Pages 154–157 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E. 1992*e*. Florida ribbon snake, Lower Keys population, *Thamnophis sauritus sackenii* (Kennicott). Pages 162–165 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E. 1992*f*. South Florida rainbow snake, *Farancia erytrogramma seminola* Neill. Pages 251–253 *in* P. E. Moler, editor. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E., editor. 1992*g*. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Press of Florida, Gainesville, Florida, USA.

Moler, P. E., and R. Franz. 1987. Wildlife values of small, isolated wetlands in the southeastern coastal plain. Pages 234–241 *in* R. R. Odom, K. A. Riddleberger, and J. C. Ozier, editors. Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium. Georgia Department of Natural Resources Game and Fish Division, Social Circle, Georgia, USA.

Monk, C. D. 1968. Successional and environmental relationships of the forest vegetation of north-central Florida. American Midland Naturalist 79:441–457.

Montague, C. L., and R. G. Wiegert. 1990. Salt marshes. Pages 481–516 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Montague, C. L., A. V. Zale, and H. F. Percival. 1984. Photographic analysis of natural and impounded salt marsh in the vicinity of Merritt Island, Florida. Florida Cooperative Fish and Wildlife Research Unit Technical Report No. 11, University of Florida, Gainesville, Florida, USA.

Montague, C. L., A. V. Zale, and H. F. Percival. 1985. Final report: a conceptual model of salt marsh management of Merritt Island National Wildlife Refuge, Florida. Florida Cooperative Fish and Wildlife Research Unit Technical Report No. 17, University of Florida, Gainesville, Florida, USA.

Montague, C. L., A. V. Zale, and H. F. Percival. 1987. The nature of export from fringing marshes, with reference to the production of estuarine animals and the effect of impoundments. Pages 438–451 *in* W. R. Whitman and W. H. Meredith, editors. Proceedings of a symposium on waterfowl and wetlands management in the coastal zone of the Atlantic Flyway. Delaware Department of Natural Resources and Environmental Control, Dover, Delaware, USA.

Moore, F. R., S. A. Gauthreaux Jr., P. Kerlinger, and T. R .Simmons. 1993. Stopover habitat: management implications and guidelines. Pages 58–69 *in* D. Finch and P. Stangel, editors. Status and management of Neotropical migratory birds. U.S. Department of Agriculture Forest Service Report RM-229.

Moore, F. R., and P. Kerlinger. 1987. Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico. Oecologia 74:47–54.

Moore, F. R., P. Kerlinger, and T. R. Simons. 1990. Stopover on a Gulf Coast barrier island by spring Trans-Gulf migrants. Wilson Bulletin 102:487–500.

Moore, F. R., and T. R. Simons. 1992. Habitat suitability and stopover ecology on Neotropical landbird migrants. Pages 345–355 *in* J. M. Hagan and D. W. Johnston, editors. Ecology and conservation on Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C, USA.

Moore, F. R., and M. S. Woodrey. 1994. Stopover habitat and its importance in the conservation of landbird migrants. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:447–459.

Moore, W. H. 1974. Some effects of chopping saw-palmetto pineland threeawn range in south Florida. Journal of Range Management 27:101–104.

Moore, W. H., and B. F. Swindel. 1981. Effects of site preparation on dry prairie vegetation in south Florida. Southern Journal of Applied Forestry 5:89–92.

Morgan, G. L. 1998. Florida mouse (*Podomys floridanus*) association with gopher tortoise (*Gopherus polyphemus*) burrows and vegetation characteristics in the Cedar Key Scrub State Preserve, Levy County, Florida. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Morgenstern, C. S. 1997. Managing Monroe County's unbridled growth. Florida Naturalist 70(2):18.

Morrison, J. L. 1997. Reproductive ecology and habitat associations of Florida's crested caracaras. Dissertation, University of Florida, Gainesville, Florida, USA.

Morrison, J. L. 1999. Breeding biology and productivity of Florida's crested caracaras. Condor 101:505–517.

Morrison, J. L., and S. R. Humphrey. 2001. Conservation value of private lands for crested caracaras in Florida. Conservation Biology 15:675–684.

Morrison, R. I. G., , and R. K. Ross. 1989. Atlas of Nearctic shorebirds on the coast of South America. Volume 1. Canadian Wildlife Service, Ottawa, Canada.

Morse, D. H. 1980. Population limitation: breeding or wintering grounds. Pages 505–516 *in* A. Keast and E. S. Morton, editors. Migrant birds in the Neotropics: ecology, behavior, distribution, and conservation. Smithsonian Institution Press, Washington, D.C., USA.

Mota, M., J. Weidlich, and J. Stiner. 2001. Population status of beach mice, *Peromyscus polionotus niveiventris*. Florida Scientist 64(Supplement 1):47–48 (abstract).

Mount, R. H. 1963. The natural history of the red-tailed skink, *Eumeces egregius* Baird. American Midland Naturalist 70:356–385.

Mount, R. H. 1975. The reptiles and amphibians of Alabama. Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama, USA.

Mount, R. H. 1981. The red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae), as a possible serious predator on some native southeastern vertebrates: direct observations and subjective impressions. Journal of the Alabama Academy of Science 52:71–78.

Moyers, J., and H. Mitchell. 1996. Beach mouse status and recovery after Hurricane Opal. Florida Department of Environmental Protection Resource Management Notes 8(2):50–52.

Mrosovsky, N., C. Lavin, and M. H. Godfrey. 1995. Thermal effects of condominiums on a turtle beach in Florida. Biological Conservation 74:151–156.

Mueller J. M., C. B. Dabbert, S. Demarais, and A. R. Forbes. 1999. Northern bobwhite chick mortality caused by red imported fire ants. Journal of Wildlife Management 63:1291–1298.

Mumme, R. L., and T. H. Below. 2000. Relocation as a management technique for the threatened Florida scrub jay. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Mumme, R. L., and T. H. Below. 1999. Evaluation of translocation for the threatened Florida scrub-jay. Journal of Wildlife Management 63:833–842.

Murcia, C. 1995. Edge effects on fragmented forests: implications for conservation. Trends in Ecology and Evolution 10:58–62.

Murphy, C. G., S. T. Emlen, and P. W. Sherman. 1993. Reproductive strategies of the treefrog *Hyla gratiosa*: implications for management. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Report, Tallahassee, Florida, USA.

Mushinsky, H. R. 1984. Observations on the feeding habits of the short-tailed snake, *Stilosoma extenuatum* in captivity. Herpetological Review 15:67–68.

Mushinsky, H. R. 1985. Fire and the Florida sandhill herpetofaunal community: with special attention to responses of *Cnemidophorus sexlineatus*. Herpetologica 41:333–342.

Mushinsky, H. R., and E. D. McCoy. 1995. Vertebrate species composition of selected scrub islands on the Lake Wales Ridge of central Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Project Report, Tallahassee, Florida, USA.

Mushinsky, H. R., and E. D. McCoy. 1995. Vertebrate species composition of selected. 1999. Studies of the sand skink (*Neoseps reynoldsi*) in central Florida. Report submitted to Walt Disney Imagineering. Department of Biology, University of South Florida, Tampa, Florida, USA.

Mushinsky, H. R., and B. W. Witz. 1993. Notes on the peninsula crowned snake, *Tantilla relicta*, in periodically burned habitat. Journal of Herpetology 27:468–472.

Myers, C. W., and S. R. Telford, Jr. 1965. Food of *Neoseps*, the Florida sand skink. Quarterly Journal of the Florida Academy of Science 28:190–194.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853–858.

Myers, R. L. 1985. Fire and the dynamic relationship between Florida sandhill and sand pine scrub vegetation. Bulletin of the Torrey Botanical Club 112:241–252.

Myers, R. L. 1990. Scrub and high pine. Pages 150–193 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Myers, R. L., and P. A. Peroni. 1983. Commentary: approaches to determining aboriginal fire use and its impact on vegetation. Bulletin of the Ecological Society of America 64:217–218.

Myers, R. L., and D. L. White. 1987. Landscape history and changes in sandhill vegetation in north-central and south-central Florida. Bulletin of the Torrey Botanical Club 114:21–32.

National Research Council. 1985. Oil in the sea: inputs, fates, and effects. National Academic Press, Washington, D.C., USA.

Neill, W. T. 1952. Burrowing habits of *Hyla gratiosa*. Copeia 1952:196.

Neill, W. T. 1957. Historical biogeography of present-day Florida. Bulletin of the Florida State Museum, Biological Sciences Series 2:175–220.

Neill, W. T. 1964. Taxonomy, natural history, and zoogeography of the rainbow snake, *Farancia erytrogramma* (Palisot de Beauvois). American Midland Naturalist 71:257–295.

Nesbitt, S. A. 1996*a*. Florida sandhill crane, *Grus canadensis pratensis*. Pages 219–229 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Nesbitt, S. A. 1996*b*. Whooping crane, *Grus americana*. Pages 13–16 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Nesbitt, S. A., and K. S. Williams. 1990. Home range and habitat use of Florida sandhill cranes. Journal of Wildlife Management 54:92–96.

Newman, C. M. 1997. The Florida mouse (*Podomys floridanus*): long-term population dynamics of a population in the high pine sandhills of Putnam County, Florida. M.S. Thesis, University of Florida, Gainesville, Florida, USA.

Nicholson, D. J. 1928. Nesting habits of the seaside sparrow in Florida. Wilson Bulletin 40:225–237.

Nicholson, D. J. 1946. Smyrna seaside sparrow. Florida Naturalist 19:39–42.

Nicholson, D. J. 1950. Disappearance of Smyrna seaside sparrow from its former haunts. Florida Naturalist 23:104.

Nisbet, I. C. T. 1994. Effect of pollution on marine birds. Pages 8–25 *in* D. N. Nettleship, J. Burger, and M. Gochfeld, editors. Seabirds on islands: threats, case studies, and action plans. Birdlife International, Cambridge, United Kingdom.

Nolan, V., Jr. 1978. The ecology and behavior of the prairie warbler *Dendroica discolor*. American Ornithological Union Ornithological Monographs No. 26, Washington, D.C., USA.

Nordlie, F. G. 1990. Rivers and springs. Pages 392–425 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Noss, R. F. 1988. The longleaf pine landscape of the Southeast: almost gone and almost forgotten. University of Michigan School of Natural Resources, Endangered Species Update 5(5):1–8.

Noss, R. F. 1991. Landscape connectivity: different functions at different scales. Pages 27–39 *in* W. E. Hudson, editor. Landscape linkages and biodiversity. Island Press, Washington, D.C., USA.

Noss, R. F, and L. D. Harris. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. Environmental Management 10:299–309.

Noss, R. F, E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. U.S. Department of the Interior National Biological Services Biological Report 28.

Noss, R. F, and R. L. Peters. 1995. Endangered ecosystems. A status report on America's vanishing habitat and wildlife. Defenders of Wildlife, Washington, D.C., USA.

Nott, M. P., O. L. Bass, Jr., D. M. Fleming, S. E. Killeffer, N. Frahley, L. Manne, J. L. Curnutt, T. M. Brooks, R. Powell, and S. L. Pimm. 1998. Water levels, rapid vegetation changes, and the endangered Cape Sable seaside sparrow. Animal Conservation 1:23–32.

Nyman, J. A., and R. H. Chabreck. 1995. Fire in coastal marshes. Pages 134–141 *in* S. I. Cerulean and R. T. Engstrom, editors. Fire in wetlands: a management perspective. Proceedings of the Tall Timbers Fire Ecology Conference No. 19, Tall Timbers Research Station, Tallahassee, Florida, USA.

O'Brien, J. J. 1998. The distribution and habitat preferences of rare *Galactia* species (Fabaceae) and *Chamaesyce deltoidea* subspecies (Euphorbiaceae) native to southern Florida pine rockland. Natural Areas Journal 18:208–222.

O'Connor, T. P. 1992. Recent trends in coastal environmental quality: results from the first five years of the NOAA mussel watch project. NOAA Report, Rockville, Maryland, USA.

Odum, E. P. 1971. Fundamentals of ecology. Third edition. W. B. Saunders, Philadelphia, Pennsylvania, USA.

Odum, W. E. 1970. Pathways of energy flow in a South Florida estuary. Dissertation, University of Miami, Coral Gables, Florida, USA.

Odum, W. E., and R. E. Johannes. 1975. The response of mangroves to man-induced environmental stress. Pages 52–62 *in* E. J. F. Wood and R. E. Johannes, editors. Tropical marine pollution. Oceanographic Series Elsevier, Amsterdam, Netherlands.

Odum, W. E., and C. C. McIvor. 1990. Mangroves. Pages 517–548 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Odum, W. E., C. C. McIvor, and T. J. Smith III. 1982. The ecology of the mangroves of south Florida: a community profile. U.S. Fish and Wildlife Service Office of Biological Services Technical Report FWS/OBS 81-24, Washington, D.C., USA.

Oertel, G. F., and M. Lassen. 1976. Developmental sequences in Georgia coastal dunes and distribution of dune plants. Bulletin of the Georgia Academy of Science 34:35–48.

Ogden, J. C. 1974. The short-tailed hawk in Florida. I. Migration, habitat, hunting techniques, and food habits. Auk 91:95–110.

Ogden, J. C. 1994. A comparison of wading bird nest colony dynamics (1931–1946 and 1974–1989) as an indication of ecosystem conditions in the southern Everglades. Pages 533–570 *in* S. M. Davis and J. C. Ogden, editors. Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida, USA.

Ogden, J. C. 1996. Wood stork, *Mycteria americana*. Pages 31–41 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Ohlendorf, H. M., R. W. Risebrough, and K. Vermeer. 1978. Exposure of marine birds to environmental pollutants. U.S. Fish and Wildlife Service Wildlife Research Report 9, Washington, D.C., USA.

Oli, M. K., N. R. Holler, and M. C. Wooten. 2001. Viability analysis of endangered Gulf Coast beach mice (*Peromyscus polionotus*) populations. Biological Conservation 97:107–118.

Olmsted, I. C., and L. L. Loope. 1984. Plant communities of Everglades National Park. Pages 167–184 *in* P. J. Gleason, editor. Environments of South Florida: present and past II. Miami Geological Society, Coral Gables, Florida, USA.

Olmsted, I. C., L. L. Loope, and C. E. Hilsenbeck. 1980. Tropical hardwood hammocks of the interior of Everglades National Park and Big Cypress National Preserve. South Florida Research Center Report T-604, Everglades National Park, Homestead, Florida, USA.

Olmsted, I. C., L. L. Loope, and R. P. Russell. 1981. Vegetation of the southern coastal region of Everglades National Park between Flamingo Bay and Joe Bay. South Florida Research Center Report T-620, Everglades National Park, Homestead, Florida, USA.

Olmsted, I. C., W. B. Robertson, Jr., J. Johnson, and O. L. Bass, Jr. 1983. The vegetation of Long Pine Key, Everglades National Park. South Florida Research Center Report SFRC-83/05, Everglades National Park, Homestead, Florida, USA.

O'Meara, T. E. and J. A. Gore. 1988. Guidelines for conservation and management of least tern colonies in Florida. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

O'Neil, D., and E. O'Neil. 1997. Road to infamy. Florida Wildlife 51(4):30–31.

Onuf, C. P., J. M. Teal, and I. Valiela. 1977. Interactions of nutrients, plant growth, and herbivory in a mangrove ecosystem. Ecology 58:514–526.

Osgood, W. H. 1909. Revision of the mice of the American genus *Peromyscus*. North American Fauna 28:1–285.

Page, G., and D. F. Whitacre. 1975. Raptor predation on wintering shorebirds. Condor 77:73–83.

Palis, J. G. 1992. Distribution of the flatwoods salamander, *Ambystoma cingulatum*, on the Apalachicola and Osceola national forests. Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Palis, J. G. 1994. *Rana utricularia* (southern leopard frog). Road mortality. Herpetological Review 25:119.

Palis, J. G. 1996. Element stewardship abstract: flatwoods salamander (*Ambystoma cingulatum* Cope). Natural Areas Journal 16:49–54.

Palis, J. G., and J. B. Jensen. 1995. Distribution and breeding biology of the flatwoods salamander (*Ambystoma cingulatum*) and gopher frog (*Rana capito*) on Eglin Air Force Base, Florida. Final Report, Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Parnell, J. F., R. N. Neeham, R. F. Soots, Jr., R. O. Fussel, III, D. M. Dumond, D. A. McCrimmon, Jr., R. D. Bjork, and M. A. Shields. 1986. Use of dredged-material deposition sites by birds in coastal North Carolina, USA. Colonial Waterbirds 9:210–217.

Parrott, R. T. 1967. A study of wiregrass (*Aristida stricta* Michx.) with particular reference to fire. M.S. Thesis, Duke University, Durham, North Carolina, USA.

Paton, W. C., and W. B. Crouch, III. 2002. Using the phenology of pond-breeding amphibians to develop conservation strategies. Conservation Biology 16:194–202.

Paul, R. T. 1987. Florida region. American Birds 41:1425–1428.

Paul, R. T. 1989. Florida region. American Birds 43:1307–1310.

Paul, R. T. 1991. Florida region. American Birds 45:91–94.

Paul, R. T. 1996. Reddish egret, *Egretta rufescens*. Pages 281–294 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Paul, R. T., and T. H. Below. 1991. Populations, distributions, habitats, and migration of gulls, terns, and shorebirds in coastal Florida: an overview. Pages 66–98 *in* D. P. Jennings, compiler. Proceedings of the coastal nongame workshop. U.S. Fish and Wildlife Service, Gainesville, Florida, USA.

Paul, R. T., and G. E. Woolfenden. 1985. Current status and recent trends in bird populations of Tampa Bay. Pages 426–446 *in* Proceedings Tampa Bay area scientific information symposium. Florida Sea Grant College Report No. 65. Sea Grant Project No. IR/82-2.

Paulic, M., and J. Hand. 1994. Florida water quality assessment 1994 305(b) main report. Florida Department of Environmental Protection, Tallahassee, Florida, USA.

Pechmann, J. H. K., R. A. Estes, D. E. Scott, and J. W. Gibbons. 2001. Amphibian colonization and use of ponds created for trial mitigation of wetland loss. Wetlands 21:93–111.

Pechmann, J. H. K., D. E. Scott, Jr., J. W. Gibbons, and R. D. Semlitsch. 1989. Influence of wetland hydroperiod on diversity and abundance of metamorphosing juvenile amphibians. Wetlands Ecology and Management 1:3–11.

Pechmann, J. H. K., D. E. Scott, Jr., J. P. Caldwell, L. J. Vitt, and J. W. Gibbons. 1991. Declining amphibian populations: the problem of separating human impacts from natural fluctuations. Science 253:892–895.

Penney, K. M. 2001. Factors affecting translocation success and estimates of dispersal and movement patterns of the sand skink *Neoseps reynoldsi* on restored scrub. M.S. Thesis, University of South Florida, Tampa, Florida, USA.

Perkins, D. W., P. D. Vickery, T. F. Dean, and M. D. Scheuerell. 1998. Florida grasshopper sparrow reproductive success based on nesting records. Florida Field Naturalist 26:7–17.

Peroni, P. A., and W. G. Abrahamson. 1985. Post-settlement vegetation loss on the southern Lake Wales Ridge, Florida. Palmetto 5:6–7.

Peroni, P. A., and W. G. Abrahamson. 1986. Succession in Florida sandridge vegetation: a retrospective study. Florida Scientist 49:176–191.

Petranka, J. W., M. E. Eldridge, and K. E. Haley. 1993. Effects of timber harvesting on southern Appalachian salamanders. Conservation Biology 7:363–370.

Pfister, C., B. A. Harrington, and M. Lavine 1992. The impact of human disturbance on shorebirds at a migration staging area. Biological Conservation 60:115–126.

Phelps, J. P., and R. A. Lancia. 1995. Effects of a clearcut on the herpetofauna of a South Carolina bottomland swamp. Brimleyana No. 22:31–45.

Phillips, K. 1994. Tracking the vanishing frogs. An ecological mystery. Saint Martin's Press, New York, New York, USA.

Pilkey, O. H., Jr., D. C. Sharma, H. R. Wanless, L. J. Doyle, O. H. Pilkey, Sr., W. J. Neal, and B. L. Gruver. 1984. Living with the East Florida shore. Duke University Press, Durham, North Carolina, USA.

Pimm, S., J. Curnutt, J. Lockwood, L. Manne, A. Mayer, M. Nott, and K. Balent. 1996. Population ecology of the Cape Sable sparrow (*Ammodramus maritimus mirabilis*). Annual Report, NBS/NPS, Everglades National Park, Homestead, Florida, USA.

Platt, W. J., G. W. Evans, and M. M. Davis. 1988. Effects of fire season on flowering of shrubs and forbs in longleaf pine forests. Oecologia 76:353–363.

Post, W. 1981. The influence of rice rats *Oryzomys palustris* on the habitat use of the seaside sparrow *Ammospiza maritima*. Behavioral Ecology and Sociobiology 9:35–40.

