

Appendix C. Conservation of Multi-species Recovery Plan (MSRP) ecological communities and listed species.

Introduction

The Endangered Species Act of 1973, as amended, (ESA) was established to provide a means to conserve endangered and threatened species and the ecosystems on which they depend. Section 7(a)(1) of the ESA requires all Federal agencies to utilize their authorities to carry out programs for the conservation of federally listed endangered and threatened species in consultation with and with the assistance of the Service. This proactive requirement of the ESA is also referred to as an affirmative obligation, or a responsibility to implement even when agency actions do not jeopardize the continued existence of species.

One instrument for accomplishing proactive species and ecosystem conservation is the Service's *Multi-species Recovery Plan for South Florida* (MSRP). The MSRP identifies the recovery needs of 68 federally listed species and 23 ecological communities in the south Florida ecosystem (Service 1999), which includes the 19 southernmost counties on the Florida peninsula, an area of about 26,000 square miles encompassing the Kissimmee River-Lake Okeechobee-Everglades, the Caloosahatchee, St. Lucie, and the Peace-Myakka River watersheds.

The MSRP provided two basic planning tools for species recovery: (1) a summary of the status and trends of south Florida listed species and ecological communities and (2) a summary of actions that would benefit recovery of those species and ecological communities. The MSRP recovery and restoration actions that are presented focus on land management activities to benefit imperiled species and their habitats. Many of the actions cannot be accomplished with Service resources alone and rely on coordinated efforts among partners and stakeholders with interests in species and ecological restoration to carry out specific tasks.

The MSRP does not suggested for which species, ecological communities, or recovery and restoration actions other Federal agencies, particularly the Corps in the case of Everglades restoration, should develop or implement conservation strategies consistent with their affirmative obligations under the ESA section 7(a)(1). However, we will work with the Corps and the District to help develop a comprehensive conservation strategy consistent with the primary mandates of the Comprehensive Everglades Restoration Plan (CERP). This list of restoration and recovery action from the MSRP for the ecological communities and federally listed species that occur within the CERP footprint and that CERP projects may affect present the basis for forming an integrated, interagency approach in developing a comprehensive conservation strategy consistent with ESA 7(a)(1) affirmative obligations for the CERP.

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The Ecological Communities

Restoration of High Pine

Restoration Objective: Maintain and enhance the structure, function, and composition of the high pine community to ensure the long-term survival in the wild of all plant and animal species that depend upon this community for their existence.

Restoration Criteria: High pine in South Florida may be considered restored when: (1) existing high pine habitat is preserved through land acquisition; Federal, State or local management actions; and/or private cooperative agreements; (2) prescribed fire or other management techniques are used to restore suitable habitat; (3) any further loss, fragmentation, and degradation of high pine habitat has been prevented; (4) appropriate ecosystem management plans have been prepared, funded, and implemented for long-term perpetuation of the high pine community; and (5) protection of high pine is adequate to ensure self-sustaining populations of endemic, rare, and imperilled species that use this community.

Community-level Restoration Actions

1. Prevent further destruction or degradation of existing high pine communities.
 - 1.1. Secure high pine sites through land acquisition, landowner agreements, and conservation easements. The highest priority should be placed on preventing development of remaining high pine sites. This is best accomplished by land acquisition, but other methods of preventing development such as conservation easements are sometimes useful. So much of South Florida's original high pine has already been irretrievably lost, that if any high pine tracts can be located they should be acquired for preservation.
 - 1.2. Control public use. Inappropriate public uses such as off-road vehicle racing and trash dumping should be prevented with signs and fences if necessary.
 - 1.3. Enforce existing regulations. Regulations against taking protected species must be enforced.
2. Restore existing degraded high pine communities.
 - 2.1. Permit the reintroduction of natural fires or prescribe controlled burns. High pine communities that have been degraded because of fire exclusion can be restored with prescribed fires. Each protected site should have a fire management plan prepared specifically for it. Management plans should specifically include allowing natural, lightning-ignited fires to burn through high pine preserves whenever possible. In addition, plans should specify how and when prescribed fires should be ignited if natural fires are inadequate to meet management objectives.

- 2.2. Encourage maintenance and recovery of natural ecotones. Ecotones are important elements of any natural landscape and should receive special attention in natural area management plans. Fire breaks and roads should be placed well away from ecotones. Ecotones that have been degraded by existing roads and fire breaks should be restored.
 - 2.3. Eliminate or control exotic and off-site species. Some high pine communities are infested with cogongrass. This invasive exotic should be controlled with herbicides and mechanical treatments.
 - 2.4. Reintroduce locally extirpated species. Red-cockaded woodpeckers and wide-leaf warea should be reintroduced into appropriate high pine sites from which they have been extirpated. High pine sites are considered appropriate if all the critical requirements (*e.g.*, old growth longleafs for red-cockaded woodpeckers) of the species are met.
 - 2.5. Eliminate any sources of pollution.
 - 2.6. Control public use. High pine communities that have been degraded by inappropriate public use can only be restored by eliminating that public use. Signs and fences may be necessary to discourage off-road vehicle use, trash dumping, and illegal plant and animal harvesting.
3. Maintain high pine communities in a natural condition in perpetuity.
 - 3.1. Continue to prescribe natural fires or controlled burns. Continue planning for natural lightning-ignited fires to be allowed to burn. Prescribe controlled burns when natural fires are inadequate to meet management objectives.
 - 3.2. Continue to control exotic species.
 - 3.3. Continue to control public use.
 - 3.4. Monitor for negative population trends among important high pine animal and plant species. Areas of high pine within ecological preserves should have specific monitoring plans that will alert managers to extirpations or downward trends in populations of selected species, including endemic species, listed species, and keystone species.
 - 3.5. Monitor and correct for any point source or non-point source pollution.
 4. Restore high pine where it has been destroyed by human activities such as mining or farming. Most of the citrus groves on the Lake Wales Ridge were established on high pine

sites. Today many of these groves are being abandoned. We may have the opportunity to restore high pine on some of these sites, although we do not yet know how to do this.

5. Create high pine in regions where it has been destroyed by human activities. It may be possible to create high pine on former strip mines, although this has not yet been attempted.
6. Connect existing high pine preserves by acquiring lands for conservation between them. Land acquisition, landowner agreements or conservation easements should be used to prevent development of lands between existing conservation areas.
7. Encourage research on ground cover restoration. In northern Florida The Nature Conservancy and the Florida DEP are restoring high pine on turkey oak barrens sites where the ground cover is still at least partly intact. On sites where the ground cover has been completely destroyed, high pine restoration is still not feasible. We need to learn how to restore wiregrass on former citrus groves and strip mines where it has been eliminated.
8. Monitor habitat and ecological processes.
 - 8.1. Monitor land management actions. All management actions should be monitored to determine their effectiveness, and changes should be made to management activities as appropriate. Managers should have a site-specific plan for monitoring vegetation response to prescribed fires and other land management actions.
 - 8.2. Monitor for negative population trends among important high pine plant and animal species. Each high pine preserve should have a monitoring plan that will alert managers to extirpations or downward trends in relative population levels of selected plant and animal species.
 - 8.3. Monitor and correct for any point source or non-point source pollution.
9. Increase public awareness. Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Florida's (CARL) program and Preservation-2000.

Restoration of Scrub, Scrubby Flatwoods and Scrubby High Pine

Restoration Objective: Maintain and enhance the structure, function, and composition of the scrub community, and increase the spatial extent of scrub as habitat throughout South Florida to insure the long-term survival in the wild of all plant and animal species that depend upon this community for their existence.

Restoration Criteria: Scrub in South Florida may be considered restored when: (1) existing scrub habitat is preserved through land acquisition; Federal, State or local management actions; and/or private cooperative agreements; (2) when prescribed fire or other management techniques are used to restore suitable habitat from overgrown scrub; (3) when any further loss, fragmentation, and degradation of scrub habitat has been prevented; (4) when appropriate ecosystem management has been prepared, funded, and implemented for long-term perpetuation of the scrub community; and (5) when protection of scrub is adequate to ensure endemic, rare, and imperilled species that use this community have self-sustaining populations.

