Introduction

"The greatest tragedy in nature is the extinction of a species...where is the man who knowingly would stand by and watch a marvelous creature-harmless to man's interests, and of no intrinsic commercial value-be forced into the vortex of extirpation without even raising his voice in protest?"

James T. Tanner
The Ivory-Billed Woodpecker (1942)

On September 23, 1993, five Federal Departments and the Environmental Protection Agency signed a five-year Interagency Agreement on South Florida Ecosystem Restoration. This agreement formally established an Interagency Task Force responsible for developing consistent policies, strategies, plans, programs, and priorities for addressing the concerns of the South Florida Ecosystem. The Water Resources Development Act of 1996 created a statutory foundation for the Task Force and Working Group and expanded its membership to include wider representation from Federal, State, local, and Tribal governments. Thus, the South Florida Ecosystem Restoration Initiative was established with the following purpose: to restore and maintain the elements of the South Florida Ecosystem to resemble the natural functions of a healthy, balanced, and functioning freshwater, estuarine, and marine environment where human activities occur in a manner that supports healthy natural conditions.

The major objectives of the South Florida Ecosystem Restoration Initiative are to:

1. Restore and maintain the biodiversity of native plants and animals in the upland, wetland, estuarine, and marine communities of the South Florida Ecosystem;
2. Recover threatened and endangered species in the South Florida Ecosystem;
3. Ensure that any development plans or permits for development are fully coordinated among affected governmental agencies and are compatible with the restoration of the South Florida Ecosystem;
4. Develop and manage the hydrology of the Kissimmee River, Lake Okeechobee, the Everglades, and associated waters in a way that maximizes ecosystem restoration goals while providing appropriate consideration for the needs of urban, rural, and agricultural users;
5. Manage the hydrological conditions in the remaining undeveloped and potentially restorable lands in a way that maximizes natural processes;

6. Restore and sustain healthy ecosystem conditions in Florida Bay, adjacent estuaries, and coastal waters of the South Florida Ecosystem; and
7. Maintain the health and biodiversity of the coral reef ecosystem associated with Florida Bay, Biscayne Bay, and the Florida Keys.

The South Florida Ecosystem Restoration Initiative consists of 10 major elements: (1) the Program to Modify Water Deliveries to Everglades National Park; (2) the Canal 111 Project; (3) the Kissimmee River Restoration; (4) the Central and Southern Florida Flood Control Project Comprehensive Review Study [C&SF Restudy]; (5) a land acquisition and management program to prevent water losses along the eastern edge of the Everglades, (6) a land acquisition program to protect and manage lands in the Big Cypress Basin; (7) a recovery plan for the threatened and endangered species of the South Florida Ecosystem; (8) a comprehensive wetlands permitting and mitigation strategy to ensure that Federal and State regulatory programs re-enforce the purposes of the Restoration Initiative; (9) a comprehensive program to mitigate the effects of existing and projected population increases on water and habitat quality in the Florida Keys (called the Florida Keys Carrying Capacity Study); and (10) a program to establish compatibility between the urban and suburban areas in Palm Beach, Broward, and Miami-Dade counties and the environmental needs of South Florida.

The Multi-Species Recovery Plan has been prepared to help fulfill the first and second major objectives of the South Florida Ecosystem Restoration Initiative, and to complete one of the major elements of the initiative itself. More importantly, the Multi-Species Recovery Plan has been prepared because none of the individuals, agencies, or organizations who support the South Florida Ecosystem Restoration could envision South Florida without the species whose recovery needs are identified in the plan. South Florida cannot be considered "restored" if the song of the Cape Sable seaside sparrow has been silenced from the marl prairies of the Everglades, if clouds of wood storks no longer cover the skies over the mangrove forests of southernmost Florida, if the footprints of marsh rabbits no longer occur in the Lower Keys, or if there are no Florida scrub-jay families defending their territories on the Central Florida Ridge.

All of the projects associated with the restoration of the South Florida Ecosystem will have substantial effects on fish and wildlife resources in the South Florida Ecosystem. Conversely, the viability of these projects will be determined, in large part, by their effects on those fish and wildlife resources, particularly threatened and endangered species. The success or failure of many of these projects will determine whether several threatened or endangered species will become extinct within the next two decades. Similarly, the success or failure of these projects will determine if other species will become threatened or endangered within the same time interval.

Approach to Multi-Species Recovery Planning

The Endangered Species Act of 1973, as amended, was established to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take

such steps as may be appropriate to achieve" these purposes. The Multi-Species Recovery Plan was developed to facilitate implementation of an ecosystem approach to fish and wildlife conservation. An ecosystem approach will more efficiently and effectively enable the FWS to fulfill the mission "to conserve, protect, and enhance the Nation's fish and wildlife and their habitats for the continued benefit of the American people" (FWS 1994). This approach does not downplay the need for individual species' recovery plans; however, it does broaden the scope of recovery planning and implementation to the landscape level. An ecosystem approach to fish and wildlife conservation means protecting or restoring the function, structure, and species composition of an ecosystem, while providing for its sustainable socioeconomic use. The ESA provides the U.S. Fish and Wildlife Service and other agencies with several major tools for use in recovery planning:

1. authority to designate critical habitat for a threatened or endangered species,
2. authority to acquire land to help conserve threatened or endangered species,
3. authority to enter into cooperative agreements with, and to provide grants to, the states to conserve threatened or endangered species,
4. a requirement for Federal agencies to use their authorities to carry out programs to conserve threatened and endangered species,
5. a requirement for Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of threatened or endangered species, or destroy or adversely modify the designated critical habitat of a threatened or endangered species,
6. prohibitions against import, export, taking, or engaging in interstate or international commerce on threatened or endangered species,
7. authority to issue permits and to promulgate protective regulations that provide exemptions to the normal prohibitions associated with threatened and endangered species, and
8. authority to enforce the provisions of the ESA.