Post, W., A. Cruz, and D. B. McNair. 1993. The North American invasion of the shiny cowbird. Journal of Field Ornithology 64:32–41.

Post, W., T. K. Nakamura, and A. Cruz. 1990. Patterns of shiny cowbird parasitism in St. Lucia and southwestern Puerto Rico. Condor 92:461–469.

Pough, F. H., E. M. Smith, D. H. Rhodes, and A. Collazo. 1987. The abundance of salamanders in forest stands with different histories of disturbance. Forest Ecology and Management 20:1–9.

Pranty, B. 1996. A birder's guide to Florida. American Birding Association, Colorado Springs, Colorado, USA.

Pranty, B., and M. D. Scheuerell. 1997. First summer record of the Henslow's sparrow in Florida. Florida Field Naturalist 25:64–66.

Price, R. 1987. Disjunct occurrence of mole snakes in peninsular Florida, and the description of a new subspecies of *Lampropeltis calligaster*. Bulletin of the Chicago Herpetological Society 22:1–48.

Pritchard, P. C. H. 1979. Encyclopedia of turtles. T. F. H., Neptune, New Jersey, USA.

Primack, M. 1980. ORVs in our national seashores. National Parks & Conservation Magazine 54(11):4–7.

Printiss, D., and D. Hipes. 1999. Rare amphibian and reptile survey of Eglin Air Force Base, Florida. Final Report, Florida Natural Areas Inventory, Tallahassee, Florida, USA.

Proulx, G. 1988. Control of urban wildlife predation by cats through public education. Environmental Conservation 15:358–359.

Provost, M. W. 1977. Source reduction in salt-marsh mosquito control: past and future. Mosquito News 37:689–698.

Puckett, L. 1995. Identifying the major sources of nutrient water pollution. Environmental Science and Technology 29:408–414.

Pulver, T. R. 1976. Transplant techniques for sapling mangrove trees, *Rhizophora mangle*, *Laguncularia racemosa*, and *Avicennia germinans*, in Florida. Florida Department of Natural Resources Marine Research Publication No. 22.

Puri, H. S., and R. O. Vernon. 1964. Summary of the geology of Florida and a guidebook to classic exposures. Florida Geological Survey Special Publication No. 5 (revised).

Raim, A., W. C. Cochran, and R. D. Applegate. 1989. Activities of a migrant merlin during an island stopover. Journal of Raptors 23:49–52.

Ramsey, P. R. 1973. Spatial and temporal variation in genetic structure of insular and mainland populations of *Peromyscus polionotus*. Dissertation, University of Georgia, Athens, Georgia, USA.

Rappole, J. H. 1995. The ecology of migrant birds: a neotropical perspective. Smithsonian Institution Press, Washington, D.C., USA.

Ratnaswamy, M. J., and R. J. Warren. 1998. Removing raccoons to protect sea turtle nests: are there implications for ecosystem management? Wildlife Society Bulletin 26:846–850.

Reagan, S. R., J. M. Ertel, and V. L. Wright. 2000. David and Goliath retold: fire ants and alligators. Journal of Herpetology 34:475–478.

Reark, J. B. 1975. A history of the colonization of mangroves on a tract of land on Biscayne Bay, Florida. Pages 776–804 *in* G. Walsh, S. Snedaker, and H. Teas, editors. Proceedings of the international symposium on the biology and management of mangroves, University of Florida, Gainesville, Florida, USA.

Rehfisch, M. M. 1994. Man-made lagoons and how their attractiveness to waders might be increased by manipulating the biomass of an insect benthos. Journal of Applied Ecology 31:383–401.

Rehm, A. E. 1976. The effects of the wood-boring isopod, *Sphaeroma terebrans*, on the mangrove communities of Florida. Environmental Conservation 3:47–57.

Repenning, R. W., and S. R. Humphrey. 1986. The Chadwick Beach cotton mouse (Rodentia: *Peromyscus gossypinus restrictus*) may be extinct. Florida Scientist 49:259–262.

Richardson, D. R. 1977. Vegetation of the Atlantic Coastal Ridge of Palm Beach County, FL. Florida Scientist 40:281–330.

Richardson, D. R., I. J. Stout, R. E. Roberts, D. F. Austin, and T. R. Alexander. 1986. Design and management recommendations for a sand pine scrub preserve: the Yamato Scrub. Ecological Consultants, Tampa, Florida, USA.

Richter, B. D., D. P. Braun, M. A. Mendelson, and L. L. Masters. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11:1081–1093.

Riekerk, H. 1983. Forested wetlands, environmental rules and silvicultural practices. Pages 74–92 *in* D. M. Flinchum, G. B. Doolittle, and K. R. Munson, editors. Appraisal of Florida's wetland hardwood resource. School of Forest Resources and Conservation, University of Florida, Gainesville, Florida, USA.

Riley, R. 1995/1996. Encased method for planting red mangrove. Florida Department of Environmental Protection Resource Management Notes 8(1):17–18.

Robbin, D. M. 1984. A new Holocene sea level curve for the Upper Florida Keys and Florida reef tract. Pages 437–458 *in* P. J. Gleason, editor. Environments of South Florida: present and past II. Miami Geological Society, Coral Gables, Florida, USA.

Roberts, G., and P. R. Evans. 1993. Responses of foraging sanderlings to human approaches. Behaviour 126:29–43.

Robertson, W. B., Jr. 1953. A survey of the effects of fire in Everglades National Park. National Park Service, Homestead, Florida, USA.

Robertson, W. B., Jr. 1954. Everglades fires—past, present, and future. Everglades Natural History 2:11–16

Robertson, W. B., Jr. 1955. An analysis of the breeding bird populations of tropical Florida in relation to vegetation. Dissertation, University of Illinois, Urbana, Illinois, USA.

Robertson, W. B., Jr. 1978. Cuban yellow warbler. Pages 61–62 *in* H. W. Kale II, editor. Rare and endangered biota of Florida. Volume 2. Birds. University Presses of Florida, Gainesville, Florida, USA.

Robertson, W. B., Jr. 1996. Brown noddy, *Anous stolidus*. Pages 559–570 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Robertson, W. B., Jr .,and J. A. Kushlan. 1984. The southern Florida avifauna. Pages 219–257 *in* P. J. Gleason, editor. Environments of South Florida: present and past II. Miami Geological Society, Coral Gables, Florida, USA.

Robertson, W. B., Jr ., and G. E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society Special Publication No. 6, Gainesville, Florida, USA.

Robertson, W. B., Jr., and M. J. Robertson. 1996. Sooty tern, *Sterna fuscata*. Pages 514–531 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Robson, M. S. 1989. Status survey of the Florida mastiff bat (*Eumops glaucinus floridanus*). Florida Game and Fresh Water Fish Commission Nongame Wildlife Section Final Performance Report, Tallahassee, Florida, USA.

Robson, M. S. 1991. Wildlife and habitat management. Florida Game and Fresh Water Fish Commission, Nongame Wildlife Section Annual Performance Report, Tallahassee, Florida, USA.

Rodgers, J. A., Jr. 1996. Florida snail kite, *Rostrhamus sociabilis plumbeus*. Pages 42–51 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Rodgers, J. A., Jr. 2001. Buffer zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft in Florida. Florida Fish and Wildlife Conservation Commission Final Report, Tallahassee, Florida, USA.

Rodgers, J. A., Jr., H. W. Kale II, and H. T. Smith, editors. 1996. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Rodgers, J. A., Jr., and H. T. Smith. 1995. Set-back distances to protect nesting bird colonies from human disturbance in Florida. Conservation Biology 9:89–99.

Rodgers, J. A., Jr., and H. T. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin 25:139–145.

Roosenburg, W. M. 1991. The diamondback terrapin: habitat requirements, population dynamics, and opportunities for conservation. Pages 227–234 *in* A. Chaney and J. Mihursky, editors. Proceedings of a conference: new perspectives in the Chesapeake system: a research and management partnership. Chesapeake Research Consortium Publication No. 137, Solomons, Maryland, USA.

Roosenburg, W. M., W. Cresko, M. Modesitte, and M. B. Robbins. 1997. Diamondback terrapin (*Malaclemys terrapin*) mortality in crab pots. Conservation Biology 11:1166–1172.

Rosenau, J. C., G. L. Faulkner, C. W. Hendry, Jr., and R. W. Hull. 1977. Springs of Florida. Florida Bureau of Geology Bulletin No. 31.

Ross, M. S., J. J. O'Brien, and L. J. Flynn. 1992. Ecological site classification of Florida Keys terrestrial habitats. Biotropica 24:488–502.

Rossi, J. V., and R. Rossi. 1993. Notes on the captive maintenance and feeding behavior of a juvenile short-tailed snake (*Stilosoma extenuatum*). Herpetological Review 24:100–101.

Rudolph, D. C., S. J. Burgdorf, R. N. Conner, and R. R. Schaefer. 1999. Preliminary evaluation of roads and associated vehicular traffic on snake populations in eastern Texas. Pages 128–135 *in* G. L. Evink, P. Garrett, and D. Ziegler, editors. Proceedings of the Third International Conference on Wildlife Ecology and Transportation, Florida Department of Transportation, Tallahassee, Florida, USA.

Runde, D. E., and N. Wamer. 1996. Black rail, *Laterallus jamaicensis*. Pages 323–328 *in* J. A. Rodgers, Jr., H. W. Kale II, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Rundle, W. D., and L. J. Fredrickson. 1981. Managing seasonally flooded impoundments for migrant rails and shorebirds. Wildlife Society Bulletin 9:80–87.

Safina, C., and J. Burger. 1983. Effects of human disturbance on reproductive success in the black skimmer. Condor 85:164–171.

Sargent, F. J., T. J. Leary, D. W. Crewz, and C. R. Kreur. 1995. Scarring of Florida's seagrasses: assessment and management options. FMRI Technical Report TR-1, Florida Marine Research Institute, St. Petersburg, Florida, USA.

Sauer, J. R., and S. Droege. 1992. Geographical patterns in population trends of neotropical migrants in North America. Pages 26–41 *in* J. M. Hagan and D. W. Johnston, editors. Ecology and conservation on Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C., USA.

Savage, T. 1972. Florida mangroves as shoreline stabilizers. Florida Department of Natural Resources Professional Paper No. 19, Tallahassee, Florida, USA.

Sawicki, R. 1997. Tropical flyways and the white-crowned pigeons. Florida Naturalist 70(2):6–7.

Schomer, N. S., and R. D. Drew. 1982. An ecological characterization of the lower Everglades, Florida Bay, and the Florida Keys. U.S. Fish and Wildlife Service Office of Biological Services Technical Report FWS/OBS 82/58.1, Washington, D.C., USA.

Schrope, M. 2001. Save our swamp. Nature 409:128–131.

Schwartz, A. 1952. The land mammals of southern Florida and the Upper Florida Keys. Dissertation, University of Michigan, Ann Arbor, Michigan, USA.

Sealander, R. K., M. H. Smith, S. Y. Yang, W. E. Johnson, and J. B. Gentry. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I. Variation of the old field mouse (*Peromyscus polionotus*). Studies in Genetics 6:49–90.

Seidel, M. E. 1994. Morphometric analysis and taxonomy of cooter and red-bellied turtles in the North American genus *Pseudemys* (Emydidae). Chelonian Conservation and Biology 1:117–130.

Seidel, M. E. 1995. How many species of cooter turtles and where is the scientific evidence?—a reply to Jackson. Chelonian Conservation and Biology 1:333–336.

Seidel, W. R., and C. McVea, Jr. 1995. Development of a sea turtle excluder device shrimp trawl for the Southeast U.S. penaeid shrimp fishery. Pages 497–502 in K. A. Bjorndal, editor. Biology and conservation of sea turtles. Revised edition. Smithsonian Institution Press, Washington, D.C.

Seigel, R. A. 1980. Nesting habits of diamondback terrapins (*Malaclemys terrapin*) on the Atlantic Coast of Florida. Transactions of the Kansas Academy of Science 83:239–246.

Seigel, R. A. 1984. Parameters of two populations of diamondback terrapins (Malaclemys terrapin) on the Atlantic Coast of Florida. Pages 77–87 in R. A. Seigel et al., editors. Vertebrate Ecology and Systematics: a Tribute to Henry S. Fitch. University of Kansas Museum of Natural History Special Publication Number 10.

Seigel, R. A., and C. K. Dodd, Jr. 2002. Translocations of amphibians: proven management method or experimental technique? Conservation Biology 16:552–554.

Sekerak, C. M., G. W. Tanner, and J. G. Palis. 1996. Ecology of flatwoods salamander larvae in breeding ponds in Apalachicola National Forest. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 50:321–330.

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12:1113–1119.

Semlitsch, R. D., and J. R. Bodie. 1998. Are small, isolated wetlands expendable? Conservation Biology 12:1129–1133.

Senner, J. W. 1980. Inbreeding depression and the survival of zoo populations. Pages 209–224 *in* M. E. Soulé and B. A. Wilcox, editors. Conservation biology: an evolutionary–ecological perspective. Sinauer, Sunderland, Massachusetts, USA.

Senner, S. E., and M. A. Howe. 1984. Conservation of Nearctic shorebirds. Pages 379–420 *in* J. Burger and B. L. Olla, editors. Shorebirds: breeding behavior and populations. Behaviour of marine animals. Volume 5. Plenum, New York, New York, USA.

Sepúlveda, M. S., P. C. Frederick, M. G. Spalding, and G. E. Williams, Jr. 1999. Mercury contamination in free-ranging great egret (*Ardea albus*) nestlings from southern Florida, USA. Environmental Toxicology and Chemistry 18:985–992.

Sewell, C. E., N. D. Joiner, M. S. Robson, and M. J. Weise. 1995. Wading bird colony protection in the Indian River Lagoon. Bulletin of Marine Science 57:237–241.

Shaffer, M. 1987. Minimum viable populations: coping with uncertainty. Pages 69–86 in M. E. Soulé, editor. Viable populations for conservation. Cambridge University Press, Cambridge, Massachusetts, USA.

Shea, D. S., and W. B. Robertson, Jr. 1979. Unusual observations of nesting bald eagles in South Florida. Florida Field Naturalist 7:3–5.

Sheldon, A. L. 1988. Conservation of stream fishes: patterns of diversity, rarity, and risk. Conservation Biology 2:149–156.

Sherrod, C. L., and C. McMillan. 1985. The distributional history and ecology of mangrove vegetation along the northern Gulf of Mexico coastal region. Contributions to Marine Science 28:129–140.

Sherry, T. W., and R. T. Holmes. 1992. Are populations of neotropical migrant birds limited in summer or winter? Implications for management. Pages 47–55 *in* D. M. Finch and P. W. Stangel, editors. Status and management of neotropical migratory birds. U.S. Department of Agriculture Forest Service Report RM-229, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Shriver, W. G., and P. D. Vickery. 1999. Aerial assessment of potential Florida grasshopper sparrow habitat: conservation in a fragmented landscape. Florida Field Naturalist 27:1–9.

Shriver, W. G., and P. D. Vickery. 2001. Response of breeding Florida grasshopper and Bachman's sparrows to winter prescribed burning. Journal of Wildlife Management 65:470–475.

Shriver, W. G., P. D. Vickery, and S. A. Hedges. 1996. Effects of summer burns on Florida grasshopper sparrows. Florida Field Naturalist 24:68–73.

Sidle, J. G., K. Mayne, and E. N. McPhillips. 1991. Protecting the piping plover under Section 7 of the Endangered Species Act. Environmental Management 15:349–356.

Silvy, N. J. 1975. Population density, movements, and habitat utilization of Key deer, *Odocoileus virginianus clavium*. Dissertation, Southern Illinois University, Carbondale, Illinois, USA.

Simberloff, D. 1993. Species-area and fragmentation effects on old-growth forests: prospects for longleaf pine communities. Pages 1–13 *in* S. M. Hermann, editor. The longleaf pine ecosystem: ecology, restoration and management. Proceedings of the Tall Timbers Fire Ecology Conference No. 18, Tall Timbers Research Station, Tallahassee, Florida, USA.

Simberloff, D. S., and L. G. Abele. 1976. Island biogeography theory and conservation practice. Science 191:285–286.

Simberloff, D. S ., and L. G. Abele. 1982. Refuge design and island biogeographic theory: effects of fragmentation. American Naturalist 120:41–50.

Simberloff, D. S ., and J. Cox. 1987. Consequences and costs of conservation corridors. Conservation Biology 1:63–71.

Simberloff, D. S., J. A. Farr, J. Cox, and D. W. Mehlman. 1992. Movement corridors: conservation bargains or poor investments? Conservation Biology 6:493–504.

Simons, R. W. 1990. Terrestrial and freshwater habitats. Pages 99–157 *in* S. H. Wolfe, editor. An ecological characterization of the Florida Springs Coast: Pithlachascotee to Waccasassa rivers. U.S. Fish and Wildlife Service Biological Report 90(21).

Singer, F. J., W. T. Swank, and E. E. C. Clebsch. 1984. Effects of wild pig rooting in a deciduous forest. Journal of Wildlife Management 48:464–473.

Smallwood, J. A., and K. D. Meyer. 1996. Merlin, *Falco columbarius*. Pages 616–623 *in* J. A Rodgers, H. W. Kale, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Smith, C. R. 1982. Food resource partitioning of fossorial Florida reptiles. Pages 173–178 in N. J. Scott, editor. Herpetological communities. U.S. Fish and Wildlife Service Wildlife Research Report No. 13.

Smith, D. J. 1996. The direct and indirect impacts of highways on the vertebrates of Payne's Prairie State Preserve. Technical Report No. FL-ER-62-96, Florida Department of Transportation, Environmental Management Office, Tallahassee, Florida, USA.

Smith, H. T. 1996. Roseate tern, *Sterna dougallii*. Pages 247–257 *in* J. A. Rodgers, Jr., H. W. Kale II, H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Smith, L. L., Smith, L. L., K. G. Smith, W. J. Barichivich, C. K. Dodd, Jr., and K. Sorenson. *In Press*. Roads and Florida's herpetofauna: a review and mitigation case study. *In* W. E. Meshaka, Jr., and K. J. Babbitt, editors. Status and conservation of Florida amphibians and reptiles. Krieger Press, Boca Raton, Florida, USA

Smith, P. C., and J. S. Bleakney. 1969. Observations on oil pollution and wintering purple sandpipers, *Erolia maritima* (Brunnich), in Nova Scotia. Canadian Field Naturalist 83:19–22.

Smith, R. B., R. A. Seigel, and K. R. Smith. 1998. Occurrence of upper respiratory tract disease in gopher tortoise populations in Florida and Mississippi. Journal of Herpetology 32:426–430.

Smith, T. J., H. Hudson, M. B. Robblee, G. V. N. Powell, and P. J. Isdale. 1989. Freshwater flow from the Everglades to Florida Bay: a historical reconstruction based on fluorescent banding in the coral *Solenastrea bournoni*. Bulletin of Marine Science 44:274–282.

Smith, T. J., III, M. B. Robblee, H. Wanless, and T. W. Doyle. 1994. Mangroves, hurricanes, and lightning strikes. BioScience 43:256–262.

Snedaker, S. C. 1963. Some aspects of the ecology of the Florida sandhills. M.S. Thesis, University Florida, Gainesville, Florida, USA.

Snedaker, S. C. 1982. Pages 111–125 *in* D. N. Sen and K. S. Rajpurohit, editors. Contributions to the ecology of halophytes. Volume 2. Dr. W. Junk, Boston, Massachusetts, USA.

Snedaker, S. C. 1989. Overview of ecology of mangroves and information needs for Florida Bay. Bulletin of Marine Science 44:341–347.

Snodgrass, J. W., M. J. Komoroski, A. L. Bryan, Jr., and J. Burger. 2000. Relationships among isolated wetland size, hydroperiod, and amphibian species richness: implications for wetland regulations. Conservation Biology 14:414–419.

Snyder, J. R. 1986. The impact of wet season and dry season prescribed fires on Miami Rock Ridge pineland, Everglades National Park. South Florida Research Center Report SFRC-86/06, Everglades National Park, Homestead, Florida, USA.

Snyder, J. R. 1991. Fire regimes in subtropical South Florida. Pages 303–310 *in* S. M. Hermann, editor. High intensity fire in wildlands: management challenges and options. Proceedings of the Tall Timbers Fire Ecology Conference No. 17, Tall Timbers Research Station, Tallahassee, Florida, USA.

Snyder, J. R., A. Herndon, and W. B. Robertson, Jr. 1990. South Florida rockland. Pages 230–277 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Snyder, N. F. R., and H. A. Snyder. 1969. A comparative study of mollusc predation by limpkins, Everglades kites, and boat-tailed grackles. Living Bird 8:177–223.

Soulé, M. E. 1991. Theory and strategy. Pages 91–104 *in* W. E. Hudson, editor. Landscape linkages and biodiversity. Island Press, Washington, D.C., USA.