Community-level Restoration Actions

1. Prevent further destruction or degradation of existing scrub communities.
 - 1.1. Secure scrub sites through land acquisition, landowner agreements, and conservation easements. The highest priority should be placed on preventing development of remaining scrub sites. This is best accomplished by land acquisition, but other methods of preventing development such as conservation easements are sometimes useful. So much of South Florida's original scrub has already been irretrievably lost that most remaining scrub tracts should be acquired for preservation. Scrubs on the acquisition lists for Florida's CARL program for the FWS Lake Wales Ridge NWR should be acquired first. In addition, scrubs identified by Fernald (1989) and the strategic habitat conservation area scrubs identified by Cox et al. (1994) should be acquired.
 - 1.2. Control public use. Indiscriminate use of off-road vehicles and illegal sand mining have contributed to the degradation of many South Florida scrubs. These and other inappropriate public uses must be discouraged if we are to prevent further degradation of existing scrubs. Signs and fences may be required.
 - 1.3. Enforce existing regulations. Regulations against collecting threatened and endangered species must be enforced.
2. Restore existing degraded scrubs.
 - 2.1. Permit the reintroduction of natural fires or prescribe controlled burns, and/or mechanical disturbance treatments. Scrubs that have been degraded because of fire exclusion can be restored with prescribed fires and/or mechanical disturbance treatments. Each protected scrub site should have a fire management plan prepared specifically for it. Management plans should specifically include allowing natural, lightning-ignited fires to burn through scrub preserves whenever possible. In addition, plans should specify how and when prescribed fires should be ignited if natural fires are inadequate to meet management objectives. The use of mechanical disturbance instead of or in addition to fire may be appropriate in some cases.

- 2.2. Encourage maintenance and recovery of natural ecotones. Ecotones are important elements of any natural landscape and should receive special attention in scrub management plans. Fire breaks and roads should be placed well away from ecotones. Ecotones that have been degraded by existing roads and fire breaks should be restored.
- 2.3. Eliminate or control exotic and off-site species. Some scrubs on the Lake Wales Ridge have been planted to bahiagrass (*Paspalum notatum*) for cattle forage. This turf forming grass excludes native scrub species and persists even when burned. Mechanical soil scarification and/or chemical herbicide treatments might be necessary to reduce bahiagrass ground cover. Some coastal scrubs on the Atlantic Coast Ridge have been colonized by exotic plant species. These infestations tend to be small, localized, and probably easy to eliminate compared to exotic plant problems in other communities.
- 2.4. Reintroduce locally extirpated species. Because of past management practices, some scrub plant and animal species may have disappeared from existing degraded scrubs. These species can be reintroduced if natural recolonization is unlikely.
- 2.5. Eliminate any sources of pollution to the scrub site.
- 2.6. Control public use. Scrubs that have been degraded by inappropriate public use can only be restored by first eliminating that public use. Signs and fences may be necessary to discourage off-road vehicle use. In some scrubs on the Lake Wales Ridge, illegal sand mining has seriously degraded habitats.
3. Maintain scrub communities in a natural condition in perpetuity.
 - 3.1. Continue to prescribe natural fires, controlled burns and/or mechanical disturbance treatments. Continue planning for natural lightning-ignited fires to be allowed to burn. Prescribe controlled burns and/or mechanical treatments when natural fires are inadequate to meet management objectives.
 - 3.2. Continue to control exotic species. Exotic plant species rarely invade interior scrub, but coastal scrubs, especially on the Atlantic Coast Ridge, are sometimes susceptible to invasion by exotics. These probably can be controlled by mechanical means without the need for chemical herbicides.
 - 3.3. Continue to control public use. Scrubs acquired for conservation of biotic resources must be protected from inappropriate public use. Sand mining, off-road vehicle use, and rare plant collecting are not compatible with scrub preservation.
 - 3.4. Monitor for negative population trends among important scrub plant species. Each

scrub preserve should have a specific monitoring plan that will alert managers to extirpations or downward trends in populations of selected scrub species, including endemic species, listed species, and keystone species.

- 3.5. Monitor and correct for any point source or non-point source pollution.
4. Recreate scrub where it has been destroyed by human activities such as mining or farming. In Polk County efforts to recreate scrub where it had been totally destroyed on former strip mines have been promising, but less than satisfactory so far. The research, monitoring, and efforts should continue.
5. Create scrub in regions where scrub has been destroyed by human activities. In Osceola County, researchers have attempted to create a scrub by spreading top soil from a scrub that was being destroyed by development onto a former cow pasture. The effort has been promising but so far less than satisfactory. The research and the efforts should continue.
6. Connect existing scrub preserves by acquiring lands for conservation between them. Land acquisition, landowner agreements, or conservation easements should be used to prevent development of lands between existing conservation areas. Lands acquired as connectors between scrub preserves need not be scrubs. Historically, scrubs existed as “islands” in a matrix of other community types, and this pattern should be maintained as much as possible.
7. Encourage community level research.
 - 7.1. Encourage research on prescribed burning in scrub. As more and more Florida scrubs are placed under management for ecological conservation the use of prescribed fire to manage scrub will become increasingly necessary. Unfortunately, there has been little prescribed burning in Florida scrub to date and there are no formal guidelines available. The National Forest Fire Laboratory does not have a fuel model for Florida scrub. Currently the U. S. Forest Service in the Ocala NF is developing a fuel model specific for sand pine forest (J. Thorsen, USFS, personal communication 1995). However, it is doubtful if such a model will describe adequately fire behavior in scrub, which lacks an overstory of sand pine trees. Managers need a fuel model for the various phases of Florida scrub.

FWS has funded DEP at Jonathan Dickinson SP to develop optimum pre-treatment methods for prescribed burning in coastal scrub and sand pine forest, and to compare stand replacement by mechanical disturbance versus prescribed burning (R. Roberts, DEP, personal communication 1995). Similar studies in Lake Wales Ridge and other interior scrubs are needed.
 - 7.2. Encourage research on alternatives to prescribed burning. In cases where prescribed

burning cannot be accomplished due to proximity of roads or other human development, mechanical disturbance may be an acceptable alternative. FWS has funded a study at Archbold Biological Station to compare the effects of mechanical treatment with prescribed fire on listed Lake Wales Ridge plants and their habitats. Similar studies in various scrub types and in other areas of South Florida are needed.

8. Monitor habitat and ecological processes.

8.1. Monitor land management actions. All management actions should be monitored to determine their effectiveness, and changes should be made to management activities as appropriate. Each scrub preserve should have a specific monitoring plan to assist managers with decisions regarding prescribed burning and other land management actions

8.2. Monitor for negative population trends among important scrub plant and animal species. Each scrub preserve should have a specific monitoring plan that will alert managers to extirpations or downward trends in populations of selected scrub species, including endemic species, listed species, and keystone species.

8.3. Monitor and correct for any point source or non-point source pollution.

9. Increase public awareness. Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Florida's Conservation and Recreational Lands (CARL) program and Preservation-2000. Federal initiatives such as the new Lake Wales Ridge NWR should be advertised. Environmental education programs in South Florida should be encouraged to distribute materials or develop lesson plans on scrub habitats, scrub species, and the importance of maintaining natural biodiversity. Educators and potentially interested organizations should be made aware of available resources such as brochures, slide programs, and video tapes from Archbold Biological Station, GFC, and others. Schools and the interested public should know about internet sites that feature Florida scrub.

Restoration of Mesic Temperate Hammock

Restoration Objective: Restoration Objective: Maintain the structure, function, and ecological processes of mesic temperate hammocks and prevent any further loss or degradation of this community in South Florida.

Restoration Criteria: Given that mesic temperate hammocks occur as ecotonal communities or as "islands" in a larger matrix of another natural community type, restoration of this community type implies protection and restoration of surrounding and adjacent communities.

Mesic temperate hammock may be considered restored when: (1) intact mesic temperate hammocks are protected from further degradation; (2) the effects of disturbance in degraded hammocks are reversed by active management; (3) ecological linkages to adjacent communities are restored and preserved; (4) management can insure the persistence in the wild of species that use mesic temperate hammocks as habitat; (5) invasive exotic species are reduced to non-threatening levels; and (6) landscape-level habitat diversity is restored.

Community-level Restoration Actions

1. Protect intact mesic temperate hammocks from further degradation. Recognizing that mesic temperate hammocks occur on the landscape either as included or ecotonal communities, it is critical to protect intact hammocks from both direct impacts and from indirect effects associated with degradation of the surrounding or adjacent communities. The primary tool for protecting mesic hammocks is therefore landscape-level approaches to conservation such as land acquisition, landowner agreements, and conservation easements. These activities will preserve the interrelationship of mesic hammocks with adjacent natural communities, as well as provide opportunities for better control of direct impacts, such as grazing, exotics invasion, vehicle use, and development. Enforcement of laws and regulations concerning trespassing, over-grazing, and wetlands conversion can also be used to protect mesic temperate hammocks on both public and private lands.
2. Restore existing degraded mesic temperate hammocks by active management.
 - 2.1. Restore ecosystem function.
 - 2.1.1. Exclude livestock from mesic temperate hammocks. Grazing and trampling by cattle destroy the herb and shrub layers in mesic hammocks and have long-term consequences for species composition of the canopy. Exclusion of cattle will allow a natural understory to develop.
 - 2.1.2. Eliminate or control exotic species. Mesic temperate hammocks, especially if grazed or otherwise heavily disturbed, are highly vulnerable to invasion by exotic plant species, which compete with native species, particularly in the shrub and herb layers. Repeated and frequent hand removal of most exotic plant species will be necessary to completely eliminate these populations from hammocks. Mesic temperate hammocks are also preferred by feral hogs for their abundant mast crops and plant roots and tubers. Hog rooting heavily impacts the soils and vegetation in hammocks and promotes invasion by non-native species. Because of the popularity of hog hunting, it is unlikely that complete eradication of this species will be politically feasible on State or Federal lands open to hunting. A reduction in the numbers of feral hogs is recommended on such lands; complete eradication is recommended on other lands.