The FWS team that authored the Multi-Species Recovery Plan recognizes that these authorities are the primary tools for returning threatened and endangered species from the brink of extinction. Further, the team recognizes that there are processes associated with each of these tools and that these processes require information if they are to be used effectively. Consequently, the Multi-Species Recovery Plan was designed to (1) assist government, Tribal, academic, non-government, and private efforts to recover threatened and endangered species and restore the South Florida ecosystem, (2) support efforts to acquire land in South Florida to conserve threatened and endangered species, (3) support interagency consultations on actions in South Florida that affect threatened or endangered species, (4) support efforts to prepare habitat conservation planning in South Florida, (5) promote outreach to involve the public in species recovery and ecosystem restoration, and (6) encourage

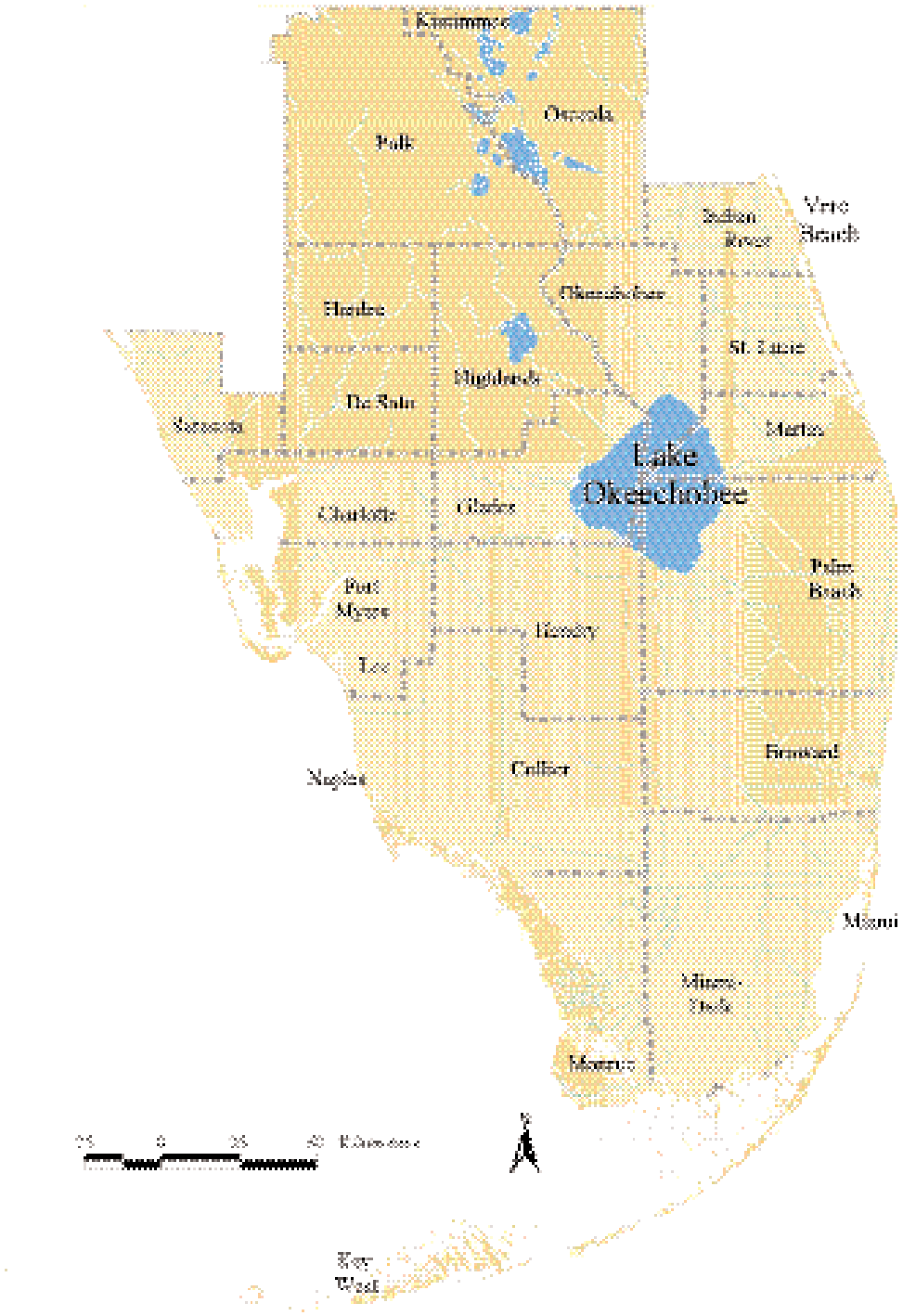
information exchange among the various Working Group efforts in South Florida.

The Multi-Species Recovery Plan achieves these purposes in three ways. First, it contains all of the available information on the distribution, abundance, biology, and ecology of 68 threatened and endangered species and 23 natural communities in South Florida in a single document. Second, the information is presented in a format that allows it to be easily transported into documents like biological opinions and environmental impact statements with little or no modification. Finally, recovery and restoration actions are presented that focus on land management activities to benefit imperiled species and their habitats. The FWS team that authored the Multi-Species Recovery Plan incorporated comments and recommendations that should improve the effectiveness of recovery planning and implementation. In the past few years, several groups have reviewed management actions that are focused on recovering threatened and endangered species. In 1995, the National Academy of Sciences published a report on science and the Endangered Species Act and made a large number of recommendations that would improve recovery planning and implementation (National Academy of Sciences 1995). In the same year, the Ecological Society of America published its recommendations on strengthening the Endangered Species Act through the use of science (Ecological Society of America 1996). In 1997, the Ecological Society of America published an article written by Schemske *et al*. (1994); although the latter article focused on recovery planning for threatened and endangered plant species, their recommendations are applicable to all threatened and endangered taxa. Tear *et al.* (1993, 1995) provided an evaluation of all FWS recovery plans. They addressed criticisms of the recovery process and provided suggestions for improving recovery efforts. The FWS team that authored the Multi-Species Recovery Plan incorporated these recommendations into the basic design of the species accounts, particularly in the design of the recovery criteria and recovery narratives (see further discussion of these changes in Recovery Objectives and Criteria).