Soulé, M. E., and D. Simberloff. 1986. What do genetics and ecology tell us about the design of nature reserves? Biological Conservation 35:19–40.

Speake, D. W., and J. A. McGlincy. 1981. Response of indigo snakes to gassing their dens. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 35:135–138.

Speake, D. W., and R. H. Mount. 1973. Some possible ecological effects of rattlesnake roundups" in the southeastern coastal plain. Proceedings of the Annual Conference of Southeastern Game and Fish Commissioners 27:267–277.

Spitzer, N. C. 1983. Aspects of the biology of the silver rice rat, *Oryzomys argentatus*. M.S. Thesis, University of Rhode Island, Kingston, Rhode Island, USA.

Spitzer, N. C., and J. D Lazell, Jr. 1978. A new rice rat (genus *Oryzomys*) from Florida's Lower Keys. Journal of Mammalogy 59:787–792.

Sprandel, G. L. 1996. Wilson's plover, *Charadrius wilsonia*. Pages 497–506 *in* J. A. Rodgers, H. W. Kale, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Sprandel, G. L. 1999. Consolidated breeding records for colonial shorebirds in Florida from 1973–1997. Florida Fish and Wildlife Conservation Commission Final Performance Report, Tallahassee, Florida, USA.

Sprandel, G. L., J. A. Gore, and D. T. Cobb. 1997. Winter shorebird survey. Florida Game and Fresh Water Fish Commission Final Performance Report, Tallahassee, Florida, USA.

Sprunt, A., Jr. 1954. Florida bird life. Coward-McCann, New York, New York, USA.

Stahle, D. W., M. K. Cleaveland, and J. G. Hehr. 1985. A 450-year drought reconstruction for Arkansas, United States. Nature 316:530–532.

Stahle, D. W., M. K. Cleaveland, and J. G. Hehr. 1988. North Carolina climate changes reconstructed from tree rings: A.D. 372 to 1985. Science 240:1517–1519.

Staine, K. J., and J. Burger. 1994. Nocturnal foraging behavior of breeding piping plovers (*Charadrius melodus*) in New Jersey. Auk 111:579–587.

Steinberg, B. 1980. Vegetation of the Atlantic coastal ridge of Broward County, Florida, USA based on 1940 imagery. Florida Scientist 43:7–12.

Steiner, T. M., O. L. Bass, Jr., and K. A. Kushlan. 1983. Status of the eastern indigo snake in southern Florida national parks and vicinity. South Florida Research Center Report SFRC-83/01, Everglades National Park, Homestead, Florida, USA.

Stephen, M. F. 1995. 30 years to recovery at Caxambas Pass, Collier County, Florida. Pages 271–286 *in* L. S. Tait, editor. Sand wars, sand shortages & sand-holding structures. Proceedings of the Eighth National Conference on Beach Preservation Technology, The St. Petersburg Hotel, St. Petersburg, Florida., Jan. 25–27, 1995. Florida Shore & Beach Preservation Association, Tallahassee, Florida, USA.

Stevenson, H. M. 1957. The relative magnitude of the trans-Gulf and circum-Gulf spring migrations. Wilson Bulletin 69:39–77.

Stevenson, H. M., and B. H. Anderson. 1994. The birdlife of Florida. University Press of Florida, Gainesville, Florida, USA.

Stevenson, H. M., W. W. Baker, and H. W. Kale, II. 1978. Wakulla seaside sparrow. Page 107 *in* H. W. Kale, II, editor. Rare and endangered biota of Florida. Volume 2. Birds. University Presses of Florida, Gainesville, Florida, USA.

Stout, I. J. 1992. Southeastern beach mouse, *Peromyscus polionotus niveiventris*. Pages 242–249 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Stout, I. J., and D. T. Corey. 1995. Effects of patch-corridor configurations on non-game birds, mammals, and herptiles in longleaf pine-turkey oak sandhill communities. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Project Report, Tallahassee, Florida, USA.

Stout, I. J., D. R. Richardson, and R. E. Roberts. 1988. Management of amphibians, reptiles, and small mammals in xeric pinelands of peninsular Florida. Pages 98–108 *in* R. C. Szaro, K. E. Severson, and D. R. Patton, technical coordinators. Proceedings of a symposium on the management of reptiles, amphibians, and small mammals in North America. U.S. Forest Service General Technical Report RM-166.

Stout, J. P. 1984. The ecology of irregularly flooded salt marshes of the northeastern Gulf of Mexico: a community profile. U.S. Fish and Wildlife Service Biological Report No. 85(7.1).

Streng, D. R., J. S. Glitzenstein, and W. J. Platt. 1993. Evaluating effects of season of burn in longleaf pine forests: a critical literature review and some results from an ongoing long-term study. Pages 227–263 *in* S. M. Hermann, editor. The longleaf pine ecosystem: ecology, restoration and management. Proceedings of the Tall Timbers Fire Ecology Conference No. 18, Tall Timbers Research Station, Tallahassee, Florida, USA.

Strong, A. M., and G. T. Bancroft. 1994*a*. Patterns of deforestation and fragmentation of mangrove and deciduous seasonal forests in the upper Florida Keys. Bulletin of Marine Science 54:795–804.

Strong, A. M., and G. T. Bancroft. 1994*b*. Postfledging dispersal of white-crowned pigeons: implications for conservation of deciduous seasonal forests. Conservation Biology 8:770–779.

Strong, A. M., R. J. Sawicki, and G. T. Bancroft. 1991. Effects of predator presence on the nesting distribution of white-crowned pigeons in Florida Bay. Wilson Bulletin 103:414–425.

Swift, C. C., R. W. Yerger, and P. R. Parrish. 1977. Distribution and natural history of the fresh and brackish water fishes of the Ochlockonee River, Florida and Georgia. Tall Timbers Research Station Bulletin No. 20, Tallahassee, Florida, USA.

Swilling, W. R., M. C. Wooten, N. R. Holler, and W. J. Lynn. 1998. Population dynamics of Alabama beach mice (*Peromyscus polionotus ammobates*) following Hurricane Opal. American Midland Naturalist 140:287–298.

Swindel, B. F., L. F. Conde, and J. E. Smith. 1982. Effects of forest regeneration practices on plant diversity and succession in Florida ecosystems. Proceedings of the Annual Symposium on the Impacts of Intensive Forest Management Practices 14:5–15. School of Forest Resources and Conservation, University of Florida, Gainesville, Florida, USA.

Sykes, P. W., Jr. 1984. The range of the Everglades snail kite and its history in Florida. Bulletin of the Florida State Museum, Biological Sciences Series 29:211–264.

Tabb, D. C., and E. J. Heald. 1973. The coastal interceptor waterway. University of Miami Seagrant Coastal Zone Management Bulletin 4.

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.

Tanner, G., and W. Terry. 1981. Effect of roller chopping and web plowing on gopher tortoise burrows in southern Florida. Proceedings of the Annual Meeting of the Gopher Tortoise Council 2:66–73.

Tanner, G. W., J. M. Wood, R. S. Kalmbacher, and F. G. Martin. 1988. Mechanical shrub control on flatwoods range in south Florida. Journal of Range Management 41:245–248.

Taylor, D. L., and A. Herndon. 1981. Impact of 22 years of fire on understory hardwood shrubs in slash pine communities within Everglades National Park. South Florida Research Center Report T-640, Everglades National Park, Homestead, Florida, USA.

Teas, H. 1977. Ecology and restoration of mangrove shorelines in Florida. Environmental Conservation 4:51–57.

Teas, H. 1979. Silviculture with saline water. Pages 117–161 in A. Hollaender, editor. The biosaline concept. Plenum, New York, New York, USA.

Teas, H., and J. Kelly. 1975. Effects of herbicides on mangrove of South Vietnam and Florida. Pages 719–728 *in* G. Walsh, S. Snedaker, and H. Teas, editors. Proceedings of the international symposium on the biology and management of mangroves. University of Florida, Gainesville, Florida, USA.

Telford, S. R., Jr. 1959. A study of the sand skink *Neoseps reynoldsi* Stejneger. Copeia 1959:110–119.

Telford, S. R., Jr. 1962. New locality records for the sank skink (*Neoseps reynoldsi*) in central Florida, with comments on the habitat. Quarterly Journal of the Florida Academy of Science 25:76–77.

Telford, S. R., Jr. 1966. Variation among the southeastern crowned snakes, genus *Tantilla*. Bulletin of the Florida State Museum, Biological Sciences Series 10:261–304.

Telford, S. R., Jr. 1992. Factors affecting the distribution of *Neoseps reynoldsi*, the sand skink, in Ocala National Forest. Unpublished report, Ocala National Forest, Silver Springs, Florida, USA.

Telford, S. R., Jr. 1993. Breeding sites for the gopher frog and the striped newt in Ocala National Forest, and the discovery of a possibly undescribed species of frog apparently restricted to the forest. Unpublished report, Ocala National Forest, Silver Springs, Florida, USA.

Thaxton, J. E., and T. M. Hingtgen 1996. Effects of suburbanization and habitat fragmentation on Florida scrub-jay dispersal. Florida Field Naturalist 24:25–37.

Thorp, J. H., E. M. McEwan, M. F. Flynn, and F. R. Hauer. 1985. Invertebrate colonization of submerged wood in a cypress-tupelo swamp and blackwater stream. American Midland Naturalist 113:56–68.

Tiebout, H. M., III, and R. A. Anderson. 1997. A comparison of corridors and intrinsic connectivity to promote dispersal in transient successional landscapes. Conservation Biology 11:620–627.

Tiebout, H. M., III, and R. A. Anderson. 2001. Mesocosm experiments on habitat choice by an endemic lizard: implications for timber management. Journal of Herpetology 35:173–185.

Tiebout, H. M., III, and K. E. Brugger. 1995. Ecological risk assessment of pesticides for terrestrial vertebrates: evaluation and application of the U.S. Environmental Protection Agency's quotient model. Conservation Biology 9:1605–1618.

Tilmant, J. T., E. S. Rutherford, and E. B. Thue. 1989. Fishery harvest and population dynamics of red drum (*Sciaenops ocellatus*) from Florida Bay and adjacent waters. Bulletin of Marine Science 44:126–138.

Timmerman, W. W. 1995. Home range, habitat use, and behavior of the eastern diamondback rattlesnake (*Crotalus adamanteus*) on the Ordway Preserve. Bulletin of the Florida Museum of Natural History 38, Part I(5):127–158.

Timmerman, W. W., J. B. Miller, and C. V. Tamborski. 1994. The herpetofauna of Jonathan Dickinson State Park, Martin County, Florida. Final Report Project No. 7618, Florida Department of Environmental Protection Division of Recreation and Parks, Hobe Sound, Florida, USA.

Toland, B. 1991. Successful nesting by reddish egrets at Oslo Island, Indian River County, Florida. Florida Field Naturalist 19:51–53.

Toland, B., and B. A. Millsap. 1996. Cooper's hawk, *Accipiter cooperii*. Pages 475–484 *in* J. A. Rodgers, H. W. Kale, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Townsend, R. 1990. Shipping safety and America's coast. Center for Marine Conservation, Washington, D.C., USA.

Trenham, P. C., and D. M. Marsh. 2002. Amphibian translocation programs: reply to Seigel and Dodd. Conservation Biology 16:555–556.

Trombulak, S. C., and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18–30.

Tuberville, T. D., J. R. Bodie, J. B. Jensen, L. LaClaire, and J. W. Gibbons. 2000. Apparent decline of the southern hog-nosed snake, *Heterodon simus*. The Journal of the Elisha Mitchell Scientific Society 116:19–40.

Tucker, A. D., N. N. Fitzsimmons, and J. W. Gibbons. 1995. Resource partitioning by the estuarine turtle *Malaclemys terrapin*: trophic, spatial, and temporal foraging constraints. Herpetologica 51:167–181.

Twilley, R. R., A. E. Lugo, and C. Patterson-Zucca. 1986. Litter production and turnover in basin mangrove forests in southwest Florida. Ecology 67:670–683.

Tyning, T. 1989. Amherst's tunneling amphibians. Defenders 64(5):20–23.

U.S. Department of the Interior. 1985. Coastal barrier resources system. Draft report to Congress. Washington, D.C., USA.

U.S. Fish and Wildlife Service. 1978. Osceola National Forest phosphate extraction and processing: impacts on federally listed threatened or endangered and other species of concern. National Fish and Wildlife Laboratory, Gainesville, Florida, USA.

U.S. Fish and Wildlife Service. 1980. St. Marks National Wildlife Refuge: forestry management and non-game wildlife. Final report. National Fish and Wildlife Laboratory, Gainesville, Florida, USA.

U.S. Fish and Wildlife Service. 1985*a*. Determination of endangered and threatened status for the piping plover. Federal Register 50(238):50720–50734.

U.S. Fish and Wildlife Service. 1985*b*. Florida Key deer recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service. 1985*c*. Key tree-cactus (*Cereus robinii*) recovery plan technical draft. U.S. Fish and Wildlife Service, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service. 1987. 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, USA.

U.S. Fish and Wildlife Service. 1999. Final rule to list the flatwoods salamander as a threatened species. Federal Register 64(62):15691–15704.

Uzzell, T. M., and A. Schwartz. 1955. The status of the turtle *Kinosternon bauri palmarum* Stejneger with notes on variation in the species. The Journal of the Elisha Mitchell Scientific Society 71:28–35.

Veno, P. A. 1976. Successional relationships of five Florida plant communities. Ecology 57:498–508.

Vermeer, K., and J. C. Castilla. 1991. High cadmium residues observed during a pilot study in shorebirds and their prey downstream from the El Salvador Copper Mine, Chile. Bulletin of Environmental Contamination and Toxicology 46:242–248.

Vos, C. C., and J. P. Chardon. 1998. Effects of habitat fragmentation and road density on the distribution pattern of the moor frog, *Rana arvilis*. Journal of Applied Ecology 35:44–56.

Voss, G. 1969. Preserving Florida's estuaries. Florida Naturalist 19:2–4.

Wade, D., J. Ewel, and R. Hofstetter. 1980. Fire in South Florida ecosystems. U.S. Department of Agriculture, Forest Service General Technical Report SE-17, Southeastern Forest Experiment Station, Asheville, North Carolina, USA.

Wahlenberg, W. G. 1946. Longleaf pine: its use, ecology, regeneration, protection, growth and management. Charles Lathrop Pack Forestry Foundation, Washington, D.C., USA.

Waisel, Y. 1972. Biology of halophytes. Academic, New York, New York, USA.

Wallace, G. E. 2000. Distribution and relative abundance of *Graptemys* c.f. *barbouri* on the Choctawhatchee River, Florida. Florida Scientist 63(Supplement 1):43 (abstract).

Walsh, P. B., D. A. Darrow, and J. G. Dyess. 1995. Habitat selection by Florida grasshopper sparrows in response to fire. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 49:340–347.

Walters, C., L. Gunderson, and C. S. Holling. 1992. Experimental policies for water management in the Everglades. Ecological Applications 2:189–202.

Webb, S. D. 1990. Historical biogeography. Pages 70–100 *in* R. L. Myers and J. J. Ewel, editors. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida, USA.

Webber, H. J. 1935. The Florida scrub: a fire-fighting association. American Journal of Botany 22:344–361.

Webber, T. 1996. Florida prairie warbler, *Dendroica discolor paludicola*. Pages 633–643 *in* J. A. Rodgers, H. W. Kale, and H. T. Smith, editors. Rare and endangered biota of Florida. Volume V. Birds. University Press of Florida, Gainesville, Florida, USA.

Weiner, A. H. 1979. The hardwood hammocks of the Florida Keys: an ecological study. National Audubon Society and Florida Keys Land Trust, Tavernier, Florida, USA.

Werner, H. W. 1975. The biology of the Cape Sable sparrow. Everglades National Park Report, Homestead, Florida, USA.

Werner, H. W. 1983. The Cape Sable sparrow: its habitat, habits, and history. Pages 55–75 *in* T. L. Quay, J. B. Funderburg, Jr., D. S. Lee, E. F. Potter, and C. S. Robbins, editors. The seaside sparrow, its biology and management. Occasional Papers of the North Carolina Biological Survey 1983–5, Raleigh, North Carolina, USA.

Wetlands for the Americas. 1993. The shorebird education project. Manomet, Massachusetts, USA.

Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Sipe. 1982. The ecology of bottomland hardwood swamps: a community profile. U.S. Fish and Wildlife Service Office of Biological Services Program FWS/OBS-81/37, Washington, D.C., USA.

Wharton, C. H., H. T. Odum, K. Ewel, M. Duever, A. Lugo, R. Boyt, J. Bartholomew, E. DeBellevue, S. Brown, M. Brown, and L. Duever. 1977. Forested wetlands of Florida—their management and use. Final Report to the Division of State Planning on a Contract for a Forested Wetlands Manual, Tallahassee, Florida, USA.

Whitaker, J. O, and W. J. Hamilton. 1998. Mammals of the eastern United States. Cornell University Press, Ithaca, New York, USA.

White, D. H., K. A. King, and N. C. Coon. 1979. Effects of No. 2 fuel oil on hatchability of marine and estuarine birds' eggs. Bulletin of Environmental Contamination and Toxicology 21:7–10.

White, W. A. 1970. The geomorphology of the Florida peninsula. Florida Department of Natural Resources Bureau of Geology Geological Bulletin No. 51, Tallahassee, Florida, USA.

Wiegert, R. G., and B. J. Freeman. 1989. Tidal salt marshes of the southeast Atlantic Coast: a community profile. U.S. Fish and Wildlife Service Office of Biological Services Report 85(7.29).

Wilbur, H. M. 1980. Complex life cycles. Annual Review of Ecology and Systematics 11:67–93.

Wilcox, B. A., and D. D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. American Naturalist 125:879–887.

Wiley, J. W. 1988. Host selection by the shiny cowbird. Condor 90:289–303.

Wilkinson, L. 1990. Sygraph: the system for graphics. SYSTAT, Evanston, Illinois, USA.

Williams, A. 1991. Transitional wetlands. Pages 32–33 *in* J. Gato, editor. The Monroe County environmental story. Monroe County Environmental Education Task Force, Big Pine Key, Florida, USA.

Williams, C. D., and J. E. Williams. 1992. Bring back the natives: a new strategy for restoring aquatic biodiversity on public lands. Transactions of the North American Wildlife and Natural Resources Conference 57:416–423.

Williams, K., K. C. Ewel, R. P. Stumpf, F. E. Putz, and T. W. Workman. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida. Ecology 80:2045–2063.

Wilson, D. E. and D. M. Reeder, editors. 1992. Mammal species of the world: a taxonomic and geographic reference. Smithsonian Institution Press, Washington D.C., USA.

Wilson, L. D., and L. Porras. 1983. The ecological impact of man on the South Florida herpetofauna. University of Kansas Museum of Natural History Special Publication No. 9.

Winsberg, M. D. 1992. Population. Pages 126–167 *in* E. A. Fernald and E. D. Purdum, editors. Atlas of Florida. University Press of Florida, Gainesville, Florida, USA.

Wolfe, J. L. 1992. Lower Keys marsh rabbit, *Sylvilagus palustris hefneri*. Pages 71–75 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Wolfe, S. H., J. A. Reidenauer, and D. B. Means. 1988. An ecological characterization of the Florida Panhandle. U.S. Fish and Wildlife Service Biological Report 88(12).

Wood, D. A. 1996. Florida's endangered species, threatened species, and species of special concern: official lists. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Woodruff, R. E. 1982. Arthropods of gopher burrows. Proceedings of the Annual Meeting of the Gopher Tortoise Council 3:24–48.

Wood, G. W., and R. H. Barrett. 1979. Status of wild pigs in the United States. Wildlife Society Bulletin 7:237–246.

Wood, R. C. 1994. The distribution, status, ecology, and taxonomy of diamondback terrapins, *Malaclemys terrapin*, in the Florida Keys. A Symposium on the Status and Conservation of Florida Turtles, 2–3 April 1994, Eckerd College, St. Petersburg, Florida. (Abstract)

Wood, R. C. 1997. The impact of commercial crab traps on northern diamondback terrapins, *Malaclemys terrapin terrapin*. Pages 21–27 *in* J. Van Abbema, editor. Proceedings: conservation, restoration, and management of tortoises and turtles—an international conference. New York Turtle and Tortoise Society, New York, New York, USA.

Woods, C. A. 1988. Final report on cooperative agreement No. 14-16-0009-1544-Work Order No. 15. Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, Florida, USA.

Woods, C. A. 1992. Florida saltmarsh vole, *Microtus pennsylvanicus dukecampbelli*. Pages 131–139 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I. Mammals. University Press of Florida, Gainesville, Florida, USA.