- 2.1.3. Restore natural hydrological regimes to adjacent and surrounding wetlands. Altered hydrology in adjacent or surrounding hydric hammocks, wet flatwoods, and floodplain impacts mesic hammocks. Unnaturally elevated high-water levels and prolonged hydroperiods may weaken or kill some mesic hammock tree species as well as destroy adjacent wetland communities. An artificially lowered water table may lead to development of another community type or render a mesic hammock vulnerable to catastrophic fire.
- 2.1.4. Restore natural fire regimes in surrounding or adjacent communities, allowing fire to enter hammocks and extinguish naturally. This effort will result in the restoration of natural ecotones between mesic hammocks and the surrounding communities, and prevent encroachment by hammock species into adjacent prairies and flatwoods. Fire breaks and roads should be placed well away from mesic hammock ecotones. Ecotones that have been degraded by existing roads and fire breaks should be restored. Infrequent, low-intensity fire is appropriate to mesic hammocks; management plans should specifically include allowing both natural and prescribed fires to burn into mesic temperate hammock.
- 2.1.5. Control public use. Some mesic temperate hammocks have been degraded by off-road vehicle use, housing construction, or extended or repeated use as camp sites. Exclusion of these uses on public lands will promote restoration of the understory in mesic hammocks. Signs and fences may be necessary to discourage off-road vehicle use. Concentration of recreational impacts on public lands to a single area of hammock will allow other, off-limit mesic hammocks to recover.
- 2.1.6. Eliminate sources of pollution to hammocks.
- 2.2. Restore native species to ground and shrub layers. The reintroduction of native species, particularly shrub and herb species, is recommended for mesic hammocks that have been heavily grazed or trampled.
3. Maintain mesic temperate hammocks in a natural condition.
 - 3.1. Continue exclusion or eradication of exotic plants and animals, including hogs and cattle.
 - 3.2. Monitor status of native plant and animal species for negative trends and potential extirpations.
 - 3.3. Maintain natural fire regimes in surrounding and adjacent pyric natural communities.

- 3.4. Monitor hydrologic conditions in adjacent and surrounding communities and correct unnatural fluctuations in water levels and hydroperiods.
- 3.5. Maintain limits and controls on human use.
- 3.6. Monitor and correct for point source and non-point source pollution.
4. Research ecological role of mesic temperate hammock. Mesic temperate hammocks have received very little attention from the scientific community. Their contribution to overall landscape diversity is poorly understood. The importance of this community for providing habitat for threatened and endangered species, particularly animals, has not been studied. These and other issues should be examined.
5. Provide educational materials to public and private land managers on the ecological importance of mesic temperate hammocks and on management needs and issues.

Restoration of Pine Rocklands

Restoration Objective: Maintain the structure, function, and ecological processes of pine rocklands, and prevent any further loss, fragmentation, or degradation of this community in South Florida.

Restoration Criteria: Given that pine rocklands occur as ecotonal communities or as “islands” in a larger matrix of another natural community type, restoration of this community type implies protection and restoration of surrounding and adjacent communities.

Pine rocklands may be considered restored when: (1) a reserve design is developed that identifies intact pine rockland habitat essential for maintaining biodiversity and self-sustaining populations of imperilled species; (2) the reserve design is effected to protect this community through land acquisition or cooperative agreements with landowners; (3) the effects of disturbance in degraded pine rocklands are reversed by active management; (4) any further loss, fragmentation, and degradation of this community has been prevented; (5) ecological linkages to adjacent communities are restored and preserved; (6) management is implemented to benefit the large number of species that depend upon pine rocklands as habitat; (7) invasive exotic species are reduced to non-threatening levels; and (8) landscape-level habitat diversity is restored.

Community-level Restoration Actions

1. Prevent further destruction or degradation of existing pine rocklands.
 - 1.1. Acquire pine rocklands threatened with development. Complete acquisitions in

Miami-Dade County under the Environmentally Endangered Lands Program. Encourage CARL, Save our Rivers, Preservation 2000, the Monroe County Land Authority and the Federal government to complete acquisition projects in the lower Florida Keys. Pine rocklands owned by the Federal government should be designated conservation areas.

- 1.2. Promote conservation easements and landowner agreements. Support the Miami-Dade County Environmentally Endangered Lands Covenant Program and assistance for private landowners of pine rocklands under DERM's Forest Resources Program. Encourage the development of similar programs in the Monroe County.
 - 1.3. Enforce regulatory protection of pine rocklands. Encourage Miami-Dade and Monroe counties to improve regulations protecting pine rocklands, creating language which enables agencies to initiate upland mitigation banks.
 - 1.4. Prevent degradation of existing preserves containing pine rocklands. Work with Federal, State, county, and municipal agencies and non-governmental organizations to prevent further degradation of existing preserves from exotic plant and animal species (including feral and domesticated pets), fire exclusion, anthropogenic fires, unauthorized site uses, illegal dumping, improper siting of facilities (including interpretive trails), poaching of animals, collecting of plants, hydrologic modifications including drainage, flooding and salt-water intrusion, and damage from pesticides and other contaminants.
2. Restore existing degraded pine rocklands through active management.
 - 2.1. Restore connections between and among pine rocklands and surrounding natural communities. Roads and fire breaks that separate pine rocklands from tropical hardwood hammocks and other connecting natural communities should be removed. Roads which dissect and fragment pine rocklands should be removed and restored, except as they are needed as fire breaks.
 - 2.2. Restore natural fire regimes. Pine rocklands that have been degraded due to fire exclusion can be restored with prescribed fires. Each protected pine rockland site should have a fire management plan prepared specifically for it. Management plans should specifically include allowing natural, lightning-ignited fires to burn through pine rockland preserves whenever possible. In addition, plans should specify how and when prescribed fires should be ignited if natural fires are inadequate to meet management objectives. Prescribed burning should occur during the proper season. Fires should be allowed to burn freely into tropical hardwood hammock edges when conducted during the proper fire season and with adequate moisture to protect the hammock interior. Control unauthorized anthropogenic fires.

- 2.3. Where possible, restore the water table to its historic levels. Rehydrate pine rocklands affected by drainage on the Miami Rock Ridge.
 - 2.4. Control exotic plants and animals. Develop control programs that eliminate, to the extent possible, exotic plants and animals from pine rocklands, including outlying populations. Ensure that control measures are not deleterious to native species.
 - 2.5. Restore areas impacted by anthropogenic fires, unauthorized site uses, illegal dumping, and the improper siting of facilities. Pine rocklands that have been impacted by misuse should be restored. Facilities such as interpretive trails that endanger populations of rare plants or animals should be closed, removed, and restored.
 - 2.6. Protect pine rocklands from point and non-point source pollution including mosquito control spraying, and drift from agricultural and commercial operations. Allow species which have been impacted from contaminants to recover naturally or with assistance.
 - 2.7. Reintroduce species which have been extirpated within their historic ranges. Develop plans to reintroduce plant and animal species which have been extirpated from South Florida where appropriate and only within historic ranges. Augment populations and establish new populations of rare species which have been impacted by habitat loss, poaching, collecting pressure, etc., to ensure the long-term persistence of the species in South Florida.
3. Maintain pine rocklands in a natural condition in perpetuity.
 - 3.1. Continue to maintain connections between and among pine rocklands and other natural communities, such as tropical hardwood hammocks.
 - 3.2. Continue to use prescribed fire to maintain pine rockland/tropical hardwood hammock ecotones. Develop and budget for prescribed fire programs in adjacent natural communities.
 - 3.3. Continue to monitor the water table to ensure that pine rocklands are provided with adequate moisture. Ensure that water levels are maintained at their historic levels, where possible.
 - 3.4. Continue to monitor for and control exotic plant and animal species.
 - 3.5. Continue to control public use and eliminate improper use, such as mosquito spraying and drift from agricultural and commercial operations.
 - 3.6. Monitor and correct for both point source and non-point source pollution, especially in