Geographic Scope of the Multi-Species Recovery Plan

The Multi-Species Recovery Plan identifies the recovery needs of the 68 threatened and endangered species and 23 natural communities in the U.S. Fish and Wildlife Service's South Florida Ecosystem (Figure 1). The South Florida Ecosystem encompasses 67,346 square kilometers (26,002 square miles) covering the 19 southernmost counties in Florida. This region includes 51,934 square kilometers (12,833,121 acres) of land and three major watersheds: the Kissimmee River-Lake Okeechobee-Everglades watershed, the Caloosahatchee River watershed, and the Peace River/Myakka River watershed. It is important to recognize that the geographic scope of this recovery plan was defined by the FWS as the area of geographic responsibility of its South Florida Ecological Services Field Office, and is larger than the area defined by the SFWMD for South Florida restoration.

Figure 1. The South Florida Ecosystem.



The Recovery Team

The Recovery Team for the Multi-Species Recovery Plan consists of over 200 individuals who have specific expertise on the species, their ecology or management, and the threats they face (see the list of names in Appendix A). Members of the Recovery Team represent academia, Federal, State, or local agencies, conservation organizations, and private industry. The recovery team assisted with the information needed to prepare "The Species" section through a series of recovery team meetings. The information obtained during these meetings, and through direct interactions with recovery team members and others (see Appendix B), was used by FWS biologists to prepare the species accounts. The Ecological Communities section, however, was written by a smaller subset of the Recovery Team. The ecosystem team members were chosen based upon their specific expertise on the ecology of the natural communities in South Florida.

The recovery teams convened for the Multi-Species Recovery Plan have:

1. Developed and reviewed species and ecosystem accounts to ensure that they represent the best scientific and commercial information available.
2. Developed and updated recovery recommendations for individual species to ensure that the FWS incorporated the most current information on the status and trends of species and their habitat into the recovery plan.
3. Helped the FWS develop management recommendations for the various ecosystems to meet the needs of the species included in the plan.

In addition, the FWS has worked with specific members of the Recovery Team to conduct peer reviews of the plan.

Organization of the Multi-Species Recovery Plan

To prepare the Multi-Species Recovery Plan, the FWS assembled an extensive library of published and unpublished literature on the biology, ecology, distribution, abundance, status, trends, and management of the threatened and endangered species and the ecological communities in South Florida. In addition, a Geographic Information System and supporting databases on the distribution of threatened and endangered species and their habitat associations in South Florida were constructed, to the extent that these are known. The FWS has presented as much of that information as possible in this recovery plan.

To accommodate this information, the Multi-Species Recovery Plan has been organized into two major sections: "The Ecological Communities," and "The Species."

"The Ecological Communities" section provides a community/ecosystem-level perspective for maintaining biodiversity, and is what truly makes this effort a Multi-Species Recovery Plan. This section follows the chapter entitled The South Florida Ecosystem, which includes some of the major ongoing multi-agency partnerships and conservation efforts to illustrate the complexity

of ecological issues within this region of the United States. The "Ecological Communities" section consists of individual community accounts, similar in format to the species accounts, that discuss the biological composition, status, trends, management and restoration needs of 23 major ecological communities within South Florida. The accounts include recommendations on how to manage, reconstruct, or restore habitats in the South Florida Ecosystem in ways that will optimize benefits to the greatest number of listed species.

Like the species of concern, each of these communities has been assigned a status rank by the Florida Natural Areas Inventory (FNAI) as part of The Nature Conservancy's Natural Heritage Program (Table 1). Refer to Appendix H (glossary) for the definition of the global and State ranks. Some of the ecological communities are combined within one account (*i.e.*, scrub, scrubby high pine, and scrubby flatwoods), resulting in a total of 18 accounts for this section. The community accounts also address issues like habitat fragmentation that affect the quantity and quality of habitat for imperiled species in South Florida.

These accounts also integrate the needs for species of concern in addition to federally listed species. Species of concern, as defined in this recovery plan, also include species listed by the State of Florida as endangered, threatened, and species of special concern, FWS species of management concern, species ranked by FNAI as G1-G3/S1-S3 (refer to glossary for the definition of these terms), and species considered as rare by the Florida Committee on Rare and Endangered Plants and Animals (FCREPA) Refer to Appendix C for a list of these species and their occurrence by community types in South Florida. Several of the State-listed species are highlighted in each community account.

The section entitled "The Species" is a compilation of individual species accounts that summarize the biology, ecology, status, trends, management, and recovery needs of 68 South Florida species that are federally listed as threatened or endangered pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.). These species are listed in Table 2; common and scientific names follow the most current FWS list of endangered and threatened wildlife and plants (50 CFR 17.11 and 17.12).

The species accounts serve either as revisions to existing recovery plans for species endemic to South Florida, or as contributions to existing recovery plans for wide ranging species that occur in South Florida (see section on Relationship of the Multi-Species Recovery Plan to Other Recovery Plans). The first page of each account contains a status box to denote the official Federal and State listing status for each species, whether critical habitat is designated for that species, and whether the account represents a new or revised plan, or whether it is contributing information to an existing rangewide plan. A "Rangewide" designation for the "Geographic Range" category indicates that the account covers the entire range of the species. If "South Florida" is the geographic range indication, then the scope of the recovery tasks is limited to the species' range in South Florida.

Information contained in the species accounts is presented in a way designed to help biologists and resource managers who need information to manage these species. In addition, the species accounts have been organized to help construction agencies, like the South Florida Water Management District and U.S. Army Corps of Engineers, plan their projects and prepare environmental compliance

Table 1. Global and State rank summary of 23 ecological communities in South Florida (adapted from FNAI 1997). Refer to the glossary for definitions of the global and State rank designations.