Woods, C. A., W. Post, and C. W. Kilpatrick. 1982. *Microtus pennsylvanicus* (Rodentia: Muridae) in Florida: a Pleistocene relict in a coastal saltmarsh. Bulletin of the Florida State Museum, Biological Sciences Series 28:25–52.

Woolfenden, G. E., and J. W. Fitzpatrick. 1988. Ecology and habitat protection needs of the threatened Florida scrub jay. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Project Report, Tallahassee, Florida, USA.

Wooten, M. C. 1994. Estimation of genetic variation and systematic status of populations of the beach mouse, *Peromyscus polionotus*, with considerations for their management. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Final Report, Tallahassee, Florida, USA.

Wyman, R. L. 1990. What's happening to the amphibians? Conservation Biology 4:350–352.

Yerger, R. W. 1977. Fishes of the Apalachicola River. Florida Marine Research Publication No. 26:22–33.

Young, G., F. Steiner, K. Brooks, and K. Struckmeyer. 1983. Determining the regional context for landscape planning. Landscape Planning 10:269–296.

Zambrano, R., M. S. Robson, D. Y. Charnetzky, and H. T. Smith. 1997. Distribution and status of least tern nesting colonies in Southeast Florida. Florida Field Naturalist 25:85–89.

Zambrano, R., H. T. Smith, and M. Robson. 2000. Summary of breeding roseate terns in the Florida Keys. Florida Field Naturalist 28:64–68.

Zimmerman, B. L., and R. O. Bierregaard. 1986. Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Amazonia. Journal of Biogeography 13:133–143.

Zuidema, P. A., J. A. Sayer, and W. Dijkman. 1996. Forest fragmentation and biodiversity: the case for intermediate-sized conservation areas. Environmental Conservation 23:290–297.

Zwartjes, P. W. 2001. Genetic structuring among migratory populations of the black-whiskered vireo, with a comparison to the red-eyed vireo. Condor 103:439–448.

Appendix A. All taxa with high (≥24) or moderately high (<24 but ≥17) biological scores, high action scores (≥35), or declining population trends (≥5) are listed. For taxa that fall under at least1 of the 5 habitat sections of the conservation plan, the habitat(s) are given, with the first habitat code pertaining to the section of Appendix B under which tasks are listed (C=coastal, B=bat, P=dry prairie, R=South Florida rocklands, S=sandhill/scrub, W=Northwest Florida wetlands/streams). For all taxa, biological and action scores (Millsap et al. 1990) and state (Wood 1996) and FCREPA status (Gilbert 1992, Humphrey 1992*i*, Moler 1992*g*, Rodgers et al. 1996) are indicated. Status codes are: E=endangered, NR=not recognized, R=rare, RE=recently extirpated, SSC=species of special concern, T=threatened, U=undetermined.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
HIGH BIOLOGICAL SCORES						
	Mammals					
R	Key deer (*Odocoileus virginianus clavium*)	43.3	5	6	E	E
	Florida panther (*Puma concolor coryi*)[a]	40.3	9	3	E	E
C	Anastasia Island beach mouse (*Peromyscus polionotus phasma*)	39	4	4	E	E
	Florida black bear (*Ursus americanus floridanus*)[a]	34.7	4	5	T	T
C	Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli*)	34	40	5	E	E
C	St. Andrew's beach mouse (*Peromyscus polionotus peninsularis*)	34	11	5	E	E
C	Perdido Key beach mouse (*P. p. trissyllepsis*)	34	0	6	E	E
R	Florida mastiff bat (*Eumops glaucinus floridanus*)	33.3	40	5	E	T
C	Florida manatee (*Trichechus manatus latirostris*)	32.3	4	5	E	E
	Sherman's short-tailed shrew (*Blarina carolinensis shermani*)[a]	32	30	5	SSC	U
CR	Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*)	32	9	5	E	E
C	Southeastern beach mouse (*Peromyscus polionotus niveiventris*)	31	11	5	T	T
B	Gray bat (*Myotis grisescens*)	30.9	9	5	E	E
R	Key Largo woodrat (*Neotoma floridana smalli*)	30	14	5	E	E
C	Everglades mink (*Mustela vison evergladensis*)	29.7	30	5	T	SSC
C	Florida mink (*M. v. lutensis*)	29.7	25	5		
CR	Key rice rat (*Oryzomys argentatus*)	29	19	4	E	R
C	Gulf Coast mink (*Mustela vison halilimnetes*)	27.7	30	5		
	River otter (*Lutra canadensis lataxina*)[a]	26.6	15	5		
R	Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*)	26	14	5	E	E
C	Choctawhatchee beach mouse (*P. polionotus allophrys*)	26	6	6	E	E
C	Santa Rosa beach mouse (*P. p. leucocephalus*)	26	6	4		
B	Southeastern big-eared bat (*Corynorhinus rafinesquii macrotis*)	24.3	40	5	E	R
SP	Sherman's fox squirrel (*Sciurus niger shermani*)	24	21	5	SSC	T
C	Sanibel Island marsh rice rat (*Oryzomys palustris sanibeli*)	23	25	4	SSC	
CR	Lower Keys cotton rat (*Sigmodon hispidus exsputus*)	23	20	5		
B	Southeastern bat (*Myotis austroriparius*)	22.6	16	5		U
S	Southeastern pocket gopher (*Geomys p. pinetis*)	22.3	30	5		
	Round-tailed muskrat (*Neofiber alleni*)	22.3	25	5		SSC
C	Insular cotton rat (*Sigmodon hispidus insulicola*)	22	30	5		
	Big Cypress fox squirrel (*Sciurus niger avicennia*)	22	25	4	T	T
S	Florida mouse (*Podomys floridanus*)	22	21	5	SSC	T
B	Northern yellow bat (*Lasiurus intermedius floridanus*)	21.3	30	5		U
C	Southern mink (*Mustela vison mink*)	20.7	25	5		
	Long-tailed weasel (*M. frenata* subsp.)	20.3	30	5		R
B	Brazilian free-tailed bat (*Tadarida brasiliensis cyanocephala*)	19.3	30	5		U
C	Micco cotton rat (*Sigmodon hispidus littoralis*)	17	31	2		
	Birds					
	Ivory-billed woodpecker (*Campephilus p. principalis*)[a]	50.6	25	6	E	E
P	Whooping crane (*Grus americana*)	45.3	0	1	SSC	RE
P	Snail kite (*Rostrhamus sociabilis plumbeus*)	44.6	5	3	SSC	E
C	Cuban snowy plover (*Charadrius alexandrinus tenuirostris*)	39.3	4	6	T	E
P	Florida grasshopper sparrow (*Ammodramus savannarum floridanus*)	37.7	16	6	E	E
P	Crested caracara (*Caracara plancus audubonii*)	37.7	16	5	T	T
C	Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*)	37.3	5	6	E	E
PR	Short-tailed hawk (*Buteo brachyurus fuliginosus*)	36.3	30	5		R
C	Florida prairie warbler (*Dendroica discolor paludicola*)	35.3	19	5		U
S	Florida scrub-jay (*Aphelocoma coerulescens*)	33.3	9	6	T	T

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
C	Piping plover (*Charadrius melodus*)	33	14	5	T	E
C	Reddish egret (*Egretta r. rufescens*)	31.9	21	3	SSC	R
C	Sanderling (*Calidris alba*)	31	14	5		
C	Black rail (*Laterallus j. jamaicensis*)	30.9	25	5		R
C	Red knot (*Calidris canutus rufa*)	30.3	14	5		
C	Worthington's marsh wren (*Cistothorus palustris griseus*)	29.7	19	5	SSC	SSC
	Red-cockaded woodpecker (*Picoides borealis*)[a]	29.6	11	6	T	E
R	White-crowned pigeon (*Columba leucocephala*)	29.6	10	2	T	T
	Stoddard's yellow-throated warbler (*Dendroica dominica stoddardi*)[a]	29.3	24	4		NR
C	Cuban yellow warbler (*D. petechia gundlachi*)	28.3	19	5		R
C	American ruddy turnstone (*Arenaria interpres morinella*)	28	14	4		
C	Whimbrel (*Numenius phaeopus hudsonicus*)	28	21	5		
C	Yellow rail (*Coturnicops n. noveboracensis*)	27.3	30	5		
P	Florida sandhill crane (*Grus canadensis pratensis*)	27	9	5	T	T
C	Little blue heron (*Egretta caerulea*)	26.6	19	6	SSC	SSC
	American bittern (*Botaurus lentiginosus*)	26.3	25	2		
CP	Wood stork (*Mycteria americana*)	26.3	14	4	E	E
P	Swallow-tailed kite (*Elanoides forficatus*)	25.7	24	2		T
C	Wakulla seaside sparrow (*Ammodramus maritimus junicolus*)	25.7	20	5	SSC	SSC
C	American oystercatcher (*Haematopus p. palliatus*)	25.3	21	2	SSC	T
C	Common loon (*Gavia immer*)	25	16	5		
C	Green heron (*Butorides virescens*)	24.3	25	2		
CP	Limpkin (*Aramus guarauna pictus*)	24.3	21	3	SSC	SSC
CR	Arctic peregrine falcon (*Falco peregrinus tundrius*)	24.3	19	2	E	E
C	King rail (*Rallus e. elegans*)	24	25	5		
	Broad-winged hawk (*Buteo p. platypterus*)[a]	24	24	5		Peripheral
	Northern flicker (*Colaptes a. auratus*)	24	10	6		
C	Louisiana seaside sparrow (*Ammodramus maritimus fisheri*)	23.7	25	6		SSC
C	Scott's seaside sparrow (*A. m. peninsulae*)	23.7	25	5	SSC	SSC
C	Semipalmated sandpiper (*Calidris pusilla*)	23.7	21	5		
C	Pectoral sandpiper (*C. melanotos*)	23.7	21	5		
C	White-rumped sandpiper (*C. fuscicollis*)	23.7	21	5		
C	Marian's marsh wren (*Cistothorus palustris marianae*)	23.7	19	5	SSC	SSC
P	Henslow's sparrow (*Ammodramus henslowii*)	23.3	25	5		
C	Horned grebe (*Podiceps auritus coronutus*)	23.3	21	3		
CP	American black duck (*Anas rubripes*)	23.3	4	6		
C	Lesser scaup (*A. affinis*)	23.3	4	4		
C	Least bittern (*Ixobrychus e. exilis*)	23	30	4		SSC
C	Gull-billed tern (*Sterna nilotica*)	23	21	5		U
C	Gray kingbird (*Tyrannus dominicensis*)	23	14	5		
C	Wilson's plover (*Charadrius w. wilsoni*)	23	14	5		SSC
C	Royal tern (*Sterna maxima*)	23	14	4		SSC
C	Marbled godwit (*Limosa fedoa*)	23	14	4		
C	Roseate tern (*Sterna dougallii*)	22.3	25	5	T	T
C	Cerulean warbler (*Dendroica cerulea*)[b]	22.3	10	5		
	Mississippi kite (*Ictinia mississippiensis*)	22	24	5		
	Red-headed woodpecker (*Melanerpes erythrocephalus*)	22	10	6		
C	Roseate spoonbill (*Ajaia ajaja*)	21.9	26	4	SSC	R
C	Great blue heron (*Ardea herodias* subsp.)	21.9	19	4		
C	Short-billed dowitcher (*Limnodromus g. griseus*)	21.7	14	5		
	Short-eared owl (*Asio flammeus*)	21.6	35	2		
	Common nighthawk (*Chordeiles minor chapmani*)	21.6	20	6		
C	Purple martin (*Progne subis* subsp.)[b]	21.6	10	5		
	Eastern screech-owl (*Otus asio floridana*)	21.3	14	4		
CP	Southern bald eagle (*Haliaeetus l. leucocephalus*)	21.3	5	3	T	T
C	Greater scaup (*Aythya m. mariloides*)	21.3	4	5		
C	Black tern (*Clidonias niger surinamensis*)	21	20	5		
C	Swainson's warbler (*Limnothlypis swainsonii*)[b]	21	16	5		

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
	Purple gallinule (*Porphyrula martinica*)	20.7	21	5		
C	Bobolink (*Dolichonyx oryzivorus*)[a]	20.3	25	5		
C	Yellow-crowned night-heron (*Nyctanassa violacea*)	20.3	25	5		SSC
C	Tricolored heron (*Egretta tricolor ruficolus*)	20.3	19	6	SSC	SSC
C	Great egret (*Ardea alba*)	20.3	19	6		SSC
C	Snowy egret (*Egretta thula thula*)	20.3	19	5		SSC
C	Painted bunting (eastern population; *Passerina c. ciris*)[b]	20	25	6		U
C	Black-whiskered vireo (*Vireo altiloquus barbatulus*)	20	14	5		R
C	Rusty blackbird (*Euphagus carolinus*)[a]	19.7	21	4		
C	Long-billed dowitcher (*Limnodromus scolopaceus*)	19.7	19	5		
C	Black-bellied plover (*Pluvialis squatarola*)	19.7	14	5		
	Barn swallow (*Hirundo rustica* spp.)	19.6	10	1		
C	Bicknell's thrush (*Catharus bicknelli*)[b]	19.3	20	5		
	Brewer's blackbird (*Euphagus cyanocephalus*)	19	19	2		
C	Dunlin (*Calidris alpina pacifica*)	19	14	5		
C	Black skimmer (*Rynchops niger*)	19	14	5	SSC	
P	Greater sandhill crane (*Grus canadensis tabida*)	19	14	3		
C	Least sandpiper (*Calidris minutilla*)	18.7	19	5		
C	Wilson's phalarope (*Phalaropus tricolor*)	18.7	16	2		
	Eastern meadowlark (*Sturnella magna* subsp.)	18.7	10	6		
C	Cape May warbler (*Dendroica tigrina*)	18.6	20	5		
C	Prothonotary warbler (*Protonotaria citrea*)[b]	18.6	10	5		
C	Bay-breasted warbler (*Dendroica castanea*)[b]	18.6	10	5		
	Common barn-owl (*Tyto alba pratincola*)	18.3	25	2		
C	Canada goose (*Branta canadensis interior*)	18.3	19	6		
C	Glossy ibis (*Plegadis f. falcinellus*)	18.3	19	4		SSC
	Fulvous whistling duck (*Dendrocygna bicolor helva*)	18.3	14	2		
C	Hooded merganser (*Lophodytes cucullatus*)	18.3	4	2		
P	Swainson's hawk (*Buteo swainsoni*)	18	24	2		
C	Yellow-billed cuckoo (*Coccyzus a. americanus*)[b]	18	20	5		
	American woodcock (*Scolopax minor*)	18	19	2		
C	Common tern (*Sterna hirundo*)	18	15	5		SSC
	Downy woodpecker (*Picoides p. pubescens*)	18	10	2		
	Wood duck (*Aix sponsa*)	18	4	4		
C	Semipalmated plover (*Charadrius semipalmatus*)	17.7	14	5		
C	Louisiana waterthrush (*Seiurus motacilla*)[b]	17.6	21	5		R
C	Rothschild's magnificent frigatebird (*Fregata magnificens rothschildi*)	17.3	21	3		T
C	Tennessee warbler (*Vermivora peregrina*)[b]	17.3	20	5		
C	White ibis (*Eudocimus albus*)	17.3	19	4	SSC	SSC
C	Northern prairie warbler (*Dendroica d. discolor*)[b]	17.3	14	5		
	Eastern wood-pewee (*Contopus virens*)	17.3	14	2		
P	Florida mottled duck (*Anas f. fulvigula*)	17.3	9	5		
C	Osprey (*Pandion haliaetus carolinensis*)	17.3	5	3		T
C	American avocet (*Recurvirostra americana*)	17	21	2		
C	Kentucky warbler (*Oporornis formosus*)[b]	17	21	5		
C	Golden-winged warbler (*Vermivora chrysoptera*)[b]	17	20	5		
C	Anhinga (*Anhinga anhinga*)	17	19	5		
	Brown-headed nuthatch (*Sitta pusilla* subsp.)	17	10	6		
C	Sooty tern (*Sterna fuscata* spp.)	17	9	5		
	<u>Reptiles</u>					
C	Atlantic salt marsh snake (*Nerodia clarkii taeniata*)	37.3	25	6	T	E
R	Rim rock crowned snake (*Tantilla oolitica*)	36.6	25	5	T	T
S	Sand skink (*Neoseps reynoldsi*)	35.6	11	6	T	T
C	Coastal dunes crowned snake (*Tantilla relicta pamlica*)	34.6	30	5		
C	Mangrove diamondback terrapin (*Malaclemys terrapin rhizophorarum*)	33.6	21	5		R
C	Florida East Coast terrapin (*M. t. tequesta*)	33.6	16	5		
RC	Florida Keys mole skink (*Eumeces e. egregius*)	32.7	25	6	SSC	SSC

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
C	Cedar Key mole skink (*E. e. insularis*)	32.7	25	5		R
S	Bluetail mole skink (*Eumeces egregius lividus*)	32.3	25	6	T	E
S	Central Florida crowned snake (*Tantilla relicta neilli*)	31	30	5		
R	Key ringneck snake (*Diadophis punctatus acricus*)	30	25	5	T	T
S	Short-tailed snake (*Stilosoma extenuatum*)	30	25	5	T	T
W	Suwannee cooter (*Pseudemys concinna suwanniensis*)	30	11	6	SSC	SSC
C	American crocodile (*Crocodylus acutus*)	29.7	9	3	E	E
C	Carolina diamondback terrapin (*Malaclemys terrapin centrata*)	29.6	25	5		
C	Ornate diamondback terrapin (*M. t. macrospilota*)	29.6	21	5		
W	Barbour's map turtle (*Graptemys barbouri*)	28.3	21	5	SSC	R
C	Atlantic ridley (*Lepidochelys kempii*)	28	19	5	E	E
C	Green turtle (*Chelonia mydas*)	27.6	0	2	E	E
SPC	Gopher tortoise (*Gopherus polyphemus*)	27.3	11	6	SSC	T
C	Mississippi diamondback terrapin (*Malaclemys terrapin pileata*)	26.3	30	5		
P	South Florida rainbow snake (*Farancia erytrogramma seminola*)	26	40	5		U
C	Leatherback (*Dermochelys coriacea*)	25.6	0	5	E	R
P	South Florida mole kingsnake (*Lampropeltis calligaster occipitolineata*)	25	35	5		R
SPRC	Eastern indigo snake (*Drymarchon corais couperi*)	24.7	21	5	T	SSC
S	Florida scrub lizard (*Sceloporus woodi*)	24.7	16	6		T
C	Mangrove salt marsh snake (*Nerodia clarkii compressicauda*)	24	30	5		
S	Florida pine snake (*Pituophis melanoleucus mugitus*)	23.7	25	5	SSC	U
SPRC	Eastern diamondback rattlesnake (*Crotalus adamanteus*)	23.7	30	6		
S	Peninsula mole skink (*Eumeces egregius peninsularis*)	23.7	30	5		
S	Florida worm lizard (*Rhineura floridana*)	23	30	5		
	Timber rattlesnake (*Crotalus horridus*)	22.7	30	4		
W	Escambia map turtle (*Graptemys ernsti*)	22.3	25	4		R
S	Southern hognose snake (*Heterodon simus*)	22	30	6		
	Gulf Coast box turtle (*Terrapene carolina major*)	22	25	5		
SPRC	Florida scarlet snake (*Cemophora c. coccinea*)	21.3	30	5		
C	Gulf salt marsh snake (*Nerodia c. clarkii*)	21.3	30	5		R
	South Florida swamp snake (*Seminatrix pygaea cyclas*)	21	30	5		
C	Marsh brown snake (*Storeria dekayi limnetes*)	21	30	5		
	Southern green anole (*Anolis carolinensis seminolus*)	20	30	5		
	Southeastern crowned snake (*Tantilla coronata*)	20	30	5		
RPC	Florida box turtle (*Terrapene carolina bauri*)	20	21	5		
	Pine woods snake (*Rhadinaea flavilata*)	19	30	5		
W	Spotted turtle (*Clemmys guttata*)	18.7	35	5		R
CS	Island glass lizard (*Ophisaurus compressus*)	18.7	30	5		
	Northern scarlet snake (*Cemophora coccinea copei*)	18.3	30	4		
C	Loggerhead (*Caretta caretta*)	18.3	4	4	T	T
	Florida kingsnake (*Lampropeltis getula floridana*)	18	30	5		
	Florida chicken turtle (*Deirochelys reticularia chrysea*)	18	30	4		
	Florida mud turtle (*Kinosternon subrubrum steindachneri*)	18	30	3		
	Mimic glass lizard (*Ophisaurus mimicus*)	17	35	5		U
	Everglades rat snake (*Elaphe obsoleta rossalleni*)	17	30	4		
W	Alligator snapping turtle (*Macroclemys temminckii*)	17	15	5	SSC	SSC
	Three-toed box turtle (*Terrapene carolina triunguis*)	17	25	5		
	<u>Amphibians</u>					
SW	Striped newt (*Notophthalmus perstriatus*)	29	21	6		R
W	Florida bog frog (*Rana okaloosae*)	26.3	20	5	SSC	R
SWP	Florida gopher frog (*R. capito aesopus*)	24.6	15	5	SSC	T
W	Georgia blind salamander (*Haideotriton wallacei*)	24.3	20	5	SSC	R
W	Pine Barrens treefrog (*Hyla andersonii*)	24	15	5	SSC	R
W	Four-toed salamander (*Hemidactylium scutatum*)	21.3	30	5		R
W	Flatwoods salamander (*Ambystoma cingulatum*)	21.3	9	6	SSC	R
W	Apalachicola dusky salamander (*Desmognathus apalachicolae*)	20.3	20	3		