- outlying areas before they become populated.
- 3.7. Monitor and correct for negative population trends among important pine rockland species. Each preserve containing pine rocklands should have a specific monitoring plan that will alert managers to extirpations or downward trends in populations of selected pine rockland species, including endemic species, listed species, and keystone species.
4. Recreate pine rocklands where they have been destroyed by human activities.
 - 4.1. Explore opportunities to utilize natural regeneration as a method to restore connections between and among pine rocklands and other natural communities, as well as to expand the total area of pine rocklands.
 - 4.2. Explore opportunities to utilize secondary pine rocklands as habitat for wildlife.
 5. Create pine rocklands where natural communities have been destroyed by human activities.
 - 5.1. Encourage the use of pine rocklands as landscape models within the built landscape.
 - 5.2. Refine guidelines and specifications for pine rockland creation. Promote the development of refined pine rockland creation guidelines and the development of specifications for all applicable areas of South Florida, including species lists which clearly articulate that species should only be out-planted within their historic ranges.
 - 5.3. Discourage the use of pine rocklands species outside of their historic ranges. Many pine rockland and tropical hardwood hammock species have been promoted for landscape use within South Florida. Unfortunately, many of these species have been and are being planted outside of their historic ranges. Some species are now escaping from cultivation and invading natural areas. The use of native species only within their natural ranges should be encouraged.
 6. Connect existing pine rocklands by acquiring lands for conservation between them. Land acquisition, landowner agreements or conservation easements should be used to prevent development of lands between existing conservation areas and to restore lands where possible. Lands acquired as connectors between conservation areas containing pine rocklands need not include pine rocklands. Historically, pine rocklands existed as a dominant habitat type with other habitat types embedded or surrounding them. Opportunities to use landscapes such as canal banks and roadsides as greenways dominated by native vegetation should be explored.
 7. Encourage community-level research. More research is needed on wildlife habitat needs in

terms of pine rockland functions and biodiversity, pine rockland creation and recreation methods, sea-level rise in the Florida Keys, and historical hydrology of pine rocklands.

8. Monitor land management actions. All management actions should be monitored to determine their effectiveness, and changes should be made to management activities as appropriate. Managers should have a plan for monitoring relative population levels of selected plant and animal species.
9. Increase public awareness. Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Miami-Dade County's Environmentally Endangered Lands Program and CARL. Environmental education programs in South Florida should be encouraged to distribute materials or develop lesson plans on pine rockland habitats, pine rockland species and the importance of maintaining natural biodiversity.

Restoration of Mesic Pine Flatwoods

Restoration Objective: Maintain the structure, function, and biological composition of hydric pine flatwoods, and increase the spatial extent of protected pinelands in South Florida.

Restoration Criteria: South Florida can contribute to the preservation of regionally significant aquifer recharge and fish and wildlife habitat values by preserving mesic flatwoods. The conservation and recovery of listed plant and animal species, wide-ranging species, neotropical birds, and large complexes of isolated and ephemeral wetlands will be accomplished by the preservation and restoration of this community.

The restoration objective will be achieved when: (1) the mesic pine flatwoods habitat is preserved through land acquisition or private landowner cooperative agreements, consistent with the GFC's "Closing the Gaps in Florida's Wildlife Habitat Conservation System," the Florida Panther Habitat Preservation Plan (South Florida Population), the Game and Fresh Water Fish Commission's Preservation 2000 Act Study (Biodiversity Conservation Analysis), current State/Federal land acquisition proposals (including CARL, SOR, etc.), other Federal listed species recovery plans, and regional wildlife habitat protection plans; (2) degraded areas are identified and restored to suitable hydric pine flatwoods habitat; (3) hydrology, fire and exotic plant management is regionally applied to restore and maintain regional plant and animal biodiversity; (4) the geographic extent of mesic pine flatwoods in South Florida is identified; and (5) the integrity of the habitat is maintained by proper South Florida management practices.

Community-level Restoration Actions

1. Identify the extent of remaining mesic pine flatwoods habitat in South Florida. Although the existing GIS, aerial photograph, and ground-truthed land cover information is available for

this community throughout South Florida, a comprehensive regional analysis has not been conducted.

- 1.1. Detail the geographic extent of mesic pine flatwoods in South Florida. This task should integrate existing GIS and other databases on land cover, soils, and hydrology, to correctly identify and separate mesic pine flatwoods from other pine flatwood and wetland types in South Florida. GIS typically cannot differentiate mesic from hydric flatwoods, resulting in an overestimate of the prevalence of mesic pine flatwoods.
 - 1.2. Update the GIS database for mesic flatwoods to monitor cumulative impacts. As areas of mesic pine flatwood are converted to other land uses, changes should be mapped to identify cumulative habitat loss.
 - 1.3. Identify old-growth mesic flatwoods in South Florida. Old-growth mesic pine flatwoods have the potential to sustain rare plant and animal communities. These areas provide unique habitats that are not replaceable within short time spans.
2. Preserve remaining areas of mesic pine flatwoods. Direct loss of habitat resulting from land conversion, habitat degradation, and fragmentation continues unabated in South Florida. However, many of the best remaining areas of intact mesic pine flatwoods have been identified for land acquisition.
 - 2.1. Complete purchase of the following CARL projects: Allapattah Flats (Martin County), Atlantic Ridge Ecosystem (Martin County), Belle Meade (Collier County), Cape Haze/ Charlotte Harbor (Charlotte County), Charlotte Harbor Flatwoods (Charlotte County), Corkscrew Regional Ecosystem Watershed (Lee, Collier counties), Fakahatchee Strand (Collier County), Hall Ranch (Charlotte County), Ocaloacoochee Slough (Hendry, Collier Counties) Pal-Mar (Palm Beach, Martin Counties), Save Our Everglades-South Golden Gates Estates (Collier County), Sebastian Creek (Indian River, Brevard counties), South Savannas (Martin, St. Lucie counties), Lykes Brothers/Palmdale (Glades County).
 - 2.2. Complete purchase of the following Save Our Rivers projects: Corkscrew Regional Ecosystem Watershed (Lee County), and Loxahatchee Slough (Palm Beach County).
 - 2.3. Develop additions to existing Federal and State land acquisition proposals in areas identified as GFC strategic habitat conservation areas and in the 1990 statewide charrette, including the following: Estero Bay Watershed, South of Corkscrew Road, east of I-75 (Lee County); West and East of Burnt Store Road (Charlotte and Lee counties), North of Cape Coral (Lee County): east of the Babcock-Webb WMA (Charlotte County); Picayune Strand in North Golden Gate Estates (Collier County); North of Belle Meade (Collier County), South and East of Myakka Prairie (Sarasota

County); Between Oscar Shearer SP and Pinelands Preserve (Sarasota County); East of the Southwest Florida International Airport (Lee County); North of Immokalee Road (Collier County); the Imperial River drainage (Lee County), areas along Horse Creek (Hardee and DeSoto counties), Brushy Creek (Hardee County), the Peace River (Hardee and DeSoto counties), the Green Swamp (Polk and Osceola counties), northern Palm Beach County and western Martin County.

- 2.4. Implement cooperative habitat preservation programs with private landowners. Much of the mesic pine flatwoods habitat is in private ownership and many private landowners may not choose to participate in fee-simple land acquisition projects (Lykes Brothers/Palmdale -Glades County). Protection through alternate methods may conserve important ecosystems by providing landowners with economic incentives and promoting good stewardship by ensuring that landowners view habitat as an asset, not a liability.
- 2.5. Support and implement cooperative regional greenways programs with landowners and other agencies. Greenways planning has successfully developed cooperative, local conservation plans that will maintain, establish, and manage landscape connections between important resource areas.
- 2.6. Target agency policy or proposed projects under review by COE, Water Management District, and DEP that degrade or eliminate mesic flatwoods habitat. Mesic flatwoods and other pinelands have declined in areal extent and patch size in South Florida because of characterization as non-jurisdictional and suitable wetland creation areas for on-site and off-site mitigation.
 - 2.6.1. Stress avoidance of impacts of this habitat type as a regional permitting concern. Both consultants and permitting entities need to be educated on the importance of this habitat to regional wildlife.
 - 2.6.2. Require type-for-type on- and off-site wetland mitigation when avoidance and minimization criteria have been exhausted. Both consultants and permitting entities often assess credit mitigation on the basis of the wetland depth, not the landscape importance or biodiversity value. This results in conversion of mesic flatwoods to wetland systems and on-site conversion of mesic flatwoods to ponds or pooled wetlands that often kill pine trees.
 - 2.6.3. Examine federal nationwide and State and Federal general permit and permit exemptions to assess impacts on mesic pine flatwoods habitat. Piecemeal development and speculative land clearing in urbanizing areas under agricultural exemptions appears to exacerbate loss of pinelands in the South Florida Ecosystem.