COMMUNITY NAME	GLOBAL RANK	STATE RANK
High Pine	G2/G3	S2
Scrub	G2	S2
Scrubby High Pine	G2/G3	S2
Beach Dune	G4?	S2
Coastal Strand	G3?	S2
Maritime Hammock	G4	S2
Mesic Temperate Hammock	Undetermined	S3/S4
Tropical Hardwood Hammock	Undetermined	S2
Pine Rockland	G1	S1
Scrubby Flatwoods	G3	S3
Mesic Pine Flatwoods	Undetermined	S4
Hydric Pine Flatwoods	Undetermined	S4?
Dry Prairie	G2	S2
Cutthroat Grass	G2	S2
Wet Prairie	Undetermined	S4?
Freshwater Marsh	G3/G4	S4
Seepage Swamp	G3/G4	S2/S4
Flowing Water Swamp	G3/G4	S2/S4
Pond Swamp	G3/G4	S2/S4
Mangrove	G3	S3
Saltmarsh	G4	S4
Seagrass	G2	S2
Nearshore and Midshelf Reefs	G1/G2	S1/S2

documents (*i.e.*, environmental impact statements). Finally, the species accounts have been designed to help FWS biologists who engage in interagency consultations and habitat conservation plans (according to sections 7 and 10 of the ESA) complete those consultations more efficiently and effectively.

This section, containing all 68 recovery plans packaged together, could have served as a Multi-Species Recovery Plan. However, because a true multi-species approach to recovery requires an understanding of the ecology of the system as a whole, this recovery plan included the section describing the natural communities of the South Florida Ecosystem.

Relationship of the Multi-Species Recovery Plan to Other Recovery Plans

The species contained in "The Species" section of the Multi-Species Recovery Plan can be grouped into three categories: species that occur only in South Florida and have no current recovery plan; species that occur only in South Florida and have approved recovery plans; and species that occur in South Florida, but also occur outside of South Florida.

The Multi-Species Recovery Plan represents the new official recovery plan for species that occur only in South Florida and have no current recovery plan, such as the Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeensis*), rice rat (*Oryzomys palustris natator)*, Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*), and Key Largo woodrat (*Neotoma floridana smalli*) (marked "N" in Table 2).

The Multi-Species Recovery Plan represents the revision and subsequent replacement of recovery plans for those species that are endemic to South Florida and have current, approved recovery plans (marked "R" in Table 2). The FWS South Florida Field Office is responsible for all subsequent revisions of those recovery plans.

For those species that occur in South Florida, but also occur elsewhere, the Multi-Species Recovery Plan outlines how South Florida will contribute to the rangewide recovery objective for those species (marked "C" in Table 2). For example, the Multi-Species Recovery Plan does not replace the existing, rangewide recovery plans for species like the red-cockaded woodpecker (*Picoides borealis*), Eastern indigo snake (*Drymarchon corais couperi*), piping plover (Charadruis melodus), wood stork (*Mycteria americana*), bald eagle (*Haliaeetus leucocephalus*), or the West Indian manatee (*Trichechus manatus*). The recovery sections for those, and other wide-ranging species, depict South Florida's contribution toward meeting the recovery objective as given in the existing, approved recovery plans for those species. The particular FWS field offices that have current recovery responsibility for those species were consulted for assistance with preparation and review of this recovery plan. Likewise, those field offices will incorporate any recovery actions identified for South Florida in subsequent revisions of recovery plans for those species.

There are also several species shown in Table 2 that are designated as threatened or endangered by similarity of appearance to a listed species: the puma (*Puma concolor*), the peregrine falcon (*Falco peregrinus*), and the American

Table 2. The federally listed endangered and threatened species of South Florida.

.

Mammals (except whales)			
E	R	Key deer	*Odocoileus virginianus clavium*
E(CH)	C	West Indian manatee	*Trichechus manatus*
E	N	Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*
T	C	Southeastern beach mouse	*Peromyscus polionotus niveiventris*
T(S/A)		Puma (=mountain lion	*Puma* (=*Felis*) *concolor*
E	C	Florida panther	*Puma* (=*Felis*) *concolor coryi*
E	R	Lower Keys rabbit	*Sylvilagus palustris hefneri*
E(CH)	N	Rice rat (= silver rice rat)	*Oryzomys palustris natator* (= *O. argentatus*)
E	N	Key Largo woodrat	*Neotoma floridana smalli*
Birds			
T	R	Audubon's crested caracara	*Polyborus plancus audubonii*
XN		Whooping crane	*Grus americana*
T	C	Bald eagle	*Haliaeetus leucocephalus*
E(S/A)		Peregrine falcon	*Falco peregrinus*
T	C	Florida scrub-jay	*Aphelocoma coerulescens*
E(CH)	R	Everglade snail kite	*Rostrhamus sociabilis plumbeus*
T	C	Piping plover	*Charadrius melodus*
E(CH)	R	Cape Sable seaside sparrow	*Ammodramus* (= *Ammospiza*) *maritimus mirabilis*
E	R	Florida grasshopper sparrow	*Ammodramus savannarum floridanus*
E	C	Wood stork	*Mycteria americana*
T	C	Roseate tern	*Sterna dougallii dougallii*
E	C	Bachman's warbler	*Vermivora bachmanii*
E	C	Kirtland's warbler	*Dendroica kirtlandii*
E	C	Ivory-billed woodpecker	*Campephilus principalis*
E	C	Red-cockaded woodpecker	*Picoides* (= *Dendrocopos*) *borealis*
Reptiles			
T(S/A)		American alligator	*Alligator mississippiensis*
E(CH)	R	American crocodile	*Crocodylus acutus*
T	R	Bluetail mole skink	*Eumeces egregius lividus*
T	R	Sand skink	*Neoseps reynoldsi*
T	C	Atlantic salt marsh snake	*Nerodia clarkii* (= *fasciata*) *taeniata*
T	C	Eastern indigo snake	*Drymarchon corais couperi*
E	C	Green sea turtle	*Chelonia mydas* (incl. *agassizi*)
E(CH)	C	Hawksbill sea turtle	*Eretmochelys imbricata*
E	C	Kemp's ridley sea turtle	*Lepidochelys kempii*
E(CH)	C	Leatherback sea turtle	*Dermochelys coriacea*
T	C	Loggerhead sea turtle	*Caretta caretta*
Invertebrates			
E	R	Schaus swallowtail butterfly	*Heraclides* (= *Papilio*) *aristodemus ponceanus*
T	R	Stock Island tree snail	*Orthalicus reses* (not incl. *nesodryas*)
Plants			
E	R	Crenulate lead-plant	*Amorpha crenulata*
E	R	Four-petal pawpaw	*Asimina tetramera*
T	C	Florida bonamia	*Bonamia grandiflora*
E	R	Fragrant prickly-apple	*Cereus eriophorus* var. *fragrans*
E	R	Deltoid spurge	*Chamaesyce* (= *Euphorbia*) *deltoidea* spp. *deltoidea*
T	R	Garber's spurge	*Chamaesyce* (= *Euphorbia*) *garberi*
E	R	Pygmy fringe-tree	*Chionanthus pygmaeus*
E	C	Florida golden aster	*Chrysopsis* (= *Heterotheca*) *floridana*
E	R	Florida perforate cladonia	*Cladonia perforata*
T	R	Pigeon wings	*Clitoria fragrans*
E	R	Short-leaved rosemary	*Conradina brevifolia*
E	R	Avon Park harebells	*Crotalaria avonensis*
E	N	Okeechobee gourd	*Cucurbita okeechobeensis* ssp. *okeechobeensis*