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
	Broad-striped dwarf siren (*Pseudobranchus s. striatus*)	20	35	5		
SWPR	Oak toad (*Bufo quercicus*)	19.6	30	4		
SW	Ornate chorus frog (*Pseudacris ornata*)	18.3	35	5		
	Everglades dwarf siren (*Pseudobranchus axanthus belli*)	18	35	5		
SW	Eastern tiger salamander (*Ambystoma t. tigrinum*)	18	35	5		U
SWP	Barking treefrog (*Hyla gratiosa*)	17.3	25	5		
W	One-toed amphiuma (*Amphiuma pholeter*)	17.3	25	2		R
PR	Florida chorus frog (*Pseudacris nigrita verrucosa*)	17.3	20	4		
SW	Mole salamander (*A. talpoideum*)	17.3	25	4		
	Fishes					
W	Shoal bass (*Micropterus* sp. nov. cf. *coosae*)	40.9	21	5	SSC	T
W	Gulf sturgeon (*Oxyrinchus desotoi*)	40.3	21	2	SSC	T
W	Blackmouth shiner (*Notropis melanostomus*)	34.9	30	6	E	T
W	River redhorse (*Moxostoma carinatum*)	34.3	25	5		T
W	Crystal darter (*Crystallaria asprella*)	33.9	30	5	T	T
W	Spotted bullhead (*Ameiurus serracanthus*)	30.6	21	6		
W	Okaloosa darter (*Etheostoma okaloosae*)	30.3	0	3	E	E
	Blueback herring (*Alosa aestivalis*)	29.3	20	6		
W	Harlequin darter (*Etheostoma histrio*)	26.9	20	2	SSC	T
W	Alabama shad (*Alosa alabamae*)	26.3	25	5		
	Lake Eustis minnow (*Cyprinodon variegatus hubbsi*)	25.3	20	5	SSC	SSC
W	Bluenose shiner (*Pteronotropis welaka*)	24.3	26	5	SSC	SSC
W	Snail bullhead (*Ictalurus brunneus*)	23.3	26	6		
W	Cypress minnow (*Hybognathus hayi*)	22.9	30	5		T
W	Blackbanded sunfish (*Enneacanthus chaetodon*)	22.3	35	5		R
W	Florida sand darter (*Etheostoma bifascia*)	22.3	20	2		
W	Alligator gar (*Atractosteus spatula*)	22	35	5		R
W	Grayfin redhorse (*Moxostoma* sp. nov. cf *poecilurum*)	22	20	2		T
W	Blacktip shiner (*Lythrurus atrapiculus*)	21.3	30	5		R
W	Ironcolor shiner (*Notropis chalybaeus*)	21.3	30	5		
W	Florida chub (*Extrarius* n. sp. cf *aestivalis*)	20.6	30	4		R
W	Goldstripe darter (*Etheostoma parvipinne*)	20.3	30	5		R
W	Southern brook lamprey (*Ichthyomyzon gagei*)	20.3	20	5		
W	Striped bass (*Morone saxatilis*)	20.3	6	4		
W	American eel (*Anguilla rostrata*)	20	20	4		
W	Florida logperch (*Percina* n. sp. cf *caprodes*)	19.6	25	5		R
W	Mud sunfish (*Acanthacus promotis*)	19.3	30	5		
W	Coastal darter (*Etheostoma colorosum*)	19.3	25	2		
W	Flagfin shiner (*Pteronotropis signipinnis*)	18.9	21	2		
W	Bandfin shiner (*Luxilus zonistius*)	18.7	25	5		R
W	Spotted sucker (*Minytrema melanops*)	18	15	2		
	Hickory shad (*Alosa mediocris*)	17.3	25	5		
W	Suwannee bass (*Micropterus notius*)	17	16	2	SSC	
HIGH ACTION SCORES						
	Mammals					
B	Hoary bat (*Lasiurus c. cinereus*)	15.3	40	5		
B	Big brown bat (*Eptesicus fuscus* subsp.)	10.3	40	5		U
B	Eastern pipistrelle (*Pipistrellus s. subflavus*)	15.3	35	5		
B	Evening bat (*Nycticeius humeralis* subsp.)	14.3	35	2		
	Eastern mole (*Scalopus aquaticus*)	7	35	5		
	Least shrew (*Cryptotis parva floridana*)	7	35	4		
	Southern short-tailed shrew (*Blarina carolinensis* spp.)	6	35	4		
	Southeastern shrew (*Sorex l. longirostris*)	6	35	2		

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
	<u>Reptiles</u>					
	Mole kingsnake (*Lampropeltis calligaster rhombomaculata*)	16	40	5		
W	Glossy crayfish snake (*Regina r. rigida*)	10.3	40	5		
W	Gulf crayfish snake (*Regina r. sinicola*)	8.3	40	5		
W	Southern coal skink (*Eumeces anthracinus pluvialis*)	8.7	35	4		R
	<u>Amphibians</u>					
	Gulf Hammock dwarf siren (*Pseudobranchus striatus lustricolus*)	12	40	2		U
W	Undescribed greater siren (*Siren* sp. nov. cf. *lacertina*)	12	40	2		
	Many-lined salamander (*Stereochilus marginatus*)	10	40	2		R
W	Undescribed lesser siren (*Siren* sp. nov. cf. *intermedia*)	14	35	5		
W	Slender dwarf siren (*Pseudobranchus striatus spheniscus*)	13	35	5		
W	Fowler's toad (*Bufo fowleri*)	11.3	35	2		
W	Undescribed "least" siren (*Siren minima*)	10	35	2		
	<u>Fishes</u>					
W	Eastern mudminnow (*Umbra pygmaea*)	14.3	35	5		
	Atlantic needlefish (*Strongylura marina*)	3	35	2		
DECLINING FLORIDA POPULATION TRENDS						
	<u>Mammals</u>					
B	Seminole bat (*Lasiurus seminolus*)	16.3	30	5		
S	Fox squirrel (*Sciurus niger* subsp.)	16	19	5		
CSR	Spotted skunk (*Spilogale putorius*)	15	25	5		
	Marsh rabbit (*Sylvilagus palustris* spp.)	14	25	5		
B	Red bat (*Lasiurus borealis borealis*)	13.3	30	5		
	Eastern cottontail (*Sylivilagus floridanus* spp.)	11	9	5		
	<u>Birds</u>					
	Common ground-dove (*Columbina passerina* spp.)	16.7	20	6		
	Vesper sparrow (*Pooecetes gramineus* spp.)	16.7	19	6		
	Loggerhead shrike (*Lanius ludovicianus* subsp.)	16.7	10	6		
C	Indigo bunting (*Passerina cyanea*)[b]	16.7	10	6		
C	Antillean nighthawk (*Chordeiles gundlachii*)	16.6	16	5		R
C	Solitary sandpiper (*Tringa solitaria solitaria*)	16.3	21	5		
C	Eastern kingbird (*Tyrannus tyrannus*)[b]	16.3	10	6		
C	Northern pintail (*Anas a. acuta*)	16.3	4	5		
C	Least tern (*Sterna antillarum antillarum*)	16	11	4	T	T
C	Wood thrush (*Hylocichla mustelina*)[b]	15.7	9	5		
C	Western kingbird (*Tyrannus verticalis*)[b]	15.3	21	5		
C	Chestnut-sided warbler (*Dendroica pennsylvanica*)[b]	15.3	20	5		
C	Least flycatcher (*Empidonax minimus*)[b]	15.3	20	5		
C	Scissor-tailed flycatcher (*Tyrannus forficatus*)[b]	15.3	20	5		
	White-throated sparrow (*Zonotrichia albicollis* subsp.)	15	16	6		
	Purple finch (*Carpodacus purpureus* subsp.)	14.7	19	5		
C	American pipit (*Anthus rubescens*)[b]	14.7	16	6		
	Grasshopper sparrow (*Ammodramus savannarum pratensis*)	14.7	9	6		R
	Red-winged blackbird (*Agelaius phoenicius*)	14.7	5	6		
C	Blackpoll warbler (*Dendroica striata*)[b]	14.3	15	5		
C	Canvasback (*Aythya valisineria*)	14.3	4	6		
C	Scarlet tanager (*Piranga olivacea*)[b]	13.7	20	5		
C	Western sandpiper (*Calidris mauri*)	13.7	14	5		
	Field sparrow (*Spizella pusilla* spp.)	13	19	6		
C	Worm-eating warbler (*Helmitheros vermivorus*)[b]	13	21	5		R
C	Gray-cheeked thrush (*Catharus minimus*)[b]	13	20	5		
C	Swainson's thrush (*C. ustulatus*)[b]	13	20	5		

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
	Pine siskin (*Carduelis pinus* subsp.)	13	14	5		
C	Veery (*Catharus fuscescens*)[b]	12.7	20	5		
C	Least sandpiper (*Calidris minutilla*)	12.7	19	5		
C	Cape May warbler (*Dendroica tigrina*)[b]	12.6	20	5		
C	Virginia rail (*Rallus l. limicola*)	12.3	25	5		
C	Clapper rail (*R. longirostris* spp.)	12.3	21	5		
	American goldfinch (*Carduelis tristis* subsp.)	12.3	19	6		
	Eastern bluebird (*Sialia sialis* subsp.)	12.3	10	5		
	Tufted titmouse (*Baeolophus bicolor* subsp.)	12.3	10	5		
	Ruddy duck (*Oxyura jamaicensis rubida*)	12.3	4	5		
	Hairy woodpecker (*Picoides villosus audubonii*)	12	19	5		SSC
	Yellow-bellied sapsucker (*Sphyrapicus varius*)	12	19	5		
C	Golden eagle (*Aquila chrysaetos canadensis*)	12	14	5		
C	Sora (*Porzana carolina*)	11.7	21	5		
C	Northern waterthrush (*Seiurus noveboracensis*)[b]	11.6	21	5		
C	Palm warbler (*Dendroica palmarum* subsp.)[b]	11.6	14	6		
C	Black-throated blue warbler (*D. caerulescens* subsp.)[b]	11.3	25	5		
C	Blue-winged warbler (*Vermivora pinus*)[b]	11.3	20	5		
C	Painted bunting (western population; *Passerina ciris pallidor*)[b]	11	30	5		
C	Ruby-throated hummingbird (*Archilochus colubris*)[b]	11	21	5		
C	Savannah sparrow (*Passerculus sandwichensis* subsp.)	11	14	6		
	American coot (*Fulica americana americana*)	11	14	5		
C	Hooded warbler (*Wilsonia citrina*)[b]	11	14	5		
C	Acadian flycatcher (*Empidonax virescens*)[b]	11	10	6		
	Eastern towhee (*Pipilo erythrophthalmus*)	11	10	6		
	Northern bobwhite (*Colinus virginianus* spp.)	11	9	6		
	Song sparrow (*Melospiza melodia* subsp.)	11	9	6		
	Common moorhen (*Gallinula chloropus chloropus*)	10.7	16	5		
C	Sedge wren (nonbreeding; *Cistothorus platensis* subsp.)	10.7	14	5		
C	American wigeon (*Anas americana*)	10.3	4	5		
	Brown creeper (*Certhia americana* subsp.)	10	16	6		
	White-breasted nuthatch (*Sitta carolinensis* subsp.)	10	14	6		SSC
C	Red-eyed vireo (*Vireo olivaceus*)[b]	10	10	6		
C	Ovenbird (*Seiurus aurocapillus*)[b]	10	19	5		
C	Seaside sparrow (nonbreeding races; *Ammodramus maritimus* subsp.)	9.7	20	5		
C	Greater yellowlegs (*Tringa melanoleuca*)	9.7	14	5		
C	Nashville warbler (*Vermivora ruficapilla*)[b]	9.3	20	5		
	Golden-crowned kinglet (*Regulus satrapa* subsp.)	9	16	5		
C	Black-throated green warbler (*Dendroica virens* spp.)[b]	8.3	25	5		
C	Cliff swallow (*Petrochelidon pyrrhonota* subsp.)[b]	8.3	21	5		
C	Blackburnian warbler (*Dendroica fusca*)[b]	8.3	20	5		
C	Magnolia warbler (*D. magnolia*)[b]	8.3	20	5		
C	Yellow warbler (*D. petechia aestiva*)[b]	8.3	16	5		
C	American redstart (*Setophaga ruticilla*)[b]	8.3	16	5		R
	Pine warbler (*Dendroica pinus*)	8.3	10	5		
	Northern mockingbird (*Mimus polyglottos* subsp.)	7	10	6		
	American robin (*Turdus migratorius* subsp.)	7	10	5		
	Smooth-billed ani (*Crotophaga ani*)	6.7	21	5		
	Red-breasted nuthatch (*Sitta canadensis*)	6.3	16	5		
	House wren (*Troglodytes aedon* spp.)	6.3	14	5		
	Chipping sparrow (*Spizella passerina* subsp.)	5	19	5		
C	Swamp sparrow (*Melospiza georgiana* spp.)	5	16	5		
RP	Red-tailed hawk (*Buteo jamaicensis borealis* and *umbrinus*)	4	10	5		
	<u>Reptiles</u>					
W	Eastern mud snake (*Farancia a. abacura*)	16.3	30	5		
W	Striped crayfish snake (*Regina alleni*)	16.3	30	5		

Appendix A. Continued.

Habitat	Taxon	Biological score	Action score	Declining score	State status	FCREPA status
S	Northern mole skink (*Eumeces egregius onocrepis*)	15.7	30	5		
SP	Eastern hognose snake (*Heterodon platirhinos*)	15.3	30	5		
W	Loggerhead musk turtle (*Sternotherus m. minor*)	13	30	6		
S	Eastern slender glass lizard (*Ophisaurus attenuatus longicaudus*)	15	30	5		
W	Eastern kingsnake (*Lampropeltis g. getula*)	13	30	5		
S	Eastern coachwhip (*Masticophis f. flagellum*)	13	30	5		
W	Gulf Coast smooth softshell (*Apalone mutica calvata*)	12.3	30	5		U
	Five-lined skink (*Eumeces fasciatus*)	6	30	5		
	Amphibians					
W	Southern dusky salamander (*Desmognathus auriculatus*)	13	16	6		
W	Eastern lesser siren (*Siren i. intermedia*)	12	20	5		
W	Spotted dusky salamander (*Desmognathus fuscus conanti*)	8.7	16	5		
Fishes						
W	Redbreast sunfish (*Lepomis auritus*)	12	9	6		
	Tessellated darter (*Etheostoma olmstedi*)	10.3	25	6		T
W	Okefenokee pigmy sunfish (*Elassoma okefenokee*)	16.7	30	5		
W	Bannerfin shiner (*Notropis leedsi*)	16	25	5		
W	Flier (*Centrarchus macropterus*)	14.3	25	5		
W	Speckled madtom (*Noturus leptacanthus*)	13	30	5		
W	Seminole killifish (*Fundulus seminolus*)	13	25	5		
	American shad (*Alosa sapidissima*)	13	20	5		
W	Cypress darter (*Etheostoma proeliare*)	11.3	30	5		
W	Black madtom (*Noturus funebris*)	10.7	30	5		
W	Everglades pigmy sunfish (*Elassoma evergladei*)	10	25	5		
W	Speckled darter (*Etheostoma stigmaeum*)	10	25	5		
W	Dusky shiner (*Notropis cummingsae*)	10	25	5		
W	Pigmy killifish (*Leptolucania ommata*)	9.7	30	5		
W	Banded sunfish (*Enneacanthus obesus*)	6.7	30	5		
	Bigmouth sleeper (*Gobiomorus dormitor*)	6.7	30	5		T
	Fat sleeper (*Dormitator maculatus*)	6	30	5		

[a] High-ranking species that does not fall under any current habitat section but for which tasks need to be developed

[b] Considered a declining neotropical migrant songbird in Florida

Appendix B. List of conservation tasks identified by the FWC's NGWP staff for vertebrates in interior scrubs and sandhills, interior dry prairies, North Florida streams and wetlands, South Florida rocklands, and coastal habitats. Tasks are listed in order by task number.

No.	Task title	Target taxa	Objectives	Biological score: Sum	Biological score: X
MULTIPLE HABITATS					
Distributional Survey					
3101	Publish an Atlas of Amphibians and Reptiles in Florida	All Herpetofaunal Taxa	Compile distributional records for each species; plot the points on maps; publish in atlas form	NA	NA
3102	Survey for the Red-cockaded Woodpecker on Wildlife Management Areas	Red-cockaded Woodpecker	South Florida populations are important to the range-wide recovery of this species, and baseline surveys were initiated in FY 1999–2000 on 3 WMAs in southern Florida to assess the status, distribution, and management needs of these 3 populations; continued support of this project is needed to move from the survey phase to the population monitoring and management phases	30	30
Education					
6101	Educate the Public on Impacts of House Cats on Wildlife Populations	Declining Neotropical Migrant Birds, Nesting Shorebirds, Colonial Nesting Seabirds, Beach Mice, Coastal Strand Rodents, Tidal Marsh Rodents, Lower Keys Marsh Rabbit; Sherman's Short-tailed Shrew; Florida Mouse; Florida Scrub-jay; Florida Scrub Lizard	Predation by feral and free-ranging cats is a significant source of mortality for many wildlife species, and widespread public support needs to be garnered for cat control programs, such as the national "Cats Indoor Program" that is being lead by the American Birding Conservancy	1688	20
Species Management					
9101	Develop a Statewide Conservation Plan for the Red-Cockaded Woodpecker	Red-cockaded Woodpecker	A comprehensive planning document is needed to identify, prioritize, and direct red-cockaded woodpecker management activities in Florida; development of a statewide management plan is underway by the FWC, but continued support for this project is needed to complete the planning process and develop an implementation strategy	30	30

INTERIOR SCRUB AND SANDHILL

Distributional Survey

3101	Inventory the Vertebrate Community on FWC-managed Scrub Parcels of the Lake Wales Ridge Ecosystem Project	Florida Gopher Frog, Sand Skink, Bluetail Mole Skink, Peninsula Mole Skink, Florida Scrub Lizard, Eastern Indigo Snake, Short-tailed Snake, Peninsula Crowned Snake, Florida Pine Snake, Southern Hognose Snake, Eastern Diamondback Rattlesnake, Florida Worm Lizard, Gopher Tortoise, Florida Scrub-jay, Florida Mouse	Conduct a comprehensive vertebrate survey (e.g., drift fences, small mammal trapping, avian transects) of various habitats found in the scrub parcels included in the Lake Wales Ridge Ecosystem Project	403	27
3102	Update the Statewide Distribution of the Florida Scrub-jay	Florida Scrub-jay	The atlas containing the statewide distribution of scrub-jays (Cox 1987) needs to be updated	33	33
3301	Survey the Distribution of the Florida Gopher Frog on Public Lands in Central and Southern Florida	Florida Gopher Frog	Document continued occurrence of historic populations and identify new localities on public lands south of Marion County	25	25

Population Monitoring

4201	Survey Florida Scrub-jay Territories for Occupancy and Monitor Populations on WMAs	Florida Scrub-jay	Monitor long-term trends in scrub-jay populations and population responses to active management on WMAs	33	33
4202	Monitor Newly Established or Enhanced Populations of the Florida Scrub-jay	Florida Scrub-jay	Monitor the immediate success and long-term population trends of newly established or enhanced colonies	33	33

Research

5101	Study the Effects on Terrestrial Vertebrates of Burning vs. Mechanically Clearing Scrub	Bluetail Mole Skink, Sand Skink, Peninsula Crowned Snake, Florida Scrub Lizard, Gopher Tortoise, Florida Mouse	Determine impacts on target scrub taxa of restoring mature scrub to early seral stages by burning vs. mechanical shrub removal	174	29
5102	Study the Effects on Terrestrial Vertebrates of the Seasonality and Frequency of Prescribed Fires in Sandhills	Peninsula Crowned Snake, Central Florida Crowned Snake, Short-tailed Snake, Striped Newt, Florida Gopher Frog, Peninsula Mole Skink, Florida Pine Snake, Eastern Diamondback Rattlesnake, Florida Worm Lizard, Florida Mouse, Florida Scarlet Snake, Oak Toad, Ornate Chorus Frog, Barking Treefrog, Mole Salamander, Eastern Tiger Salamander, Southern Hognose Snake	Conduct a drift-fence survey to determine population responses of sandhill vertebrates to winter versus summer burning and different fire regimes	395	23