- 2.7. Protect natural communities from point source and non-point source pollution.
 - 2.8. Use existing regulatory mechanisms to protect mesic pine flatwoods by identifying their contribution to the function of adjacent wetlands and wetland dependent species.
 - 2.9. Promote protection of mesic flatwoods by encouraging local government resource planning, including identification of the importance, location, and areal extent in local government comprehensive plans.
3. Manage/enhance mesic pine flatwoods on public lands.
 - 3.1. Develop/identify effective habitat management techniques to maximize the biodiversity of the mesic flatwoods community. South Florida mesic pine flatwoods may benefit from alternate management practices that are sensitive to hydrology, climate, and subtropical vegetation. Standard “southeastern” prescribed fire management, employed in the South Florida Ecosystem, may lower biodiversity of plant and animal species. Diversification of management techniques may increase biodiversity.
 - 3.2. Implement or ensure continuance of habitat management on public lands. State and Federal land managers are faced with funding deficits that prevent or reduce management actions. Perpetual funding sources for staff and equipment should be secured.
 - 3.3. Coordinate land management practices between public land managers. Management of mesic flatwoods on a landscape scale will benefit listed species, particularly wide-ranging species, game species, and neotropical migrants.
 - 3.4. Establish management partnerships with private landowners. Successful fire management and hydrological practices can continue to be supported by or expanded to private lands to achieve a higher level of plant and animal diversity in the South Florida Ecosystem. For some listed species, including the Florida panther and red-cockaded woodpecker, management partnerships may be critical to the regional South Florida recovery.
 - 3.5. Create, maintain, or restore important habitat linkages. Public landowners should coordinate land acquisition and habitat management activities to ensure the protection of large, contiguous tracts of land that include a mosaic of native habitats, including mesic pine flatwoods. The maintenance of regional refugia for wide-ranging species such as the Florida panther or red-cockaded woodpecker may not be sufficient to protect these species in a developing landscape.

- 3.6. Identify and disallow incompatible public uses that degrade mesic pine flatwoods. Incompatible public uses that disrupt hydrology, prevent fire management, pollute, encourage exotic plant or animal invasion, overharvest resources, harvest resources too frequently, or destroy habitat beyond the ability for effective management should be identified and eliminated.
 - 3.7. Monitor compatible adjacent land uses to protect mesic pine flatwood ecological function. Secondary and cumulative impacts to public lands can result from adjacent development, including loss of habitat, wildlife-endangering litter, chemical discharges, dumping, enhancement of exotic plant and animal invasion, prevention of fire management, alteration of adjacent hydrology, and noise/light pollution.
 - 3.8. Encourage maintenance and recovery of natural ecotones. Ecotones are important elements of any natural landscape but may be overmanaged or eliminated by “restoration” efforts. Fire breaks and roads should be placed well away from ecotones. Ecotones that been degraded by existing roads and fire breaks should be restored.
 - 3.9. Control exotic plants and animals.
 - 3.10. Prevent collecting of rare plant species such as bromeliads on public lands. Discourage collecting of rare plant species on private lands.
4. Restore mesic pine flatwoods habitat where feasible.
 - 4.1. Identify locations of mesic flatwoods habitat that can be restored.
 - 4.2. Restore the natural seasonal hydroperiod and fire regime of mesic flatwoods communities. The natural South Florida pattern of fire occurrence and seasonal hydrology has contributed to the third highest plant species diversity of any community in South Florida and has resulted in this community being the dominant component of the South Florida upland landscape essential to wide-ranging wildlife.
 - 4.3. Restore sheetflow hydrologic conditions by restoring the regional landscape to natural contour. Much of South Florida has been significantly altered by public and private drainage projects that have resulted in both overdrainage and flooding of natural systems. Where possible, off-site, regional hydrological restorations may be necessary to restore mesic flatwoods function. Areas where restoration should occur include the South Golden Gate Estates and Camp Keais Strand in Collier County, the Estero Bay watershed in Lee County, and the Babcock-Webb WMA in Charlotte County, Loxahatchee Slough in Palm Beach County, and the Charlotte Harbor Flatwoods CARL project in Lee and Charlotte counties.

- 4.4. Re-establish important habitat linkages by constructing wildlife crossings. A wide variety of development and linear infrastructure projects fragment mesic pine flatwoods. Future design and retrofit/rebuild of these projects should include undercrossings, overpasses and other features that reduce wildlife mortality and preserve hydrology, and increase connectivity with adjacent habitat.
- 4.5. Enhance and manage pinelands containing beautiful pawpaw. Prevent habitat damage by off-road vehicle use, over-grazing by cattle and hogs, or over-collection.
- 4.6. Encourage mitigation banks that restore and enhance mesic pine flatwoods.
5. Identify, acquire and manage mesic flatwoods for the conservation of wide-ranging state and federally listed species. The preservation of pinelands, including mesic pinelands, is critical to the recovery of the Florida panther, Florida black bear, red-cockaded woodpecker, bald eagle, eastern indigo snake, Florida sandhill crane, Big Cypress fox squirrel, Sherman's fox squirrel, and southeastern American kestrels, as well as neotropical migrants.
 - 5.1. Complete purchase of and manage mesic flatwoods in the Belle Meade and South Golden Gate Estates CARL projects for regional protection of Florida panther, Florida black bear, eastern indigo snake, Big Cypress fox squirrel, Florida sandhill crane, and other wildlife.
 - 5.2. Complete purchase of and manage mesic flatwoods in the coastal areas to augment neotropical migratory bird migration and bald eagle foraging and nesting activities, including at the Charlotte Harbor Flatwoods and Cape Haze/Charlotte Harbor Buffer CARL projects, and Pine Island.
 - 5.3. Complete purchase of and manage mesic flatwoods within Priority I and II areas identified in the Florida Panther Habitat Preservation Plan.
 - 5.4. Complete purchase of and manage mesic flatwoods on the east coast for a diverse assemblage of non-game species, including at the Pal-Mar, Atlantic Ridge Ecosystem, Loxahatchee Slough, and Allapattah Ranch CARL projects.
 - 5.5. Determine if old-growth mesic pinelands support red-cockaded woodpecker clusters. Red-cockaded woodpeckers nest and roost in cavities that are typically excavated in old-age living pines if available. Study the utilization of mesic pine flatwoods by red-cockaded woodpeckers, including development of landscape-scale management recommendations for the recovery of this species in South Florida.
 - 5.6. Manage pinelands on public lands in southwest Florida to expand occupation by red-cockaded woodpeckers. The large contiguous public preserves that begin in the

- Picayune State Forest (Belle Meade and South Golden Gate Estates) and extend east and north the Fakahatchee Strand, Florida Panther NWR and Big Cypress National Preserve should be managed as a larger ecological reserve to improve and augment the existing red-cockaded woodpecker population in southwest Florida.
- 5.7. Exclude fire from identified areas of mesic flatwoods that include understory thickets of tall thick palmetto to provide resting and denning cover for panthers.
 - 5.8. Prioritize the protection of coastal mesic flatwoods as bald eagle nesting habitat, and neotropical migratory bird habitat. Bald eagles prefer nest and perch sites on the largest and tallest trees available near large, open water bodies and are primarily coastal in South Florida. Neotropical birds require available forage as close to the coast as possible to augment migration across the Gulf of Mexico and Caribbean. Coastal pinelands are targeted for urban and agricultural development. Pine Island in Lee County is an example of an area of pinelands that should be protected.
 - 5.9. Identify important habitat linkages. Important connecting areas include: CREW to the Southwest International Airport mitigation lands (Lee County), Rookery Bay National Estuarine Research Reserve to Belle Meade CARL (Collier County), Corkscrew Sanctuary to Lake Trafford (Lee and Collier counties), Babcock-Webb WMA to Charlotte Harbor Flatwoods and Charlotte Harbor State Buffer Preserves (Charlotte County)
6. Complete purchase of and manage mesic flatwoods in contiguous, connected, unfragmented patches for the conservation of South Florida biodiversity, including nongame species, rare and unique species, and keystone species such as the swallowtailed kite, Florida weasel, and various owl and raptor species.
 - 6.1. Purchase additional mesic flatwoods for the preservation of the beautiful pawpaw. Very few populations of this plant are protected on public lands. The Charlotte Harbor Flatwoods (Charlotte County) area should be prioritized for ongoing and additional public land purchase.
 - 6.2. Determine if old-growth mesic pine flatwoods support rare plant and animal species, or specific species guilds. Examine the habitat value of mesic pine flatwoods for rare and endemic plants. Old-growth pinelands may support rare and unique species of plants and animals or community guilds.
 - 6.3. Inventory and characterize the importance of mesic flatwoods to avian populations, particularly neotropical migrants, owls and raptors.
 - 6.4. Examine wading bird use of the wetland enclosures of mesic pine flatwoods, including

prairies and freshwater “isolated” wetlands.