Legend

Column 1: Status of Species

E: Endangered
T: Threatened
S/A: Endangered or threatened by Similarity of Appearance
CH: Critical Habitat
XN: Nonessential Experimental population

Column 2: Relationship of MSRP to Other Recovery Plans

N: New recovery plan
R: Revision of existing recovery plan
C: South Florida's contribution to existing rangewide recovery plan

Table 2. The federally listed endangered and threatened species of South Florida, continued.

E	R	Beautiful pawpaw	*Deeringothamnus pulchellus*
E	R	Garrett's mint	*Dicerandra christmanii*
E	R	Scrub mint	*Dicerandra frutescens*
E	R	Lakela's mint	*Dicerandra immaculata*
T	C	Scrub buckwheat	*Eriogonum longifolium* var. *gnaphalifolium*
E	R	Snakeroot	*Eryngium cuneifolium*
E	R	Small's milkpea	*Galactia smallii*
E	R	Highlands scrub hypericum	*Hypericum cumulicola*
E	R	Beach jacquemontia	*Jacquemontia reclinata*
E	R	Scrub blazing star	*Liatris ohlingerae*
E	C	Scrub lupine	*Lupinus aridorum*
E	R	Britton's beargrass	*Nolina brittoniana*
T	R	Papery whitlow-wort	*Paronychia chartacea* (= *Nyachia pulvinata*)
E	R	Key tree-cactus	*Pilosocereus* (= *cereus*) *robinii*
E	R	Lewton's polygala	*Polygala lewtonii*
E	R	Tiny polygala	*Polygala smallii*
E	R	Wireweed	*Polygonella basiramia* (= *ciliata* var. *b.*)
E	R	Sandlace	*Polygonella myriophylla*
E	C	Scrub plum	*Prunus geniculata*
E	C	Wide-leaf warea	*Warea amplexifolia*
E	R	Carter's mustard	*Warea carteri*
E	R	Florida ziziphus	*Ziziphus celata*

alligator, (*Alligator mississippiensis*). These species are not included in the count of federally listed species in South Florida, as they are not biologically threatened or endangered according to the ESA. They are afforded protection from "take", though, because they are physically similar in appearance to listed species, and enforcement personnel would have difficulty in differentiating between the listed and unlisted species. For example, the American alligator is designated as T/SA because of the need for control of its commercial products so that other listed crocodilians are not taken and labeled as "American alligator" to circumvent restrictions of the ESA. A species account for the American peregrine falcon (*F. p. anatum*) was not included in this recovery plan. This species is currently proposed for removal from the official List of Endangered and Threatened Wildlife (50 CFR 17.11). Until its delisting, however, the E/SA designation will remain for the migratory peregrine falcons in South Florida.

Restoration Objectives and Criteria

All species-level recovery plans must identify *recovery* objectives and criteria for the federally listed species included in the plans. Because this recovery plan includes multiple species, there was a need to include tasks at the community level that are also necessary for species' recovery. In 'The Ecological Communities" section, *restoration* is used as the analogous term to recovery at the community level.

Ecological restoration in the broad sense is defined as any activity which improves the overall ecological condition of a natural community or disturbed site. It includes both ecological restoration *sensu strictu*, the return of a community or ecosystem to a pre-disturbance condition, as well as the creation of an ecosystem *de novo* when it uses an historic natural community as a model. Restoration activities may involve biological or hydrological manipulation, repatriation of extirpated or nonviable native species, control and elimination of invasive or damaging non-native (exotic) species, and cleanup of environmental contaminants.

In-kind restoration refers to the restoration of a natural community which did not occupy the precise location of the restoration, but which is normally found within the immediate vicinity of it. Not-in-kind restoration may be a legitimate activity when it is no longer possible to restore the community which historically occupied the site due to significant site alterations.

Management which attempts to restore natural community functions, structures and/or composition is termed restorative management, and includes both in-kind restoration and not-in-kind restoration. In South Florida, for certain communities that exist as isolated fragments of the landscape, human intervention in the form of restorative management will always be needed to facilitate the functioning of ecological processes.

The restoration of a natural community on land which has been massively disturbed through mining, hydrological alteration or other agricultural activities, road-building, *etc*., so that the site no longer has any resemblance to the original natural community which once occupied the landscape, is termed

re-creation. Re-creation also may include both in-kind restoration and not-in-kind restoration. This type of restoration can be used to expand, add buffers to, or connect existing preserves.