5301	Study the Effects on Herpetofauna of Planting Sand Pines on Sandhill Sites	Florida Gopher Frog, Striped Newt, Gopher Tortoise, Peninsula Mole Skink, Peninsula Crowned Snake, Central Florida Crowned Snake, Short-tailed Snake, Eastern Indigo Snake, Florida Pine Snake, Eastern Diamondback Rattlesnake, Southern Hognose Snake, Florida Worm Lizard, Florida Scarlet Snake, Oak Toad, Ornate Chorus Frog, Barking Treefrog, Mole Salamander, Eastern Tiger Salamander	Determine relative population densities of herpetofaunal taxa in natural sand-hill habitat compared to nearby sand pine plantations of various ages and stocking densities	428	24
5302	Study the Long-term Effects on Terrestrial Vertebrates of Different Fire Regimes in Scrub	Bluetail Mole Skink, Sand Skink, Peninsula Crowned Snake, Florida Scrub Lizard, Gopher Tortoise, Florida Mouse	Determine long-term population responses of target scrub taxa to implementation of different burning schedules in scrub habitat on the Lake Wales Ridge	174	29
5303	Determine Home Range Size and Habitat Use of the Sherman's Fox Squirrel Statewide	Sherman's Fox Squirrel	Such research has been conducted in some areas, but information is needed from throughout their range in Florida	24	24
5304	Experimentally Introduce Sand-swimming Reptile Species into Manmade Scrubs	Bluetail Mole Skink, Sand Skink, Peninsula Crowned Snake	Determine feasibility of introducing these taxa into manmade scrubs created by mining, logging, or overgrazing	100	34
5305	Experimentally Introduce the Florida Scrub Lizard into Manmade Scrubs	Florida Scrub Lizard	Determine feasibility of introducing this taxon into manmade scrubs created by mining, logging, or overgrazing	25	25
5306	Experimentally Introduce the Florida Mouse into Manmade Scrubs	Florida Mouse	Determine feasibility of introducing this taxon into manmade scrubs created by mining, logging, or overgrazing	23	23
Education					
6201	Educate the Public and Landowners about Scrub Endemism	Sand Skink, Bluetail Mole Skink, Peninsula Crowned Snake, Florida Scrub-jay, Florida Scrub Lizard	Continue using the OIS and education specialists to inform the public about the uniqueness of scrub habitat and its many endemic taxa; solicit public support for the proposed Lake Wales Ridge NWR	158	32
6202	Develop an Internet Website Containing the Distribution of Gopher Tortoise Populations Infected with Upper Respiratory Tract Disease	Gopher Tortoise	Data on the distribution of URTD-infected tortoise populations have been published, but a website would provide greater dissemination of the information to the public, including consultants	27	27
6301	Encourage Xeriscaping and Retention of Native Scrub Vegetation in Residential Communities	Sand Skink, Peninsula Crowned Snake, Bluetail Mole Skink, Short-tailed Snake, Florida Scrub-jay, Florida Scrub Lizard	Encourage retention of and landscaping with native vegetation to benefit taxa able to survive in low-density residential developments in scrub habitat; suburbs may be sinks for some scrub-jay populations but provide needed connectivity among populations	188	31

Habitat Protection

7201	Develop a Program to Provide Landowners with Economic Incentives to Preserve Xeric Uplands	All Target Taxa	Xeric uplands are prime sites for residential development and citrus agriculture; incentives are needed for private landowners to preserve and properly manage these uplands	640	24

Species Management

9101	Develop a Comprehensive Wildlife Management and Monitoring Program for FWC-managed Scrub Parcels of the Lake Wales Ridge Ecosystem Project	Bluetail Mole Skink, Sand Skink, Florida Scrub Lizard, Gopher Tortoise, Florida Gopher Frog, Short-tailed Snake, Eastern Indigo Snake, Florida Pine Snake, Peninsula Crowned Snake, Florida Mouse, Florida Scrub-jay	Develop wildlife management programs (first priority should be given to WMAs, such as Lake Arbuckle) focused on the conservation of priority taxa; synthesize management profiles for priority taxa based on existing management literature; ensure that priority taxa distributions are maintained or extended and population densities are maintained or increased; develop and implement wildlife management plan and monitoring program to detect taxa responses; assess management effects and revise and/or refine the management plan to enhance priority taxa	311	28
9102	Develop a Statewide Management Plan for the Gopher Tortoise	Gopher Tortoise	The FWC is currently developing a management plan and looking at the listing status for the gopher tortoise; relocation of tortoises from areas being developed is a questionable option due to the problem of disease transmission and lack of suitable, unoccupied habitat	27	27
9103	Develop a Policy for Relocating and Transplanting the Florida Scrub-jay	Florida Scrub-jay	Develop a biologically sound policy to address future needs/requests to relocate or transplant Florida scrub-jays	33	33
9104	Develop Guidelines to Protect Florida Scrub-jay Habitat and Nesting Territories	Florida Scrub-jay	The FWC and USFWS should coordinate and develop guidelines to protect scrub-jay habitat and nesting territories; take of scrub-jay habitat is currently allowed to proceed without regulation or enforcement	33	33
9201	Develop Scrub Management Plans to Benefit the Florida Scrub-jay on WMAs	Florida Scrub-jay	Develop and implement management plans for Florida scrub-jays on WMAs	33	33
9202	Provide Management Assistance to Scrub Landowners	All Scrub Taxa	Private landowners might need assistance to manage scrub habitat properly; infrequent, prescribed burning is preferable but often not feasible due to the "fire-fighting" properties of the vegetation and smoke concerns; mechanical treatment is a possible alternative	461	26
9301	Develop Design Criteria for Construction of Sandhill Amphibian Breeding Ponds	Florida Gopher frog, Striped Newt, Barking Treefrog, Eastern Tiger Salamander, Mole Salamander, Oak Toad, Ornate Chorus Frog	Characterize physical parameters (e.g., water depth, dimensions, hydroperiod, substrate) of ephemeral ponds used by breeding sandhill amphibian species; develop techniques for constructing suitable amphibian breeding ponds	145	21

9302	Develop Scrub Management Plans to Benefit Protected Skink Species on WMAs	Sand Skink, Bluetail Mole Skink	Develop management plans to create or maintain ideal habitat conditions for these 2 species, which apparently prefer open, sandy areas free of rooted vegetation and with some leaf litter; populations may be higher in areas with longer fire-return intervals.	68	34
9303	Develop Scrub Management Plans to Benefit the Florida Mouse on WMAs	Florida Mouse	Develop management plans to create or maintain ideal habitat conditions for the Florida mouse, which benefits from fire in oak scrub every 8–20 years (like the scrub-jay) and apparently benefits from the open areas created by roller chopping, especially when combined with fire.	23	23

INTERIOR DRY PRAIRIE AND ASSOCIATED COMMUNITIES

Systematics and Taxonomy

1301	Review the Taxonomy of the Florida Sandhill Crane in Florida	Florida Sandhill Crane	A DNA-based study is needed to better understand its taxonomy in relation to other crane populations, especially sedentary southern populations such as the Mississippi and Cuban sandhills	27	27
1302	Review the Taxonomy of the Short-tailed Hawk	Short-tailed Hawk	Florida birds may be distinct from Mexican birds, but this has not been studied using modern genetic techniques; the results may impact Florida's stewardship role for a potentially distinct taxon	36	36

Distributional Survey

3101	Identify Areas of Potential Habitat for the Florida Grasshopper Sparrow and Continue Distributional Surveys	Florida Grasshopper Sparrow	Use Landsat satellite data and coordinates of locations currently occupied to search for similar prairie habitat; map areas of potential habitat >100 ha in size; identify and contact landowners; conduct surveys in areas identified as potential habitat to locate other populations	38	38
3102	Map the Distribution of Florida Sandhill Crane Habitat	Florida Sandhill Crane	Use GIS technology to determine where the proper mix of upland & wetland habitats occur that represents good crane habitat; use this map, Breeding Bird Atlas data, and aerial survey sampling to develop a population estimate	27	27
3103	Survey the Distribution of the Short-tailed Hawk	Short-tailed Hawk	Locate nest sites in addition to the 30- 40 known territories of this little-known, semi-endemic species	36	36
3104	Determine the Distribution and Status of the Limpkin	Limpkin	Compile historical data (e.g., CBC, BBS, BBA); identify distribution of areas and habitats that represent good limpkin habitat; survey all or selected areas, possibly using call counts; determine distribution and population estimate	24	24

3201	Identify Important Wintering Areas for the Henslow's Sparrow on Public Lands	Henslow's Sparrow	Conduct surveys along transects in grasslands (perhaps using Project Prairie Bird protocol) on public lands to determine use by overwintering birds; monitor use with mist-net stations	23	23
Population Monitoring					
4101	Monitor Populations of Target Avian Taxa on Public Lands	Crested Caracara, Florida Sandhill Crane, Florida Grasshopper Sparrow, Florida Mottled Duck, Short-tailed Hawk	Monitor avian populations at 5-year intervals on WMAs, state parks, and federal lands containing dry prairie habitat; determine avian population responses to habitat management practices, such as prescribed fire	156	31
4102	Monitor Movements, Nesting, and Productivity of the Experimental Population of the Whooping Crane	Whooping Crane	Continued intensive monitoring of the experimental, nonmigratory crane population is needed to ensure its survival; successful fledging of wild-hatched birds has not yet occurred	45	45
4201	Monitor Population Status and Trends of the Florida Grasshopper Sparrow on Protected Lands	Florida Grasshopper Sparrow	Continue point-count surveys at Avon Park AFR, Three Lakes WMA, and Kissimmee Prairie State Preserve; monitor population trends over time and in relation to post-burn	38	38
Research					
5101	Determine Survival and Recruitment Rates of Juvenile Crested Caracaras	Crested Caracara	Increase knowledge of life history to assess population trends and management efforts	38	38
5102	Study the Life History of the Short-tailed Hawk Using Radiotelemetry	Short-tailed Hawk	Gather life history data; determine territory occupancy	36	36
5103	Reintroduce an Experimental Migratory Population of the Whooping Crane	Whooping Crane	Establish a population of whooping cranes that will nest in Wisconsin and winter in Florida	45	45
5104	Determine Factors Influencing Reproduction and Juvenile Survival of the Florida Grasshopper Sparrow	Florida Grasshopper Sparrow	Monitor nests to determine causes of nest failure; radio-instrument juveniles to determine causes of mortality	38	38
5105	Study the Impacts of Lake/Wetland Restoration on Nesting Snail Kites	Snail Kite	Assess the impacts of lake drawdowns for fishery and lake vegetation management on snail kite productivity	45	45
5106	Study the Ecology and Habitat Use of the South Florida Rainbow Snake	South Florida Rainbow Snake	Determine the continued existence of the taxon at Fisheating Creek; then determine food habits, habitat use, and movements	26	26
5201	Study the Impacts of Coyotes on the Florida Sandhill Crane	Florida Sandhill Crane	Evaluate the increasing coyote population as a potential limiting factor on crane populations	27	27
5202	Compare Habitat Values and Functions of Native Prairie vs. Tame-grass Pasture	Prairie	Determine differences in carrying capacity and natural function between native prairie and tame-grass pasture	NA	NA
5203	Identify Major Prairie Ecosystem Processes and Their Management Implications	Prairie	Identify the major ecosystem processes (fire, water regimes, herbivory, etc.) of the prairie; develop management guidelines	NA	NA

5204	Study the Role of Livestock Grazing and Prescribed Fire in Managing Prairie Wetlands	Prairie	Determine effects of fire and grazing on prairie wetlands; develop management recommendations for these habitats	NA	NA
5205	Study the Effects of Grazing on Florida Grasshopper Sparrow Population Dynamics and Reproductive Success	Florida Grasshopper Sparrow	Determine the effects of grazing; develop management recommendations based on findings	38	38
5206	Study the Winter Ecology and Habitat Use of the Florida Grasshopper Sparrow	Florida Grasshopper Sparrow	Recent research projects have identified sparrow breeding habitat characteristics, but little is known of the wintering habitat requirements; conduct surveys along transects in grasslands (perhaps using Project Prairie Bird protocol) on public lands to determine use by overwintering birds; monitor use with mist-net stations	38	38
5207	Determine Nesting Habitat Requirements of the Limpkin	Limpkin		24	24
5208	Assess Value and Management of Cattails for Marsh-nesting Bird Species	Snail Kite, Green Heron, Least Bittern, Purple Gallinule, Red-winged Blackbird	Cattail occurs naturally and as an invasive aquatic weed in areas of nutrient enrichment in Florida, where it is used for nesting by waterbirds and songbirds (including low-ranking species such as the common moorhen, boat-tailed grackle, and long-billed marsh wren), and in dry years, by snail kites; elimination of cattail for fisheries and recreation management may be needed to maintain natural wetland functions in areas where it is not native, but this may be at odds with kite conservation (at least in some years) and may adversely impact other marsh-nesting species	127	25
Education					
6201	Develop a Public Education Campaign on the Florida Prairie Ecosystem	All Target Taxa	Develop public education programs similar to those done for scrub communities to make the public aware of the qualities and values of prairie habitat; inform citizens and county governments using a nontechnical format on how to conserve prairies	675	26
6201	Annually Educate the Public to Inform/Remind Farmers to Plow Peanuts Under After Harvest	Florida Sandhill Crane, Greater Sandhill Crane	Develop an annual, recurring education program to help avert aflatoxin poisoning	46	23
6202	Develop and Implement a Nuisance Sandhill Crane Management Program	Florida Sandhill Crane, Greater Sandhill Crane	Develop public education tools on how to deal with sandhill cranes that threaten crops	46	23

Habitat Protection

7101	Develop Private Landowner Habitat Protection Incentives	Prairie	Determine the cost/benefit ratio of conversion of native prairie to pasture; develop habitat protection incentives for private landowners; develop constructive relationship with private landowners; encourage landowners to maintain suitable grasshopper sparrow habitat by regular burning and establishing levels of grazing conducive to sparrow welfare	NA	NA
7102	Develop Prairie Restoration Techniques	Prairie	Develop techniques for restoring modified or highly disturbed prairies	NA	NA
7201	Identify Areas for Dry Prairie Restoration	Prairie	Identify areas, especially on managed public lands, that fall within the historical dry prairie region and eliminate pine plantations and encroaching pines and oaks; prioritize areas that are within or adjacent to established Florida grasshopper sparrow populations.	NA	NA
7202	Determine Protection Status of Prairie Habitat Areas Important to Target Taxa	All Target Taxa	Determine land ownership and degree of vulnerability of habitat areas important to target taxa; develop land acquisition/protection recommendations	675	26
7203	Promote Interagency Coordination of Habitat Protection for Prairie Wetlands	Florida Mottled Duck, Whooping Crane, Florida Sandhill Crane, Greater Sandhill Crane, Limpkin, Florida Gopher Frog, Oak Toad, South Florida Swamp Snake, Florida Chorus Frog, Florida Mud Turtle, Florida Chicken Turtle, Barking Treefrog	Devise and negotiate an interagency agreement to improve South Florida Water Management District mitigation procedures for loss of prairie wetlands	268	22
7301	Control Expansion of Prairie Hammocks	Prairie	Run hot, fast fires into prairie hammocks; most hammocks have greatly expanded due to years of fire exclusion and winter burning.	NA	NA

Species Management

9101	Develop Habitat Management Recommendations for the Crested Caracara	Crested Caracara	Develop habitat management recommendations for caracaras and disseminate to public agencies and ranch owners	38	38
9102	Manage Protected Lands for the Crested Caracara	Crested Caracara	Determine if caracaras are using protected lands and, if not, how they could be better managed for them; maintain dry prairie and open pastures on public lands	38	38
9103	Develop Management Plans for Florida Grasshopper Sparrow Habitat on Public Lands	Florida Grasshopper Sparrow	Develop burning and mechanical habitat management prescriptions for grasshopper sparrow populations on Three Lakes WMA; maintain low scrub pastures to the extent possible on Avon Park Air Force Range; prescribe burn on public lands at 2–3 year intervals; assess effects of management practices through population monitoring on public lands	38	38

9104	Control Exotic Vegetation	Florida Grasshopper Sparrow	Cogongrass becomes established very easily in dry prairie; grasshopper sparrows cannot utilize areas with cogongrass or areas with herbicide-killed cogongrass.	38	38
9105	Develop Best Management Practices for Dry Prairie Habitat	Prairie	Develop specific guidelines for landowners to properly manage dry prairie habitat, including fire frequency and timing, mechanical treatment methods, grazing density, and prairie hammock and wetland protection.	NA	NA
9201	Develop Translocation Methodology for the Florida Grasshopper Sparrow	Florida Grasshopper Sparrow	Determine the feasibility and develop methodology for translocating the Florida grasshopper sparrow to establish new populations in vacant suitable habitat	38	38
9202	Reduce Effects of Predation on the Experimental Nonmigratory Population of the Whooping Crane	Whooping Crane	Bobcat predation is a major source of mortality in the experimental population; mortality from predation needs to be minimized for successful recruitment	45	45
SOUTH FLORIDA ROCKLANDS					
Systematics and Taxonomy					
1301	Review the Current Taxonomy of the Key Largo Cotton Mouse	Key Largo Cotton Mouse	Determine the systematic validity of the Key Largo cotton mouse	26	26
Distributional Survey					
3101	Document the Approximate Distribution and Population Size of Established Exotic Lizard Species in South Florida	Exotic Lizard Species	Determine the present geographic range, approximate population size, and habitat use of established exotic lizard species in South Florida in order to permit future determinations of population trends, range expansion, and wildlife threats	NA	NA
3201	Survey the Herpetofauna of Southern Dade County's Pine Rocklands	Rim Rock Crowned Snake, Eastern Indigo Snake, Eastern Diamondback Rattlesnake, Florida Scarlet Snake, Florida Box Turtle, Florida Chorus Frog, Oak Toad	Drift-fence surveys are needed of the fragmented tracts of pine rockland habitat in Dade County in order to document the presence of rare taxa and to determine the minimum island size needed to sustain viable populations of various species; time-constrained searches by FWC biologists yielded inadequate species lists	163	23
3202	Survey the Herpetofauna of Rockland Hammocks in the Keys	Rim Rock Crowned Snake; Key Ringneck Snake; Eastern Indigo Snake; Eastern Diamondback Rattlesnake; Florida Box Turtle; Oak Toad; Lower Keys Populations of the Florida Brown Snake, Red Rat Snake, Peninsula Ribbon Snake, and Striped Mud Turtle	Drift-fence surveys are needed to compile comprehensive lists of various tracts of rockland hammock habitat in the Keys and to determine the effect of habitat fragmentation on species composition	155	26

3301	Survey the Herpetofauna of Pine Rocklands in the National Key Deer Refuge	Rim Rock Crowned Snake, Key Ringneck Snake; Eastern Indigo Snake; Eastern Diamondback Rattlesnake; Florida Scarlet Snake; Florida Box Turtle; Oak Toad; Lower Keys Populations of the Florida Brown Snake, Red Rat Snake, Peninsula Ribbon Snake, and Striped Mud Turtle	Conduct a drift-fence survey to determine the presence, relative abundance, and habitat preferences of herpetofaunal species in protected pine rocklands in the NWR; evaluate impacts of habitat management practices for the Key deer on herpetofaunal populations	176	25

Population Monitoring

4201	Conduct Long-term Population Monitoring of the Key Largo Woodrat and Key Largo Cotton Mouse	Key Largo Woodrat, Key Largo Cotton Mouse	Conduct population surveys of Key Largo woodrats and cotton mice at 3-year intervals at selected sites to detect trends in population sizes	56	28

Research

5101	Study the Effects of Habitat Alteration on the Key Largo Woodrat and Key Largo Cotton Mouse	Key Largo Woodrat, Key Largo Cotton Mouse	Examine the impacts of habitat fragmentation, increased edge disturbance, and domestic and non-native animals on populations of Key Largo woodrats and cotton mice	56	28
5301	Study the Ecological Impacts of Introduced Plants and Their Removal on Rockland Hammock Vertebrates	Eastern Indigo Snake, Rim Rock Crowned Snake, Key Ringneck Snake, Florida Box Turtle, Key Largo Woodrat, Key Largo Cotton Mouse, White-crowned Pigeon	Invasive plant species are a problem in South Florida hammocks, especially disturbed ones, and may impact some vertebrate species by changing the vegetative structure or affecting their food supply; however, the massive disturbance associated with vegetative control efforts may also be detrimental	197	28
5302	Study the Effects of Different Fire Regimes on Pine Rockland Herpetofauna	Rim Rock Crowned Snake, Key Ringneck Snake, Eastern Indigo Snake, Eastern Diamondback Rattlesnake, Florida Box Turtle, Florida Scarlet Snake, Oak Toad, Florida Chorus Frog	Conduct research on the effects of fire frequency on the herpetofauna of pine rocklands in National Key Deer Refuge, ENP, and/or Dade County parks	193	24
5303	Determine Dispersal and Recruitment Patterns of the Key Deer	Key Deer	Determine reproductive and survival rates of deer on various keys and movements of deer among keys	43	43
5304	Experimentally Develop Open-area Disturbed Sites for Nutrient Supplementation of the Key Deer	Key Deer	Conduct research on the effects of chopping, fertilizing, and burning patches of pine rocklands to provide nutritional browse for Key deer	43	43