7. Perform additional research on mesic pine flatwoods.
 - 7.1. Survey mesic flatwoods in southwest Florida for the beautiful pawpaw, and conduct research on appropriate fire regimes for this species. Updated surveys for the beautiful pawpaw have not been conducted. The range of this species should be determined in order to better understand how to manage the population.
 - 7.2. Determine what fire regimes are recommended in mesic flatwoods to stabilize or increase beautiful pawpaw populations on public lands in southwest Florida.
 - 7.3. Perform a hydrologic study of the water recharge potential of mesic pine flatwoods under natural hydrologic conditions.
 - 7.4. Examine the correlation between soil type and mesic pine flatwoods habitats.
 - 7.5. Examine the influence of fire regimes in maintaining optimal plant and animal species diversity.
 - 7.6. Examine invertebrate diversity and life-cycles in the mesic pine flatwoods.
 - 7.7. Monitor mesic pine flatwoods to evaluate biodiversity. Monitor community-level processes, community structure, and community composition, including rare and keystone species, and species guilds.
 - 7.8. Improve reference ecosystem information for community composition, biodiversity, and site-to-site variability.
8. Increase public awareness concerning mesic pine flatwoods. Identify mesic flatwoods in text, maps, and on resource presentations to raise public awareness of the different types of pine flatwoods. Stress the important ecosystem function of isolated and ephemeral wetlands included in the mesic flatwoods community. Establish the landscape-scale importance of this community to wide-ranging species and the significance of regional losses of this habitat in South Florida.

Restoration of Hydric Pine Flatwoods

Restoration Objective: Maintain the structure, function, and biological composition of hydric pine flatwoods, and increase the spatial extent of protected pinelands in South Florida.

Restoration Criteria: South Florida can contribute to the preservation of regionally significant wetland habitat, hydrology, aquifer recharge, and fish and wildlife habitat values by preserving the geographic extent of hydric pine flatwoods. The conservation and recovery of listed plant and animal species, wide-ranging species, neotropical birds, and large complexes of isolated and ephemeral wetlands will be accomplished by the preservation and restoration of this community.

The restoration objective will be achieved when: (1) the hydric pine flatwoods habitat is reserved through land acquisition or private landowner cooperative agreements, consistent with the Game and Fresh Water Fish Commission's "Closing the Gaps in Florida's Wildlife Habitat Conservation System," the Florida Panther Habitat Preservation Plan (South Florida Population), the Game and Fresh Water Fish Commission's Preservation 2000 Act Study (Biodiversity Conservation Analysis), current State/Federal land acquisition proposals (including CARL, SOR, etc.), other federal listed species recovery plans, and regional wildlife habitat protection plans; (2) degraded areas are identified and restored to suitable hydric pine flatwoods habitat; (3) hydrology, fire and exotic plant management is regionally applied to restore and maintain regional plant and animal biodiversity; (4) the geographic extent of hydric pine flatwoods in South Florida is identified; and (5) the habitat is identified as a true forested, wetland community and no longer portrayed as a transitional habitat.

Community-level Restoration Actions

1. Identify the extent of remaining hydric pine flatwoods habitat in South Florida. Although the existing GIS, aerial photograph, and ground-truthed land cover information is available for this community throughout South Florida, a comprehensive regional analysis has not been conducted.
 - 1.1. Detail the geographic extent of hydric pine flatwoods in South Florida. This task should integrate existing GIS and other databases on land cover, soils, and hydrology, to correctly identify and separate hydric pine flatwoods from other pine flatwood and wetland types, particularly cypress, in South Florida. GIS and National Wetlands Inventory maps often misinterpret hydric flatwoods as cypress.
 - 1.2. Update the GIS database for hydric flatwoods to monitor cumulative impacts. As areas of hydric pine flatwood are converted to other land uses, changes should be mapped to identify cumulative habitat loss.
 - 1.3. Identify old-growth hydric flatwoods in South Florida. Old-growth hydric pine flatwoods have the potential to sustain rare plant and animal communities. These areas provide unique habitats that are not replaceable within short time spans.
2. Preserve remaining areas of hydric pine flatwoods. Direct loss of habitat resulting from land

conversion, habitat degradation, and fragmentation continues unabated in South Florida. However, many of the best remaining areas of intact hydric pine flatwoods have been identified for land acquisition.

- 2.1. Complete purchase of the following CARL projects: Allapattah Flats (Martin County), Atlantic Ridge Ecosystem (Martin County), Belle Meade (Collier County), Cape Haze/ Charlotte Harbor (Charlotte County), Charlotte Harbor Flatwoods (Charlotte County), Corkscrew Regional Ecosystem Watershed (Lee, Collier Counties), Fakahatchee Strand (Collier County), Hall Ranch (Charlotte County), Ocaloacoochee Slough (Hendry and Collier counties) Pal-Mar (Palm Beach and Martin counties), Save Our Everglades-South Golden Gates Estates (Collier County), Sebastian Creek (Indian River and Brevard counties).
- 2.2. Complete purchase of the following Save Our Rivers projects: Corkscrew Regional Ecosystem Watershed (Lee County), and Loxahatchee Slough (Palm Beach County).
- 2.3. Develop additions to existing Federal and State land acquisition proposals in areas identified as GFC strategic habitat conservation areas and in the 1990 statewide charrette, including the following: Estero Bay Watershed, south of Corkscrew Road, east of I-75 (Lee County); west and east of Burnt Store Road (Charlotte and Lee counties), north of Cape Coral (Lee County): east of the Babcock-Webb WMA (Charlotte County); Picayune Strand in North Golden Gate Estates (Collier County); north of Belle Meade (Collier County), south and east of Myakka Prairie (Sarasota County); between Oscar Shearer SP and Pinelands Preserve (Sarasota County); east of the Southwest Florida International Airport (Lee County); north of Immokalee Road (Collier County); Imperial River drainage (Lee County); and areas in northern Palm Beach County that contain hydric pine flatwoods.
- 2.4. Implement cooperative habitat preservation programs with private landowners. Much of the hydric pine flatwoods habitat is in private ownership and many private landowners may not choose to participate in fee-simple land acquisition projects. Protection through alternate methods may conserve important ecosystems by providing landowners with economic incentives and promoting good stewardship by ensuring that landowners view habitat as an asset, not a liability.
- 2.5. Support and implement cooperative regional greenways programs with landowners and other agencies. Greenways planning has successfully developed cooperative, local conservation plans that will maintain, establish, and manage landscape connections between important resource areas.
- 2.6. Target wetland agency policy or proposed projects under review by COE, Water Management Districts, and DEP that degrade or eliminate hydric flatwoods habitat.

Hydric flatwoods and other pinelands have significantly declined in areal extent and patch size in South Florida, primarily because of characterization as uplands or “habitat in transition.”

- 2.6.1. Stress avoidance of impacts of this habitat type as a regional wetlands permitting concern. Both consultants and permitting entities need to be educated on the importance of this habitat to regional fish and wildlife.
 - 2.6.2. Require type-for-type on- and off-site wetland mitigation when avoidance and minimization criteria have been exhausted. Both consultants and permitting entities often assess credit mitigation on the basis of the wetland depth, not the landscape importance or biodiversity value. This results in off-site mitigation of hydric flatwoods to deeper cypress systems and on-site conversion of hydric flatwoods to pooled wetlands that often kill pine trees.
 - 2.6.3. Examine Federal nationwide and State and Federal general permit and permit exemptions to assess impacts on hydric pine flatwoods habitat. Piecemeal development and speculative land clearing in urbanizing areas under agricultural exemptions appears to exacerbate loss of pinelands in the South Florida Ecosystem.
- 2.7. Protect natural communities from point source and non-point source pollution.
 - 2.8. Use existing regulatory mechanisms to protect hydric pine flatwood wetlands. Identify their contribution to the function of adjacent wetlands and wetland-dependent species.
 - 2.9. Promote protection of hydric flatwoods by encouraging local government resource planning, including identification of the importance, location, and areal extent in local government comprehensive plans.
 - 2.10. Prioritize hydric pine flatwoods that need protection higher in land acquisition criteria.
3. Manage/enhance hydric pine flatwoods on public lands.
 - 3.1. Develop/identify effective habitat management techniques to maximize the biodiversity of the hydric flatwoods community. Hydric pine flatwoods may benefit from alternate management practices that are sensitive to hydrology, climate, and subtropical vegetation. Standard “southeastern” prescribed fire management, employed in the South Florida Ecosystem, may lower biodiversity of plant and animal species. Diversification of management techniques may increase biodiversity.
 - 3.2. Implement or ensure continuance of habitat management on public lands. State and