Finally, the term creation refers to the design of natural community analogs on massively disturbed land where it is impossible or unfeasible to restore an historic natural community. Historic natural communities are used as general models, and only species which are within their historic ranges are used to construct these natural community analogs (*e.g.* the restoration of tropical hardwood hammocks on fill pads surrounding buildings along the Tamiami Trail).

The "Ecological Communities" section provides a comprehensive overview of the ecology of each of the communities in South Florida; information that is needed in the development and implementation of effective restoration plans. Community-level restoration actions, following each account, equate to recovery actions for the federally listed species. These actions are the tasks needed at the community/ecosystem level to restore the structure, function, and biological composition of a particular ecological community, to the extent possible.

Recovery Objectives and Criteria

The FWS generally takes two basic approaches to developing recovery criteria for recovery plans. The most common recovery criteria consist of specifying a number of populations of a particular size (with the usual notation: *M* populations of *N* individuals). A smaller percentage of recovery plans, generally more recent ones, use recovery criteria that specify demographic and habitat goals for a species. For example, the recovery plan for the grizzly bear (*Ursus arctos horribilis)* identifies delisting criteria based on targets for minimum population size, number of populations, population mortality rates, and population reproductive rates calculated as running averages. The recovery plan for the Delmarva Peninsula fox squirrel (*Sciurus niger cinereus*) identifies recovery criteria based on the establishment of a number of new colonies; the fox squirrel's recovery plan also called for populations that are stable or increasing and required collection of detailed demographic and ecological data on the species to ensure the accuracy of these projections. The recovery plan for the Arctic peregrine falcon (*Falco peregrinus tundrius*) identified recovery criteria based on the number of nesting pairs distributed over several areas, reproduction and mortality statistics, and elimination of the effects of environmental contaminants on reproduction. The recovery plan for the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) required identification of the reasons for the population decline, water management that ensures long-term protection of the sparrow's habitat, a minimum population of 6,600 birds, and population fluctuations that do not fall below this level.

The latter approaches are consistent with the recommendations of the National Academy of Sciences (1995), Ecological Society of America (1996), Schemske *et al*. (1994), and Tear *et al*. (1995), all of whom recommended recovery criteria that include demographic variables (such as reproductive rates, mortality rates, and age or stage-structure) as well as habitat-based variables (such as numbers of reserves, reserve size, and habitat condition). The Multi-Species Recovery Plan used the latter approach to develop recovery criteria.

The recovery criteria in the Multi-Species Recovery Plan are short, narrative statements consisting of: (1) a statement that requires amelioration of threats to the species or its habitat, (2) a statement of the probability of persistence for the species (that is, 95 percent probability of persisting for 100 years), (3) the rate of increase (*r*) to measure over a specific period of time, (4) the minimum number of populations (or subpopulations) to establish, (5) a minimum population size, and (6) a habitat condition over a particular geographic area (or areas). Not all of these variables have been included in recovery criteria for each of the 68 species in the Multi-Species Recovery Plan, however, because not all of these variables were applicable.

Variables Used to Develop Recovery Criteria

The following is a brief description of the variables used in the recovery criteria, their value as recovery criteria, and methods for calculating those variables that require computation. Refer to examples in Box 1 and Box 2.

Elimination or amelioration of threats to the species

The species addressed in this recovery plan are threatened or endangered because of the threats posed primarily by human actions. In recovery plans, the prerequisite for delisting should be elimination or amelioration of the threats that imperil the species.

Persistence time (also known as time to extinction)

Persistence time ($T_{(N)}$) is an estimate of the number of years it would take for a species to become extinct given its rates of birth, death, immigration, emigration, and population variability. This would be used to determine if the species has a 95 percent probability of persisting for 100 years (which is the standard the FWS has set for this recovery plan).

There are several ways of calculating $T_{(N)}$. There are several software packages (such as those developed by Applied Biomathematics, Inc.) that calculate persistence time based on simulations or based on static formulae. One estimator of persistence time uses a formula developed by Goodman (1987). This model, which synthesizes models developed by Leigh (1981) and Richter-Dyn and Goel (1972), is one of the most widely published and commonly used estimators. Shaffer (1983, 1987) and Shaffer and Samson (1985) used this model to develop recovery objectives for the grizzly bear. Pimm *et al*. (1988) used this model to estimate the persistence times of many species of migratory birds.

Rate of increase (r)

Rates of increase are measures of the difference between the birth and death rates of populations. As long as a population's birth rates exceed death rates over time, that population will increase in size regardless of almost any other variable. When humans destroy or modify habitat and cause a species to decline, that decline manifests itself as a change in that population's rate of increase (from a positive

value to a negative value). This variable is particularly useful for monitoring long-term demographic trends.

To measure rates of increase in populations of the species included in the Multi-Species Recovery Plan, the rate of increase (r) is used [refer to Caughley (1977) for a valuable comparison of the rates of increase]. If $r > 0.0$, the population is growing; if $r = 0.0$, the population is neither increasing nor decreasing; if $r < 0.0$, the population is declining. To avoid drawing the wrong conclusions about a population, and to capture "natural" population fluctuations, the rate of increase is considered only as a running average (for example, a mean of 5 or 10 years; the number used is based on a species' generation time). For the purposes of setting recovery criteria, the rate of increase should be equal to or greater than 0.0 over time; the only complication is setting the correct time interval for the criterion.