Education

6201	Develop Interagency Cooperative Education Project on the Importance of Coastal Rockland Habitats to Migratory Bird Species	Declining Neotropical Migrant Songbirds, Migrant Raptors	Educate the public, developers, and county planners on the importance of forested coastal tracts in southern Dade County and the Florida Keys to migratory birds, focusing on songbirds and raptors	704	14

6301	Develop Public Education Program to Minimize Human Interactions with the Key Deer	Key Deer	Educate the public on the importance of not feeding Key deer and attracting them to populated areas where they are more prone to highway mortality and nutritional problems	43	43
6302	Develop Public Education Campaign to Encourage the Use and Protection of Tropical Hardwood Trees Vital to the White-crowned Pigeon	White-crowned Pigeon	Educate the public on the importance of preserving and planting native fruit-producing trees in suburban areas because certain tree species are important for successful nesting by white-crowned pigeons	30	30
Species Management					
9201	Enhance the Distribution and Availability of Freshwater Sources for the Key Deer	Key Deer	Clean out detritus from existing wetlands and establish plastic guzzlers on Keys with limited fresh water in order to expand the range of Key deer during the dry season	43	43
9301	Enhance Key Largo Woodrat Populations Using Rubble Piles	Key Largo Woodrat	Determine effects on Key Largo woodrat populations of providing rock rubble in suboptimal habitats with limited natural refugia	30	30
9302	Develop a Management Plan for the Striped Mud Turtle in the Lower Keys	Lower Keys Population of the Striped Mud Turtle	Mud turtle populations are being impacted by the loss of freshwater wetlands, including the filling in of mosquito ditches to reduce mortality of Key deer fawns; a management plan would help ensure the continued survival of turtle populations	NA	NA
9303	Develop a Management Plan for the Key Largo Woodrat	Key Largo Woodrat		30	30
9304	Develop a Management Plan for the Key Largo Cotton Mouse	Key Largo Cotton Mouse		26	26
NORTH FLORIDA STREAMS AND WETLANDS					
Systematics and Taxonomy					
1101	Describe New Species of Sirens	Undescribed Lesser Siren, Undescribed Greater Siren, Undescribed "Least" Siren	Prepare a scientific paper describing 3 new species of sirens from the Panhandle that are currently considered lesser sirens	24	12
1201	Review the Current Taxonomy of the Shoal Bass	Shoal Bass	Determine the taxonomic status of this taxon	41	41
1202	Review the Current Taxonomy of the Grayfin Redhorse	Grayfin Redhorse	Determine the taxonomic status of this taxon	22	22
1301	Review the Current Taxonomy of the Suwannee Cooter	Suwannee Cooter	Evaluate taxonomic validity of species status and if warranted, re-rank the taxon (see Seidel 1994)	30	30

Distributional Survey

3101	Survey for Winter-breeding Amphibian Species Using Ponds on Public Lands	Ornate Chorus Frog, Florida Gopher Frog, Flatwoods Salamander, Eastern Tiger Salamander, Mole Salamander, Striped Newt	Conduct call counts, dipnetting surveys, and/or drift-fence surveys for high-ranking, winter-breeding amphibian species on public lands	128	21
3102	Survey the Distribution of the Shoal Bass in the Chipola River	Shoal Bass	Determine population numbers and identify new localities	41	41
3103	Survey the Distribution of the Crystal Darter	Crystal Darter	Survey suitable habitats in the Escambia River to determine whether it is extant in Florida and if so, determine its distribution	34	34
3104	Survey Fish Communities Occupying Low-gradient Streams and Backwaters in the Escambia River Drainage	Crystal Darter, Cypress Minnow, Goldstripe Darter, Harlequin Darter, Bluenose Shiner	Determine sites that are critical for these taxa within lowland habitats throughout the Escambia River Drainage	128	26
3105	Identify Critical Habitats for Rare Amphibian Species on Public Lands	Florida Bog Frog, Pine Barrens Treefrog, Four-toed Salamander, Apalachicola Dusky Salamander	Locate rare or narrowly distributed habitats on public lands that are used by target amphibian taxa; determine relative abundance of species using these habitats	92	23
3106	Identify Critical Areas for Rare Fish Taxa	All Biologically Vulnerable Fish Taxa	Identify areas that are critical to the survival of fish taxa in northern Florida with biological scores $\geq$17	758	25
3201	Survey Amphibian Communities Utilizing Hillside and Stream Seepage Bogs in the Panhandle	Pine Barrens Treefrog, Florida Bog Frog, Four-toed Salamander	Use drift-fence trapping to determine composition relative abundance of herpetofaunal species using hillside and seepage bogs and streamside bogs in the Panhandle	72	24
3202	Survey for the Flatwoods Salamander on Private Lands	Flatwoods Salamander	Survey private forest lands for the species by dipnetting ponds for larva	21	21
3203	Survey the Distribution of the Harlequin Darter	Harlequin Darter	Survey floodplain, low-gradient creeks in the Escambia River to identify new localities, determine the extent of the range, and the relative abundance throughout the range	27	27
3204	Survey the Distribution of the Florida Bog Frog in Walton County	Florida Bog Frog	Determine status of Walton County populations	26	26
3205	Survey the Distribution of the Diamondback Water Snake in Florida	Diamondback Water Snake	There is a museum record of this species from the Escambia River	NA	NA
3301	Survey for the Alligator Snapping Turtle in the Big Bend Region	Alligator Snapping Turtle	Survey for the species between the Steinhatchee and Wakulla rivers	17	17
3302	Determine the Distribution of Alabama Shad Spawning Sites	Alabama Shad	Identify sites with habitat used for spawning	26	26
3303	Survey the Distribution of the River Redhorse	River Redhorse	Determine extent of distribution and relative abundance throughout the distribution	23	23

Population Monitoring

4201	Conduct Long-term Population Monitoring of the Florida Bog Frog	Florida Bog Frog	Conduct call counts to sample known localities at 5-year intervals to determine status	26	26
4202	Conduct Long-term Population Monitoring of the Flatwoods Salamander	Flatwoods Salamander	Conduct larval dipnetting surveys at known breeding ponds at 5-year intervals to determine status	21	21
4203	Conduct a Baseline Population Survey of the Escambia Map Turtle	Escambia Map Turtle	Conduct basking counts at known localities at 10-year intervals to determine status	22	22
4301	Conduct Long-term Population Monitoring of the Pine Barrens Treefrog	Pine Barrens Treefrog	Conduct call counts to sample known localities at 10-year intervals to determine status	24	24
4302	Conduct Long-term Population Monitoring of the Barbour's Map Turtle	Barbour's Map Turtle	Conduct basking counts at known localities at 10-year intervals to determine status	28	28
4303	Conduct Long-term Population Monitoring of the Blackmouth Shiner	Blackmouth Shiner	Monitor status of species at 10-year intervals	35	35
4304	Conduct Long-term Population Monitoring of the Bluenose Shiner	Bluenose Shiner	Monitor status of species at 5-year intervals	24	24
4305	Conduct Long-term Monitoring of Fish Communities in Middle- and Upper-level Tributaries of Streams West of the Yellow River	River Redhorse, Cypress Minnow, Blackmouth Shiner, Crystal Darter, Harlequin Darter, Blacktip Shiner, Bluenose Shiner, Coastal Darter		196	24

Research

5101	Study the Effects of Forestry Practices on Amphibian Communities in the Apalachicola National Forest	Striped Newt, Flatwoods Salamander, Eastern Tiger Salamander, Mole Salamander, Ornate Chorus Frog, Barking Treefrog, Florida Gopher Frog, Oak Toad	Compare amphibian use of ephemeral wetlands and cypress dome swamps impacted by clear cutting, site preparation, or ditching versus nearby undisturbed wetlands	165	21
5102	Study the Effects of Forestry Practices on Amphibian Communities on Public Lands in the Western Panhandle	Flatwoods Salamander, Eastern Tiger Salamander, Mole Salamander, Ornate Chorus Frog, Barking Treefrog, Florida Gopher Frog, Oak Toad	Compare amphibian use of ephemeral wetlands and cypress dome swamps impacted by clear cutting, site preparation, or ditching versus nearby undisturbed wetlands on public lands, such as Blackwater River State Forest and Eglin AFB	136	19
5103	Determine Dispersal Distance of the Flatwoods Salamander from Breeding Ponds	Flatwoods Salamander		21	21
5201	Assess Aquifer Water Quality for the Georgia Blind Salamander	Georgia Blind Salamander	Determine potential for surface and groundwater pollution to impact populations	24	24
5202	Study the Ecology of the Florida Bog Frog	Florida Bog Frog	Determine reproduction, feeding, growth, movements, and habitat requirements	26	26

5203	Assess Contaminant Levels in Riverine Turtle Species	Alligator Snapping Turtle, Suwannee Cooter	Compare contaminant levels in a carnivorous and herbivorous species of turtle inhabiting large river systems	47	24
5204	Evaluate Harvest Pressure on Riverine Turtle Populations	Suwannee Cooter, Barbour's Map Turtle, Escambia Map Turtle, Alligator Snapping Turtle	Interview turtle fishermen and conduct boat counts in areas of the Panhandle where turtle harvest for food is occurring	98	24
5205	Study the Ecology of the Shoal Bass	Shoal Bass	Determine reproduction, feeding, growth, movements, and habitat requirements	41	41
5206	Study the Effects of Water Pollution on Fish Communities in Northwest Florida Streams	Okaloosa Darter, Crystal Darter, Blackmouth Shiner, Harlequin Darter, River Redhorse, Cypress Minnow, Goldstripe Darter, Blacktip Shiner, Coastal Darter		244	27
5207	Study the Effects of Forestry Practices on Fish Communities in Streams on Public Lands	All Biologically Vulnerable Fish Taxa except the Blueback Herring, Lake Eustis Minnow, and Hickory Shad		732	24
5208	Identify Causes for Declining Dusky Salamander Populations	Apalachicola Dusky Salamander, Spotted Dusky Salamander, Southern Dusky Salamander	Populations of some southern and spotted dusky salamanders have either disappeared or declined substantially despite seemingly suitable habitat	42	14
5209	Determine the Effects of Feral Hogs on Amphibian Communities in North Florida Wetlands	Flatwoods Salamander, Eastern Tiger Salamander, Mole Salamander, Striped Newt, Four-toed Salamander, Apalachicola Dusky Salamander, One-toed Amphiuma, Ornate Chorus Frog, Barking Treefrog, Florida Gopher Frog, Oak Toad, Florida Bog Frog, Pine Barrens Treefrog	Determine effects of hog disturbance of wetlands on amphibian communities in suitable WMAs in either the northern peninsula or Panhandle	275	21
5210	Conduct a Radiotelemetry Study on the Spotted Turtle	Spotted Turtle	Trap for spotted turtles and transmitter them to determine their habitat use, seasonal activity, and movements	19	19
5301	Determine the Effects of Roads and Off-road Vehicles on Amphibian Communities on Public Lands	Flatwoods Salamander, Eastern Tiger Salamander, Mole Salamander, Striped Newt, Ornate Chorus Frog, Barking Treefrog, Florida Gopher Frog	Determine amphibian highway mortality and compare reproductive success of populations using roadside ditches and adjacent borrow pits versus nearby natural wetlands; determine impacts of ORV disturbance of ephemeral wetlands	142	20
5302	Study the Ecology of the Bluenose Shiner	Bluenose Shiner	Determine reproduction, feeding, growth, movements, and habitat requirements	24	24
5303	Determine Harvest Pressure on Bluenose Shiner Populations	Bluenose Shiner	Develop recommendations to protect populations from over-harvest for the commercial pet trade	24	24
Education					
6201	Educate the Public and FWC Law Enforcement Personnel Regarding Existing Harvest Restrictions on Certain Turtle Taxa	Suwannee Cooter, Barbour's Map Turtle, Escambia Map Turtle, Alligator Snapping Turtle	Develop programs to educate the public about the necessity of catch limits; post notices at boat ramps and other public places, etc.	98	24

6301	Educate the Public Regarding the Importance of Permanent and Ephemeral Breeding Sites for Amphibians	Florida Gopher frog, Eastern Tiger Salamander, Striped Newt, Flatwoods Salamander	Determine use of those sites and habitat areas in which they occur	92	23
6302	Educate the Public Regarding Changes in Land Use and Water Quality and Their Effects on Riverine Fish Communities in Northwest Florida	Okaloosa Darter, Crystal Darter, Blackmouth Shiner, Harlequin Darter, River Redhorse, Cypress Minnow, Goldstripe Darter, Blacktip Shiner, Coastal Darter	To increase public awareness of detrimental effects of land use practices and deteriorating water quality on fish communities inhabiting Northwest Florida rivers and streams	244	27
Habitat Protection					
7101	Develop Recommendations to Protect Wetland Sites with Rare Herpetofauna	Spotted Turtle, Flatwoods Salamander, Striped Newt, One-toed Amphiuma, Apalachicola Dusky Salamander, Florida Bog Frog, Pine Barrens Treefrog (Gulf Hammock Dwarf Siren, Many-lined Salamander)	Identify areas supporting communities that include one or more robust populations of taxa with restricted ranges in Florida; develop recommendations to protect these sites	157	22
7201	Develop Recommendations to Protect Habitats with Unique Fish Communities	All Biologically Vulnerable Fish Taxa	Use survey data to identify sites with habitat critical for the long-term preservation of one, or more, fish taxa	758	25
7301	Develop Guidelines to Protect Alabama Shad Spawning Sites	Alabama Shad	Develop recommendations for protection and preservation of known spawning sites	26	26
Species Management					
9201	Develop Management Recommendations for Pine Barrens Treefrog Habitat	Pine Barrens Treefrog	Implement prescribed fire regimes to maintain hillside seepage bogs on Eglin A.F.B and Blackwater River State Forest	24	24
9202	Develop Management Recommendations for Florida Bog Frog Habitat	Florida Bog Frog	Implement prescribed fire regimes to maintain streamside bogs; prevent stream impoundment or degradation	26	26
9203	Develop Habitat Management Plans for Flatwoods Salamander Populations on Public Lands	Flatwoods Salamander	Develop habitat management plans for breeding ponds and surrounding uplands to preserve flatwoods salamander populations at known sites on public lands	21	21
9301	Develop Management Recommendations to Protect Critical Habitats for Fish Below the Jim Woodruff Dam	Shoal Bass, Grayfin Redhorse	Develop recommendations to protect critical habitats for fish below the dam on the Apalachicola River from gravel removal or ill-timed water releases	63	31
COASTAL HABITATS					
Systematics and Taxonomy					
1101	Review the Current Taxonomy of Populations of the Mink	Florida Mink, Everglades Mink, Gulf Coast Mink, Southern Mink	Evaluate taxonomic status of mink subspecies based on genetic analysis	108	27
1102	Review the Current Taxonomy of Populations of the Rice Rat	Sanibel Island Rice Rat, Key Rice Rat, (Marsh Rice Rats)	Determine taxonomic status of Florida subspecies	52	26

1103	Review the Current Taxonomy of Populations of the Cotton Rat	Insular Cotton Rat, Lower Keys Cotton Rat, Micco Cotton Rat	Determine uniqueness of various subspecies; determine degree of genetic differentiation among subspecies, especially on the Gulf Coast	62	21
1104	Review the Current Taxonomy of Populations of the Beach Mouse	Choctawhatchee Beach Mouse, St. Andrew's Beach Mouse, Anastasia Island Beach Mouse, Perdido Key Beach Mouse, Santa Rosa Beach Mouse, Southeastern Beach Mouse		190	32
1201	Review the Current Taxonomy of Endemic Populations of the Seaside Sparrow	Louisiana Seaside Sparrow, Wakulla Seaside Sparrow, Cape Sable Seaside Sparrow, Scott's Seaside Sparrow, nonbreeding races	Reevaluate Florida classification incorporating genetic data	128	26
1202	Review the Current Taxonomy of Endemic Populations of the Marsh Wren	Worthington's Marsh Wren, Marian's Marsh Wren	To determine systematic status of various marsh wren populations	53	27
<u>Survey Technique Development</u>					
2101	Develop Techniques to Accurately Survey Nest Numbers in Wading Bird Colonies	Reddish Egret, Little Blue Heron, Roseate Spoonbill, Great Egret, Great Blue Heron, Tricolored Heron, Snowy Egret, Green Heron, Glossy Ibis, White Ibis	Develop techniques to accurately count the number of nests in wading bird colonies, particularly for inconspicuous species that nest near the ground and are difficult to detect from the air	199	22
2201	Develop Survey Techniques for Breeding American Oystercatchers	American Oystercatcher	Develop methods to locate and census nesting American oystercatchers	25	25
2202	Develop Techniques for Locating Breeding Night-herons	Yellow-crowned Night-heron, Black-crowned Night-heron	Identify, test, and develop efficient method to locate nesting colonies	37	18
<u>Distributional Survey</u>					
3101	Compile Locality Records for the Mink	Everglades Mink, Florida Mink, Gulf Coast Mink, Southern Mink	Conduct a literature search and contact wildlife personnel and various natural resource agencies and groups to obtain sightings of mink in Florida; add records to the FWOS data base	108	27
3102	Combine Survey Data for the 3 Statewide Nesting Colonial Wading Bird Surveys	Reddish Egret, Little Blue Heron, Roseate Spoonbill, Great Egret, Great Blue Heron, Tricolored Heron, Snowy Egret, Green Heron, Glossy Ibis, White Ibis	By inputting the data from Nesbitt et al. (1982), comparisons can be made between the 1999 survey and the 2 previous FWC surveys to examine long-term trends in colony locations and turnover	199	22
3103	Identify Florida Nesting Range and Habitat Requirements for Coastal Arboreal Songbird Species	Gray Kingbird, Florida Prairie Warbler, Cuban Yellow Warbler, Black-whiskered Vireo	Identify areas needing protection; determine the potential for expanding the range and occurrence of these avian species by restoring/planting mangroves	105	26

3104	Conduct a Statewide Snowy Plover Survey	Cuban Snowy Plover	A statewide survey was conducted nearly 10 years ago and populations are believed to have since declined; the FWC has entered into a cooperative agreement with the USFWS to survey snowy plovers in FY 2001–2002 to obtain wintering and breeding population and distributional data	39	39
3105	Compile Sites with Vacant Habitat Suitable for Beach Mice	Beach Mice	Identify vacant habitat within the historic range of each beach mouse taxon suitable for the reintroduction or transplantation of beach mice	190	32
3106	Identify and Compile Important Neotropical Migrant Bird Concentration Areas	Declining Neotropical Migrant Birds	Document location of coastal "hotspots" for species; assess habitat quality; identify areas needing active management	671	15
3201	Identify Important Nesting, Migration, and Wintering Areas for All High-ranking Shorebird Species	Cuban Snowy Plover, Piping Plover, Sanderling, Red Knot, American Ruddy Turnstone, Whimbrel, Pectoral Sandpiper, American Oystercatcher, Wilson's Plover, Semipalmated Sandpiper, White-rumped Sandpiper	Identify important areas of concentration for all shorebird species with biological scores ≥24	307	28
3202	Survey the Distribution of the Key Rice Rat in Previously Unsurveyed Areas of the Florida Keys	Key Rice Rat	Survey suitable-looking habitat for Key rice rats in unsurveyed areas of the Keys to determine the extent of this taxon's distribution	29	29
3203	Survey the Winter Distribution of the Yellow Rail	Yellow Rail	Identify coastal wintering sites in conjunction with black rail surveys	27	27
3204	Survey the Distribution of Coastal Rail Species	Yellow Rail, Black Rail, Clapper Rail	Survey suitable habitats for rails to determine their distribution and habitat preferences in Florida	76	26
3205	Determine Distribution and Habitat Use by Adult Bald Eagles During the Non-nesting Season	Southern Bald Eagle		21	21
3206	Survey the Distribution of Breeding Night-herons	Yellow-crowned Night-heron, Black-crowned Night-heron	Determine current breeding distribution; identify important use areas	37	18
3207	Investigate Status and Distribution of the Painted Bunting	Painted Bunting		20	20
3208	Survey the Breeding Distribution and Population Trend of the American Oystercatcher	American Oystercatcher	Summarize available information from literature; determine key nesting areas; determine protection and management strategies	25	25
3209	Survey the Distribution of the Crocodile on the Southwestern Gulf Coast	American Crocodile	Survey for crocodiles from Flamingo north to Naples, especially the Ten Thousand Islands	30	30