- Federal land managers are faced with funding deficits that prevent or reduce management actions. Perpetual funding sources for staff and equipment should be secured.
- 3.3. Coordinate land management practices between public land managers. Management of hydric flatwoods on a landscape scale will benefit listed species, particularly wide-ranging species and wading birds, and neotropical migrants.
 - 3.4. Establish management partnerships with private landowners. Successful fire management and hydrological practices can continue to be supported by or expanded to private lands to achieve a higher level of plant and animal diversity in the South Florida Ecosystem. For some listed species, including the Florida panther and red-cockaded woodpecker, management partnerships may be critical to the regional South Florida recovery.
 - 3.5. Create, maintain, or restore important habitat linkages. Public landowners should coordinate land acquisition and habitat management activities to ensure the protection of large, contiguous tracts of land that include a mosaic of native habitats, including hydric pine flatwoods. The maintenance of regional refugia for wide-ranging species such as the Florida panther or wood stork may not be sufficient to protect these species in a developing landscape.
 - 3.6. Identify and disallow incompatible public uses that degrade hydric pine flatwoods. Incompatible public uses that disrupt hydrology, pollute, encourage exotic plant or animal invasion, overharvest resources, or destroy habitat beyond the ability for effective management should be identified and eliminated.
 - 3.7. Monitor compatible adjacent land uses to protect hydric pine flatwood ecological function. Secondary and cumulative impacts to public lands can result from adjacent development, including loss of habitat, wildlife-endangering litter, chemical discharges, dumping, enhancement of exotic plant and animal invasion, prevention of fire management, alteration of adjacent hydrology, and noise/light pollution.
 - 3.8. Protect and manage hydric flatwoods for the beautiful pawpaw (*Deeringothamnus pulchellus*) and the other listed plant species.
 - 3.9. Control exotic plants and animals.
 - 3.10. Prevent collecting of rare plant species such as bromeliads on public lands. Discourage collecting of rare plant species on private lands.
4. Restore hydric pine flatwoods habitat where feasible.

- 4.1. Identify locations of hydric flatwoods habitat that can be restored.
- 4.2. Restore the natural seasonal hydroperiod and fire regime of hydric flatwoods communities. The natural South Florida pattern of alternating dry season fire and wet season flood has contributed to the highest plant species diversity of any community in South Florida and has resulted in this community being an essential component of the annual wetland drawdown that supports listed wading birds.
- 4.3. Restore sheetflow hydrologic conditions by restoring the regional landscape to natural contour. Much of South Florida has been significantly altered by public and private drainage projects that have resulted in both overdrainage and flooding of natural systems. Where possible, off-site, regional hydrological restorations may be necessary to restore hydric flatwoods function. Areas where restoration should occur include the South Golden Gate Estates and Camp Keais Strand in Collier County, the Estero Bay watershed in Lee County, and the Babcock-Webb WMA in Charlotte County, the Charlotte Harbor Flatwoods CARL project in Lee and Charlotte counties, and the Loxahatchee Slough in Palm Beach County.
- 4.4. Re-establish important habitat linkages by constructing wildlife crossings. A wide variety of development and linear infrastructure projects fragment hydric pine flatwoods. Future design and retrofit/rebuild of these projects should include undercrossings, overpasses and other features that reduce wildlife mortality and preserve hydrology, and increase connectivity with adjacent habitat.
- 4.5. Enhance and manage pinelands with beautiful pawpaw populations for beautiful pawpaw. Prevent habitat damage by off-road vehicle use, over-grazing by cattle and hogs, or overcollection.
- 4.6. Encourage mitigation banks that restore and enhance hydric pine flatwoods.
5. Identify, acquire and manage hydric flatwoods essential to the conservation of wide-ranging state and federally listed species. The preservation of pinelands, including hydric pinelands, is critical to the recovery of the Florida panther, wood stork, red-cockaded woodpecker, bald eagle, eastern indigo snake, Florida sandhill crane, little blue heron, snowy egret, tri-colored heron, limpkin, white ibis, Big Cypress fox squirrel, Sherman's fox squirrel, and southeastern American kestrels, as well as neotropical migrants.
 - 5.1. Complete purchase of and manage hydric flatwoods in the Belle Meade and South Golden Gate Estates CARL projects for regional protection of Florida panther, Florida black bear, eastern indigo snake, Big Cypress fox squirrel, Florida sandhill crane, and other State listed wading birds. Complete the Loxahatchee Slough purchase, and

manage for the regional protection of the sandhill crane.

- 5.2. Complete purchase of and manage hydric flatwoods in the coastal areas to augment neotropical migratory bird migration, and bald eagle foraging and nesting activities, including the Charlotte Harbor Flatwoods and Cape Haze/Charlotte Harbor Buffer CARL projects, and Pine Island.
- 5.3. Complete purchase of and manage hydric flatwoods within 15 km of wading bird rookeries and 30 km of wood stork rookeries including Belle Meade, Corkscrew Regional Ecosystem Watershed, the Estero and Imperial River watersheds, and areas east of the Southwest International Airport.
- 5.4. Complete purchase of and manage hydric flatwoods within Priority I and II areas identified in the Florida Panther Habitat Preservation Plan.
- 5.5. Determine if old growth hydric pinelands support red-cockaded woodpecker clusters. Red-cockaded woodpeckers nest and roost in cavities that are typically excavated in old-age living pines if available. Study the utilization of hydric pine flatwoods by red-cockaded woodpeckers, including development of landscape-scale management recommendations for the recovery of this species in South Florida.
- 5.6. Manage pinelands on public lands in southwest Florida to expand occupation by red-cockaded woodpeckers. The large contiguous public preserves that begin in the Picayune State Forest (Belle Meade and South Golden Gate Estates) and extend east and north to the Fakahatchee Strand, Florida Panther NWR, and Big Cypress National Preserve should be managed as a larger ecological reserve to improve and augment the existing red-cockaded woodpecker population in southwest Florida.
- 5.7. Identify the potential pineland nesting habitat available to the bald eagle in South Florida. Determine regional eagle concentration areas based on nest location data and pineland location. Model potential response of bald eagle populations in South Florida based on potential and existing nest habitat in public holdings.
- 5.8. Prioritize the protection of coastal hydric flatwoods as bald eagle nesting habitat and neotropical migratory bird habitat. Bald eagles prefer nest and perch sites on the largest and tallest trees available near large, open water bodies and are primarily coastal in South Florida. Neotropical birds require available forage as close to the coast as possible to augment migration across the Gulf of Mexico and Caribbean. Coastal pinelands are targeted for urban and agricultural development. Pine Island in Lee County is an example of an area of pinelands that should be protected.
- 5.9. Identify important habitat linkages. Important connecting areas include: the CREW to

the Southwest International Airport mitigation lands (Lee County), Rookery Bay National Estuarine Research Reserve to Belle Meade CARL (Collier County), Corkscrew Sanctuary to Lake Trafford (Lee and Collier counties), Babcock-Webb WMA to Charlotte Harbor Flatwoods and Charlotte Harbor State Buffer Preserves (Charlotte County), DuPuis Reserve/J.W. Corbett Water Management Area to the West Palm Beach Water Catchment Area (Palm Beach County).

6. Complete purchase of and manage hydric flatwoods in contiguous, connected, unfragmented patches for the conservation of South Florida biodiversity, including nongame species, rare and unique species, and keystone species such as the swallow-tailed kite, American bittern, various owl and raptor species.
 - 6.1. Purchase additional hydric flatwoods for the preservation of the beautiful pawpaw. Very few populations of this plant are protected on public lands. The Charlotte Harbor Flatwoods (Charlotte County) area should be prioritized for ongoing and additional public land purchase.
 - 6.2. Determine if old-growth hydric pine flatwoods support rare plant and animal species, or specific species guilds. Examine the habitat value of hydric pine flatwoods for rare and endemic plants. Old growth pinelands may support rare and unique species of plants and animals or community guilds.
 - 6.3. Inventory and characterize the importance of hydric flatwoods to avian populations, particularly neotropical migrants, woodpeckers, owls and raptors.
7. Perform additional research on hydric pine flatwoods.
 - 7.1. Examine the habitat value of hydric pine flatwoods in Palm Beach and Martin counties, Florida.
 - 7.2. Continue and update studies in the utilization of hydric pine flatwoods by red-cockaded woodpeckers, including development of landscape-scale management recommendations for the recovery of this species in South Florida.
 - 7.3. Perform a hydrologic study of the water recharge potential of hydric pine flatwoods under natural, sheetflow conditions.
 - 7.4. Examine wading bird use of the hydric pine flatwoods, including prairies and freshwater “isolated” wetlands.
 - 7.5. Inventory and characterize the importance of hydric flatwoods to avian populations, particularly neotropical migrants, owls and raptors.