Box 1. Example of Recovery Criteria for the Southeastern Beach Mouse

Information from recent surveys in Indian River and St. Lucie counties indicate the southeastern beach mouse is rare and may be threatened with extirpation due to natural and anthropogenic factors. The nature of the habitat loss provides limited potential for habitat restoration or rehabilitation in South Florida. Consequently, the objective of this recovery plan is to prevent the extirpation of the southeastern beach mouse in South Florida by increasing the numbers of individuals in existing subpopulations and by increasing the number of subpopulations. This objective will be achieved when further degradation of suitable, occupied habitat due to trampling and coastal erosion has been prevented; when native and non-native nuisance species have been eliminated in suitable, occupied beach mouse habitat; when existing populations, within their historic range, are protected either through land acquisition or cooperative agreements; when the coastal dune and coastal strand habitats which form the habitat for the southeastern beach mouse are managed to control native and non-native nuisance species; when potential coastal dune and coastal strand habitats are restored or rehabilitated to provide habitat for the southeastern beach mouse; when translocations of this subspecies from Brevard County are conducted into adequate, suitable, protected habitat within Indian River and St. Lucie counties; and when the Indian River and St. Lucie county populations of southeastern beach mice sustain a rate of increase (r) equal to or greater than 0.0 as a 3-year running average for 6 years, and a 1:1 male:female ratio.

Box 2. Example of Recovery Criteria for Florida Perforate Cladonia

Cladonia perforata may be reclassified from endangered to threatened when enough demographic data are available to determine the appropriate numbers of self-sustaining patches and sites needed to ensure a 20 to 90 percent probability of persistence for 100 years; when these sites, within the historic range of *Cladonia perforata*, are adequately protected from further habitat loss, degradation, and fragmentation; when these sites are managed to maintain the rosemary phase of xeric oak scrub communities to support *Cladonia perforata*; and when monitoring programs demonstrate that populations of *Cladonia perforata* on these sites support the appropriate numbers of self-sustaining patches and those patches are stable throughout the historic range of the species.

These are interim criteria because of the limited data on the biology, ecology, and management needs of this species. The recovery criteria will be re-assessed annually based on new research, management, and monitoring information on the species. De-listing criteria may be developed if new information identifies new ways of re-establishing populations of this species or expanding its current range.

Number of subpopulations

Some of the species in the South Florida Ecosystem exist as discrete populations. Other species, like the Cape Sable seaside sparrow, however, exist as separate, discrete groups or subpopulations. For these species, the FWS usually uses multiple subpopulations (or subgroupings) as a requirement for recovery. Recovery plans for these species normally call for a specific number of subpopulations consisting of a particular number of individuals. If it is determined that there is movement by animals among subpopulations, then both a number of subpopulations and a total minimum number of individuals should be contained in the recovery criteria (numbers adequate for a viable population). If subpopulations are determined to be genetically discreet, however, a number of subpopulations and a minimum number of individuals in each subpopulation should be targeted for recovery. In each case, the rate of increase of the population or subpopulation should be positive over a specified number of years.

Population size and variance

Demographic stochasticity, the variance in a population's size over time, represents one of the more significant factors contributing to a species' probability of extinction (Shaffer 1981, 1987). In small populations, normal, random fluctuations can cause a species' extinction. Therefore, this plan's recovery objectives include a criterion for population variability.

Although many readers of the Multi-Species Recovery Plan will expect to see a target population size in the recovery criteria, the authors specifically avoided setting such a target because of the limited demographic information available for many of South Florida's threatened or endangered species.

Information on the size of populations, however, does provide an index of a species' progress toward recovery. Because most of the species included in the plan have small population sizes, their recovery requires those populations to grow over time. As a result, there should be no further, significant reductions from current population sizes, either from direct pressure on the species or through population fluctuations.

Habitat

Reductions in habitat quality and quantity threaten species in South Florida more than any other factor. Ensuring the recovery of these species will require providing them with sufficient, suitable habitat. This will be difficult since, for many of South Florida's species, recovery will require more suitable habitat than currently exists, and restoration of habitat that has been destroyed is uncertain. Examples of this include the Florida panther (*Puma concolor coryi*), the Key deer (*Odocoileus virginianus clavium*), and most of the pine rockland plant species, each which has lost so much habitat that both density-dependent and density-independent factors keep them at perilously small population levels.

Nevertheless, a habitat-related criterion is provided. For species like the Cape Sable seaside sparrow, Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), Everglade snail kite (*Rostrhamus sociabilis plumbeus*), and wood stork that are affected by changes in habitat quality, criteria are included that require an improvement in habitat quality or a reversal of the habitat conditions that imperilled the species before the recovery objective could be achieved.

Application

Although these criteria may seem overly complicated, they are based on (or can be estimated from) a simple set of variables: (1) survival by age (or stage), (2) fecundity by age (or stage), (3) frequency distribution of ages (or stages), (4) sex ratios, and (5) numbers or density. From these variables, one can estimate birth rates (b), death rates (d), and rates of increase (*r*). Caughley (1977) stated that these variables collectively describe the significant properties of a population, they make it possible to extrapolate beyond the basic data from which they were calculated, they have a direct relationship to population processes, and they can be generalized to many populations. Schemske *et al*. (1994) argued that these variables must be known to develop effective, reliable recovery plans.

The most compelling argument for collecting these variables is simple: if these variables are understood for threatened and endangered species, the FWS can use the ESA to protect and recover them more effectively (Ecological Society of America 1996, National Academy of Science 1995, Schemske *et al*. 1994, Tear *et al.* 1993, 1995). If information on these variables is not known, their extinction cannot effectively be prevented.

This approach may sound onerous to many who read it (see Box 3). At the same time, it is consistent with the language contained in many of the best recovery plans. More importantly, the recovery criteria should reliably determine when a species is "healthy." The FWS team that authored the Multi-Species Recovery Plan believe the approach used produced recovery criteria that, when met, will allow the FWS to confidently act on them.

Species Classification

The Endangered Species Act of 1973 recognizes three categories: "endangered," "threatened," and "conserved." An endangered species is "any species which is in

Box 3. Recovery criteria for the Multi-Species Recovery Plan were developed using the following steps:

Criterion 1: State what primary threats must be ameliorated or eliminated;

Criterion 2: State the persistence probability; the target is 95 percent for 100 years;

Criterion 3: State the target for the rate of increase (r). The target is always to have a mean rate of increase that is greater than 0.0, but the time interval used to compute the mean depends on the species; the time interval is generally derived from the generation time of the species;

Criterion 4: State the minimum number of subpopulations that should occur in South Florida within the species' historical range;

Criterion 5: Set the minimum population size. For many species the goal is to make certain the census population does not fall below current levels at any time; if the census population meets that target and maintains a rate of increase that is significantly greater than 0.0, the population will grow to the carrying capacity of its habitat, and the rate of increase will then fluctuate around 0.0.