3210	Survey the Distribution of the Marsh Brown Snake	Marsh Brown Snake	This taxon is apparently restricted in Florida to coastal marshes in Pensacola Bay, but a survey might indicate a wider distribution	21	21
3301	Identify Important Wintering Areas for the Peregrine Falcon	Arctic Peregrine Falcon	Identify important wintering areas in Florida and determine potential impacts that might affect peregrine falcons	24	24
3302	Add Distribution Records for the Seaside Sparrow and Marsh Wren to the FWOS Data Base	Louisiana Seaside Sparrow, Wakulla Seaside Sparrow Cape Sable Seaside Sparrow, Scott's Seaside Sparrow, nonbreeding races of seaside sparrows, Marian's Marsh Wren, Worthington's Marsh Wren	Add recent locality data into the FWOS data base; determine additional survey needs	182	26
Population Monitoring					
4101	Develop a Population Monitoring Plan for Tidal Marsh Wildlife	Florida Salt Marsh Vole, Lower Keys Marsh Rabbit, Florida Mink, Everglades Mink, Lower Keys Cotton Rat, Insular Cotton Rat, Gulf Coast Mink, Micco Cotton Rat, Black Rail, Yellow Rail, King Rail, Worthington's Marsh Wren, Marian's Marsh Wren, Gulf Salt Marsh Snake, Florida East Coast Terrapin, Carolina Diamondback Terrapin, Ornate Diamondback Terrapin, Mississippi Diamondback Terrapin	To determine population monitoring needs for this target group; to develop realistic schedules for accomplishing needed monitoring of taxa for which specific monitoring plans are not being developed	492	27
4102	Annually Survey Nesting Bald Eagle Territories	Southern Bald Eagle		21	21
4201	Assess the Population Status of Gulf Coast Seaside Sparrow Subspecies	Louisiana Seaside Sparrow, Wakulla Seaside Sparrow, Cape Sable Seaside Sparrow, Scott's Seaside Sparrow	Develop population monitoring program to provide baseline population data; initiate fire management plans to enhance habitat; document breeding success of seaside sparrows	110	28
4202	Periodically Survey for Nesting Wood Storks	Wood Stork		26	26
4203	Periodically Survey Nesting Colonial Wading Birds Statewide	Reddish Egret, Little Blue Heron, Roseate Spoonbill, Great Egret, Great Blue Heron, Tricolored Heron, Snowy Egret, Green Heron, Glossy Ibis, White Ibis	To monitor trends in colony occupancy and gross population size of selected species every 5 to 10 years using the same methodology; confidence intervals should be given for species estimates	199	22
4204	Periodically Monitor Size and Distribution of Colonial Seabird Breeding Colonies	Royal Tern, Least Tern, Roseate Tern, Sandwich Tern, Caspian Tern, Gull-billed Tern, Sooty Tern, Black Skimmer	Conduct routine monitoring of nesting colonies of gulls, terns, and black skimmers using the timing interval recommendations for monitoring breeding shorebirds (Task 4302)	159	20
4205	Conduct Migration Counts at Key	Declining Neotropical Mi-	Document importance of Florida to mi-	671	15

	Migratory Bird Concentration and Wintering Sites	grant Birds	grant and wintering populations; test feasibility of monitoring using BBS methods and routes		
4206	Monitor Status and Trends of Coastal Arboreal Songbird Populations	Coastal Arboreal Songbirds	To monitor trends in songbird numbers in selected tidal swamp sites	105	26
4207	Monitor Populations of the Key Rice Rat	Key Rice Rat	Periodically monitor all known populations of the Key rice rat via trapping	29	29
4301	Monitor Populations of the Atlantic Salt Marsh Snake	Atlantic Salt Marsh Snake	Census populations of subspecies and compare with past results; characterize habitat use in terms of vegetation and salinity; examine captured specimens for phenotypic characteristics	37	37
4302	Develop a Monitoring Plan for Breeding Shorebird Species	Cuban Snowy Plover, American Oystercatcher, Wilson's Plover, Black-necked Stilt, Willet	To determine the need and approach for monitoring populations of breeding shorebirds; to develop a schedule for monitoring	115	23
Research					
5201	Determine Endemic Seaside Sparrow Nest Failure Rate and Causes	Louisiana Seaside Sparrow, Scott's Seaside Sparrow, Wakulla Seaside Sparrow	Determine amount of nest loss of seaside sparrows to nest predators; relate nest loss to habitat type; determine if nest loss is due to improper habitat management	73	24
5202	Study the Life History of the Cuban Snowy Plover	Cuban Snowy Plover	Determine habitat use during breeding and nonbreeding periods; monitor reproductive success and nesting population size at a sample of locations	35	35
5203	Determine the Impacts of Towers on Neotropical Migrant Birds	Declining Neotropical Migrant Birds	Assess the distribution and magnitude of the mortality of migrant birds from collisions with towers; work with the industry and the FAA to find lighting designs that minimize mortality and to encourage co-location of towers	671	15
5204	Determine the Impacts of Mosquito Control Programs on Neotropical Migrant Birds	Declining Neotropical Migrant Birds	Assess the impacts of mosquito control programs on the distribution and abundance of insectivorous migrant birds	671	15
5205	Investigate Factors Affecting the Productivity of Wading Bird Colonies	Reddish Egret, Roseate Spoonbill, Little Blue Heron, Yellow-crowned Night-heron, Wood Stork, Great Egret, Great Blue Heron, Tricolored Heron, Snowy Egret, Green Heron, Glossy Ibis, White Ibis	Determine the factors that limit the reproductive success and annual recruitment into colonial wading bird populations	253	21
5206	Study Beach and Cotton Mouse Habitat Use Patterns on Barrier Islands	Choctawhatchee Beach Mouse, St. Andrew's Beach Mouse, Anastasia Island Beach Mouse, Perdido Key Beach Mouse, Santa Rosa Beach Mouse, Southeastern Beach Mouse, Insular Cotton Rat, Micco Cotton Rat	Determine habitat requirements of beach and cotton mice along coastal strands; determine changes in habitat requirements with seasonal and population levels	229	29

5207	Determine the Effects of Land Development on Local Beach Mouse Populations	Choctawhatchee Beach Mouse, St. Andrew's Beach Mouse, Anastasia Island Beach Mouse, Perdido Key Beach Mouse, Santa Rosa Beach Mouse, Southeastern Beach Mouse	Where development occurs, monitor populations to identify declines and reasons	190	32
5208	Study Beach Mouse Food Habits on Barrier Islands	Choctawhatchee Beach Mouse, St. Andrew's Beach Mouse, Anastasia Island Beach Mouse, Perdido Key Beach Mouse, Santa Rosa Beach Mouse, Southeastern Beach Mouse	Determine feeding habits and requirements of beach mice	190	32
5209	Study the Population Biology of Migrant and Wintering Peregrine Falcons	Peregrine Falcon	Determine sex and age ratios of wintering peregrine falcon populations in Florida; determine habitat use of wintering Florida peregrines; determine movement patterns of wintering Florida peregrines	24	24
5210	Determine the Effects of Prescribed Fire on Tidal Marsh Wildlife	Atlantic Salt Marsh Snake, Gulf Salt Marsh Snake, Mangrove Salt Marsh Snake, Black Rail, Florida Salt Marsh Vole, Florida Mink	Determine need for burning to maintain herbaceous habitat, especially ecotones; determine effects of burning on specific tidal marsh taxa; if burning is useful, identify guidelines for burning	177	29
5301	Determine the Extent and Effects of Cowbird Nest Parasitism on Coastal Arboreal Songbird Population	Gray Kingbird, Florida Prairie Warbler, Cuban Yellow Warbler, Black-whiskered Vireo	Assess the current distribution of cowbirds in this plant community; assess the extent of parasitism problems (geographic and taxonomic); predict likely impacts on affected taxa; develop reasonable management recommendations	105	26
5302	Determine the Relative Productivity of Roof-nesting Shorebird Species	Least Tern, Royal Tern, Roseate Tern, Black Skimmer, American Oystercatcher	Determine proportion of young raised on roofs that survive to reproduce; identify limitations on productivity on roofs	111	22
5303	Investigate Nesting Colony Fidelity of Wading Birds	Reddish Egret, Roseate Spoonbill, Little Blue Heron, Yellow-crowned Night-heron, Wood Stork, Great Egret, Great Blue Heron, Tricolored Heron, Snowy Egret, Green Heron, Glossy Ibis, White Ibis	Investigate whether individual wading birds always nest in the same colony and whether fledged birds return to their natal colony; determine distances that birds will move to nest in other colonies under various ecological conditions	253	21
Education					
6101	Develop an Educational Program on Shorebirds and Marine Birds	Shorebirds, Common Loon	Educate public about impacts of human disturbance on nesting shorebird colonies and wintering aggregations of shorebirds and loons	508	24
6102	Respond to Information Requests on Bald Eagle Nest Territories and Provide Technical Assistance for Habitat Management	Southern Bald Eagle	Provide the public with information on how to deal with bald eagles that nest near human dwellings or in areas scheduled for development	21	21
6201	Develop a Beach and Dune Wildlife Education Program	Nesting Sea Turtles, Beach Mice, Coastal Dunes Crowned Snake, Cedar Key Mole Skink	Educate public about types of non-marine wildlife inhabiting beaches/dunes; identify actions public can take to conserve species	357	30

Habitat Protection					
7201	Initiate Cooperative Participation with Other Agencies in the Review of Development/Actions Impacting Tidal Marsh and Coastal Grasslands	Tidal Marsh and Grassland Taxa	Become active in development review for identified critical coastal marshes	1222	25
7202	Develop Guidelines to Protect Important Shorebird Areas	Wintering Shorebirds, Breeding Shorebirds	Develop specific management plans for concentration sites for shorebirds while wintering, breeding, or migrating; develop cooperative management arrangements with land owners, managers, etc.	503	24
7203	Restore and Acquire Coastal Hammocks to Benefit Neotropical Migrant Birds	Declining Neotropical Migrant Birds	Restore native coastal upland habitats (e.g., maritime hammock) that are important to migrants on public lands	671	15
7204	Initiate Cooperative Participation with Other Agencies in the Review of Development Plans in Migrant Bird Concentration Areas	Declining Neotropical Migrants, Shorebirds, Peregrine Falcon	Coordinate with other agencies to help reduce the impact of human developments in coastal areas and habitats important to migrating birds	1198	18
7301	Protect Atlantic Coastal Ridge Scrub Habitat Within the Range of the Coastal Dunes Crowned Snake	Coastal Dunes Crowned Snake, Gopher Tortoise, Eastern Indigo Snake, Florida Pine Snake, Eastern Diamondback Rattlesnake, Florida Scrub Lizard, Peninsula Mole Skink, Florida Gopher Frog, Florida Scrub-jay	This subspecies of the crowned snake has a limited distribution and occurs in prime habitat for residential development; Atlantic Coastal Ridge scrub habitat has already been seriously fragmented; habitat protection will benefit a variety of high-ranking xeric upland species	240	27
Species Management					
9101	Develop Management Guidelines to Protect Bald Eagle Nesting Territories	Southern Bald Eagle	Assess effectiveness of Southeast region guidelines in protecting nest sites by following up on individual nest case histories; if de-listing occurs in the near future, this exercise should result in modified guidelines that will be adopted at the state level to protect nesting territories	21	21
9102	Develop Guidelines to Manage Colonial Wading Bird Colonies	Reddish Egret, Roseate Spoonbill, Little Blue Heron, Yellow-crowned Night-heron, Wood Stork, Great Egret, Great Blue Heron, Tricolored Heron, Snowy Egret, Green Heron, Glossy Ibis, White Ibis	Develop general guidelines to protect colonies; formulate management recommendations for colonies	270	22
9201	Implement Management of Important Shorebird Areas Identified in Task 7202	Shorebirds		503	24
9202	Protect and Enhance Habitat to Support Coastal Arboreal Songbird Species	Florida Prairie Warbler, Cuban Yellow Warbler, Gray Kingbird, Black-whiskered Vireo	Enhance populations through regulation of coastal development and mangrove clearing, managing habitats, and acquiring lands	107	27
9203	Develop Plans to Protect Beach Mouse Habitat on Public Lands	Beach Mice		190	32

9204	Control Exotic Plants and Animals in Beach Mouse Habitat	Anastasia Island Beach Mouse, Southeastern Beach Mouse	Develop plans to eradicate exotic vegetation from dunes and to control house mice and feral cats where they pose a threat to beach mouse populations	70	35
9205	Regulate Beach Mouse Predators in Areas with High Predator Populations and/or Limited Habitat	Beach Mice	Regulate populations of feral cats, foxes, skunks, and other predators in beach mouse habitat close to human dwellings or in habitat that has been impacted by hurricanes or beachfront development	190	32
9206	Reintroduce the St. Andrew's Beach Mouse on Cape San Blas	St. Andrew's Beach Mouse	Reestablish St. Andrew's beach mouse populations on Cape San Blas and Crooked Island; monitor populations to determine success or failure	34	34
9207	Stabilize Eroded Dunes By Planting Vegetation or Using Sand Fences	Beach Mice	Stabilize dunes that have been degraded through pedestrian or vehicular traffic or destroyed by hurricanes	190	32
9208	Determine the Significance of Anthropogenic Mortality to Diamondback Terrapin Populations	Diamondback Terrapins	Determine if incidental take by crab traps and shrimpers warrants management or regulation	153	31
9301	Develop a Coastal Wading Bird Nesting Area Protection Network	Reddish Egret, Roseate Spoonbill, Yellow-crowned Night-heron, Tricolored Heron	Determine threats to key use areas; develop and implement species and habitat management plans; designate disturbed sites as Critical Wildlife Areas	94	24
9302	Reintroduce Beach Mice into Previously Occupied Habitats	Beach Mice	Reintroduce beach mice into new dune habitat after recovery or restoration from hurricanes or other disturbances	190	32
9303	Monitor Recolonization of Beach Mice into Previously Occupied Habitats	Beach Mice	Monitor beach mouse populations that recolonize areas after eradication by hurricanes or other catastrophic events	190	32

BATS

Systematics and Taxonomy

1201	Review the Current Taxonomy of the Florida Mastiff Bat	Florida Mastiff Bat	Determine if the Florida subspecies is genetically or morphologically distinct from the Caribbean subspecies	33	33

Distributional Survey

3101	Determine the Population Status of the Southeastern Big-eared Bat	Southeastern Big-eared Bat	Determine distribution and relative abundance of southeastern big-eared bats by locating and censussing roosts	24	24
3201	Determine the Population Status of the Brazilian Free-tailed Bat	Brazilian Free-tailed Bat	Determine distribution and relative abundance of Brazilian free-tailed bats by locating and censussing roosts	19	19
3202	Determine the Population Status of the Florida Mastiff Bat	Florida Mastiff Bat	Determine distribution and relative abundance of Florida mastiff bats by locating and censussing roosts	33	33
3203	Determine the Population Status of the Big Brown Bat	Big Brown Bat	Determine distribution and relative abundance of big brown bats by locating and censussing roosts	10	10

3204	Survey the Breeding Distribution of the Jamaican Fruit Bat	Jamaican Fruit Bat	Determine if a resident breeding population of Jamaican fruit bats exists in Florida	NA	NA
Population Monitoring					
4101	Monitor Populations of the Southeastern Brown Bat in Maternity Caves	Southeastern Brown Bat	Monitor the number of southeastern brown bats using maternity caves over several years to determine patterns of use and trends in colony size	23	23
4102	Identify Summer and Winter Population Trends for the Gray Bat	Gray Bat	Identify trends in summer and winter populations of the gray bat and identify causes of any declines	31	31
4201	Determine the Population Status of Evicted Bat Colonies	Brazilian Free-tailed Bat, Southeastern Bat, Southeastern Big-eared Bat, Big Brown Bat, Evening Bat	Determine the survival, reproductive success, and roost selection of bat colonies that are evicted from roosts in buildings	91	18
4301	Estimate Population Trends for the Florida Mastiff Bat	Florida Mastiff Bat	Estimate population trends in the size of Florida mastiff bat populations	33	33
Research					
5101	Study the Breeding Biology of the Florida Mastiff Bat	Florida Mastiff Bat	Identify mating and birthing periods, maternity colony size and composition, survival and developmental rates of pups, and other basic characteristics of the breeding biology of Florida mastiff bats	33	33
5102	Study the Breeding Biology of the Southeastern Big-eared Bat	Southeastern Big-eared Bat	Identify mating and birthing periods, maternity colony size and composition, survival and developmental rates of pups, and other basic characteristics of the breeding biology of southeastern big-eared bats	24	24
5201	Compare the Reproductive Success of Southeastern Brown Bat Maternity Colonies in Various Roosts	Southeastern Brown Bat	Compare reproductive success of southeastern brown bat maternity colonies in caves, trees, and artificial structures such as buildings and culverts	23	23
5202	Characterize Florida Mastiff Bat Roosts	Florida Mastiff Bat	Characterize roosts (physical characteristics, orientation, microclimate) used by Florida mastiff bats throughout their range and identify possible disturbances or hazards to roosts or roosting bats	33	
5203	Determine the Life History Requirements of Cavity-nesting Florida Mastiff Bats	Florida Mastiff Bat	Determine habitat use and life history requirements of the Florida mastiff bat based upon a review of land cover types, land use, and other habitat features associated with known location records of the taxon	33	33
5304	Study the Roosting and Breeding Biology of the Northern Yellow Bat	Northern Yellow Bat	Characterize the roosting and breeding biology of the northern yellow bat, which is Florida’s most commonly rabid bat species and only part-time colonially roosting species	21	21

5305	Determine the Annual Incidence of Rabid Bats	Biologically Vulnerable Bats	Determine relative number and species of bats found to be rabid each year by county health departments	237	20

Education

6201	Revise Public Information Materials Regarding Bat Exclusion and Bat Houses	Southeastern Bat, Big Brown Bat, Evening Bat, Southeastern Big-eared Bat, Brazilian Free-tailed Bat	Revise public information materials that explain how to exclude bats from buildings and how to construct bat houses for use by excluded bats	91	18

Habitat Protection

7301	Prepare Guidelines to Protect Bat Roosts in Caves	Southeastern Bat, Gray Bat, Eastern Pipistrelle, Big Brown Bat	Prepare guidelines for protecting bat roosts in caves for use by land managers and recreational spelunkers	79	20

Species Management

9201	Develop Bridge Designs Favorable for Roosting Colonial Bats	Big Brown Bat, Brazilian Free-tailed Bat, Southeastern Bat, Evening Bat	Work with the Florida Department of Transportation to design bridges that can serve as roosts for colonial bats	66	17
9301	Evaluate the Effectiveness of Large Bat Houses	Brazilian Free-tailed Bat, Southeastern Bat, Southeastern Big-eared Bat, Big Brown Bat, Evening Bat	Evaluate the effect of erecting large Gainesville-style bat houses on the number of nuisance bat roosts in a community	91	18

Appendix C.

CONSERVATION PROJECT IDENTIFICATION FORM

Submit to:
Conservation Coordinator
Bureau of Wildlife Diversity Conservation
Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, FL 32399-1600

Taxon or Functional Group Name:

Conservation Plan Name:

Problem Project Addresses:

Project Type (circle one):

1. Survey Technique Development 2. Distributional Survey 3. Research

4. Population Monitoring 5. Education 6. Habitat Protection 7. Law Enforcement

8. Species Management 9. Systematic/Taxonomic

Project Title:

Project Objective(s):

Anticipated Duration of Project in Months:

Commission Regions Involved in Project:

Importance (circle one):

1. Must be completed before other work on this taxon/group

2. Important, but not necessary before other work

3. Useful, but not absolutely necessary

Ease of Completion (circle one):

1. Can be completed with existing funds and personnel

2. Will require outside (OPS or contracted) assistance

3. Will require major (>$10,000) budget increases, OCO monies, or additional positions

---

Feasibility (circle one):

1. High likelihood that this project would achieve the desired results

2. Moderate probability that this project would achieve the desired results

3. Low likelihood that this project would achieve the desired results

---

TAXA INVOLVED

List taxa this project addresses:

____

____

What is the cumulative biological score of affected taxa?:

What is the cumulative action score of affected taxa?:

If the project is completed successfully, what will be the cumulative change in biological scores?:

If the project is completed successfully, what will be the cumulative change in action scores?:

CONTRIBUTOR INFORMATION

Name:

Affiliation:

Address:

Phone: ____________________ **e-mail:** ____________________ **Date submitted:** ___/___/

This Agency does not allow
discrimination by race, color, nationality, sex, or handicap. If you
believe you have been discriminated against in any program, activity or
facility of this agency, write to:
Florida Fish and Wildlife Conservation Commission
620 S. Meridian St.,
Tallahassee, FL 32399-1600, or to
Office for Human Relations,
USFWS, Dept. of Interior,
Washington, D.C. 20240