Criterion 6: State a habitat condition for the species. If the recovery objective is to reclassify a species from endangered to threatened, this criterion requires some degree of habitat restoration or, at a minimum, a significant increase in the carrying capacity of the habitat for the species so the habitat can support a population level that is higher than current levels.

danger of extinction throughout all or a significant portion of its range." A threatened species is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." A species that has been "conserved" is one that has reached the point at which the measures provided pursuant to the ESA are no longer necessary.

As part of the recovery planning process, the authors had to consider when to reclassify a species from endangered to threatened (or, in the worst case, reclassification from threatened to endangered). Rather than develop and propose separate reclassification criteria for each of the 68 threatened and endangered species included in this Multi-Species Recovery Plan, objective standards were developed and are proposed for the reclassification based on persistence times (or extinction probabilities) and threats.

The Multi-Species Recovery Plan recognizes the following three categories, and defines them using the following attributes:

(a) *Recovered:* a species which, based on stochastic modeling, has a 95 percent probability (± .05 percent) of persisting for at least 100 years (conversely, it has a probability of extinction equal to or less than 5 percent during a 100-year interval). This criterion also assumes threats to the species have been eliminated or ameliorated and the species has met all other recovery criteria.

(b) *Threatened:* a species which, based on stochastic modeling, has a 20 to 90 percent probability (± .05 percent) of persisting for 100 years (conversely, it has a 10 to 80 percent probability of extinction during a 100-year interval), regardless of other criteria. This criterion assumes the broadest range of persistence probability because protection under the ESA for threatened and endangered species is essentially equivalent, and, in addition, threatened species can be afforded additional protection with a special 4(d) rule.

(c) *Endangered:* a species which, based on stochastic modeling, has less than a 20 percent probability (± .05 percent) of persisting for 100 years (conversely, it has at least an 80 percent probability of extinction during a 100-year interval), regardless of other criteria. This criterion assumes a critical situation for classification.

Similar criteria have been proposed by Akçakaya (1992), the International Union for the Conservation of Nature and Natural Resources (IUCN 1994), and Mace and Lande (1991). The main difference is that these other proposals recognize four categories (stable, vulnerable, endangered, critical) while the Multi-Species Recovery Plan only includes the three categories recognized by the ESA.

Literature Cited

Akçakaya, H.R. 1992. Population viability analysis and risk assessment. Pages 148-157 *in* D.R. McCullough and R.H. Barrett, eds. Wildlife 2001: Populations. Elseviers Publishers; London.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, Inc.; New York, New York.

Ecological Society of America, Ad Hoc Committee on Endangered Species. 1996. Strengthening the use of science in achieving the goals of the Endangered Species Act: an assessment by the Ecological Society of America. Ecological Applications 6: 1-11.

Florida Natural Areas Inventory [FNAI]. 1997. Plants and lichens, vertebrates, invertebrates, and natural communities tracked by Florida Natural Areas Inventory. FNAI; Tallahassee, Florida.

Goodman, D. 1987. The demography of chance extinction. Pages 11-43 in M.E. Soulé (ed.) Viable populations for conservation. Cambridge University Press; New York, New York.

International Union for the Conservation of Nature and Natural Resources [IUCN]. 1994. IUCN Red List categories. IUCN Species Survival Commission; Gland, Switzerland.

Leigh, E.G., Jr. 1981. The average lifetime of a population in a varying environment. Journal of Theoretical Biology 90: 213-239.

Mace, G.M. and R. Lande. 1991. Assessing extinction threats: toward a reevaluation of IUCN threatened species categories. Conservation Biology 5: 148-157.

National Academy of Sciences. 1995. Science and the Endangered Species Act. National Academy Press; Washington, D.C.

Pimm, S.L., H.L. Jones, and J. Diamond. 1988. On the risk of extinction. American Naturalist 132: 757-785.

Richter-Dyn, N. and N.S. Goel. 1972. On the extinction of a colonizing species. Theoretical Population Biology 3:406-433.

Schemske, D.W., B.C. Husband, M.H. Ruckelshaus, C. Goodwillie, I.M. Parker, and J.G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75(3):584-606.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31: 131-134.

Shaffer, M.L. 1983. Determining minimum viable population sizes for the grizzly bear. International conference on bear research and management 5: 133-139.

Shaffer, M.L. 1987. Minimum viable populations: coping with uncertainty. Pages 69-86 in M.E. Soulé (ed.) Viable populations for conservation. Cambridge University Press; New York, New York.

Sutter, R.D. 1996. Monitoring. Pages 235-264 *in* D.A. Falk, C.I. Millar, and M. Olwell (eds.) Restoring diversity: strategies for reintroduction of endangered plants. Island Press; Washington, D.C.

Shaffer, M.L. and F.B. Samson. 1985. Population size and extinction: a note on determining critical population sizes. American Naturalist 125: 144-152.

Tanner, J.T. 1942. The ivory-billed woodpecker. National Audubon Society research report no. 1. National Audubon Society; New York, New York.

Tear, T.H., J.M. Scott, P.H. Hayward, and B. Griffith. 1993. Status and prospects for success of the Endangered Species Act: a look at recovery plans. Science 262(12):976-977.

Tear, T.H., J.M. Scott, P.H. Hayward, and B. Griffith. 1995. Recovery plans and the Endangered Species Act: are criticisms supported by data? Conservation Biology 9(1):182-195.

U. S. Fish and Wildlife Service [FWS]. 1994. An ecosystem approach to fish and wildlife conservation. U. S. Fish and Wildlife Service concept document, March 1994; Washington, D.C.