- 7.6. Re-examine the fish and wildlife values traditionally attributed to pine flatwoods by Federal, State and local regulatory entities.
- 7.7. Examine the correlation between soil type and hydric pine flatwoods habitats.
- 7.8. Examine the influence of fire regimes in maintaining optimal plant and animal species diversity.
- 7.9. Re-examine the “empty-niche” ecotonal theory of melaleuca invasion in southwest Florida, relative to human-altered and natural hydric pine flatwoods.
- 7.10. Examine invertebrate diversity and life-cycles in the hydric pine flatwoods.
- 7.11. Examine plant seasonality and invasion dynamics in the understory of hydric pine flatwoods.
- 7.12. Examine invertebrate, forage fish, reptile and amphibian populations associated with wet prairie and freshwater ponded wetlands in hydric flatwoods ecosystems.
- 7.13. Identify and survey hydric flatwoods in southwest Florida for the beautiful pawpaw. Updated surveys for the beautiful pawpaw have not been conducted. The range of this species should be determined in order to manage the population.
- 7.14. Determine what fire regimes are recommended in hydric flatwoods to stabilize or increase beautiful pawpaw populations on public lands in southwest Florida.
- 7.15. Monitor hydric pine flatwoods to evaluate biodiversity. Monitor community level processes, community structure, and community composition, including rare and keystone species, and species guilds.
- 7.16. Improve reference ecosystem information for community composition, biodiversity, and site-to-site variability.
- 7.17. Identify historical hydroperiods in hydric pine flatwoods in South Florida. The timing and duration of wetland drawdown in hydric pine flatwoods systems has not been widely documented in South Florida and may differ temporally and in coastal and inland systems.
- 7.18. Investigate wood stork foraging ecology and behavior in the hydric pine flatwoods, particularly in conjunction with rookeries such as the Corkscrew Sanctuary in Collier County.

8. Increase public awareness concerning hydric pine flatwoods. Identify hydric flatwoods in text, maps, and on resource presentations to raise public awareness of the different types of pine flatwoods. Stress the important ecosystem function of isolated and ephemeral wetlands included in the hydric flatwoods community. Establish the landscape-scale importance of this community to wide-ranging species and the significance of regional losses of this habitat in South Florida.

Restoration of Dry Prairie

Restoration Objective: Restoration Objective: Maintain and enhance the structure, function, and composition of the dry prairie community, protect dry prairie biodiversity to encompass the range of geographic variation, and increase the spatial extent of dry prairie habitat in South Florida.

Restoration Criteria: The restoration objective will be achieved when: (1) dry prairies within the historic range of the community are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression; (2) degraded areas are identified, acquired and restored to suitable dry prairie habitat; (3) appropriate ecosystem management plans (including monitoring and research) have been prepared, funded, and implemented for long-term perpetuation of the dry prairie landscape; (4) dry prairie is appropriately protected and managed to benefit community-dependent species; (5) ecological linkages to adjacent communities are restored; and (6) landscape-level habitat diversity is restored.

Community-level Restoration Actions

1. Determine the historical and current distribution and status of dry prairie in peninsular Florida. Published and unpublished data on both the distribution and status of dry prairie is inconsistent and based in part on misinterpretation of Landsat data (see section on Status and Trends in this account). Estimates of the current status of dry prairie vary from virtually none remaining to rather large blocks remaining on privately owned rangeland.
 - 1.1 Determine the historical extent and location of dry prairie for all counties in the dry prairie region as defined by Davis (1943), by utilizing the original land surveys for Florida conducted in the 1850s. These land surveys could be used to produce a historical map of Florida dry prairie and calculate the historical area of dry prairie for each county. See discussion on Status and Trends in this account.
 - 1.2 Determine the current distribution and status of dry prairie on both private and public lands in Florida. This action could be accomplished by using recent aerial photography and Landsat imagery that has been intensively ground-truthed to eliminate errors in interpretation. Digital Orthophoto Quads (DOQ's) could be used to digitize the current

distribution of dry prairie as a GIS coverage.

- 1.3. Identify, map, and conduct ecological (plant and animal) inventories of the remaining dry prairie to determine locations for the highest-quality dry prairie sites. Data from a systematic and comprehensive inventory could be used to develop, rank and prioritize the most ecologically significant dry prairie areas and determine the degree of vulnerability of sites. Plant and animal inventories and de novo searches for rare species would uncover previously unknown sites and thereby provide updated documentation on the status and distribution of rare species.
2. Prevent further destruction or degradation of existing dry prairie.
 - 2.1. Secure protection of all the remaining intact, high-quality dry prairie sites. Develop a protection plan for all tracts identified in 1.2 and 1.3. Continue through land acquisition, landowner agreements, and conservation easements, land trades, or other conservation measures, protection of dry prairie sites. Priority should be placed on preventing the loss of any remaining high-quality dry prairie sites, with emphasis on protection of sites with intact landscapes and an intact, diverse native ground cover. Devise and negotiate interagency agreements (with WMDs, DEP, FWS, etc.) to improve mitigation procedures for loss of wetlands in dry prairie landscapes. Sites identified as most threatened with destruction should be targeted and protected to prevent destruction.
 - 2.2. Prevent further degradation of disturbed, but recoverable examples of dry prairie by securing protection of such sites. This may best be accomplished by conservation methods other than land acquisition that prevent development, such as conservation easements, particularly on large cattle ranches where land acquisition is cost-prohibitive.
 - 2.3. Ensure proper protection of existing protected areas. Drainage and other hydrologic alterations on private land adjacent to existing protected areas continues to be an ongoing and unresolved crisis on at least two protected sites-Three Lakes WMA in Osceola County, and the National Audubon Society's Ordway-Whittell Kissimmee Prairie Sanctuary in Okeechobee County. Federal and State agencies need to work more efficiently and closely together to solve problems that cross the jurisdictional boundaries of an agency.
 - 2.4. Ensure proper management of existing protected areas. Staffing and budgetary constraints continue to present the greatest threat to proper management of existing protected areas. Other problems faced by land managers that hinder implementation of proper management strategies include lack of technical guidance information, and insufficient equipment and manpower. In the formulation of management plans, avoid

uniformity of management treatments which artificially simplify what probably was once a far more varied set of communities that constituted prairie biodiversity (Howe 1994). Varied treatments and experimental management should be encouraged, since so few quantitative studies exist on management effects on prairie biodiversity (Howe 1994). A rethinking of management priorities is needed if such experiments suggest that prairie biodiversity could be managed out of existence by certain practices (Howe 1994).

- 2.5. Develop private landowner protection incentives for dry prairie (Enge et al. 1997). Provide an economic or tax incentive to private landowners to prevent conversion of native pastureland into improved pastureland. Federal, State and county governments should explore new and innovative ways to provide tax breaks or other economic incentives to private landowners that choose ecological stewardship of their lands. Economic opportunities for private landowners to retain native vegetation should be encouraged, including hunting, eco-tourism, low intensity grazing of native rangeland, harvesting of native grass seed for mining reclamation and other restoration purposes, and harvesting of saw palmetto fruits for medicinal uses. All of these help provide economic incentives to landowners to retain areas in natural dry prairie vegetation.
- 2.6. Connect existing dry prairie preserves by acquiring lands for conservation between them. Land acquisition, landowner agreements, or conservation easements should be used to prevent development of lands between existing conservation areas. Lands acquired as connectors between dry prairie preserves need not be dry prairie. Historically, the dry prairie/flatwoods landscape covered vast areas of south-central Florida, and this pattern should be maintained as much as possible.
- 2.7. Conduct vegetation monitoring of dry prairie to determine responses to various management strategies. Several potential results could come from vegetation monitoring of dry prairie habitat which have implications for the Florida grasshopper sparrow. First, by considering the effects of management on a broader set of ecosystem components (e.g. all the plant species present), the possibility of misleading results (in the context of ecosystem management) based on a single species subject to possible non-management related events (i.e. predation) is minimized. Secondly, because much more replication is possible in a vegetation study, the chances of uncovering statistically significant differences between treatments is increased. Thirdly, long-term trends in the abundance of conservative versus weedy or opportunistic species can be monitored within vegetation monitoring plots, and can be used as input for management decisions. The long-term population trends of Florida grasshopper sparrows are best addressed by beginning to monitor the health of the ecosystem as a whole, and a better understanding of the microhabitats selected by the species in order to incorporate the perpetuation of these microhabitats into ecosystem management decisions.

- 2.8. Encourage and support the efforts of the central and South Florida interagency prescribed fire councils. Without the ability and flexibility to use prescribed burning, management of dry prairie would be virtually impossible. The role of the prescribed fire councils in safeguarding, promoting and educating the public about the use of prescribed fire is essential to the future of prescribed burning.
3. Restore existing degraded dry prairies. Develop techniques for restoring modified or disturbed dry prairie (Enge et al. 1997) and criteria for monitoring the success of restoration efforts (Anderson 1997, Zedler 1997).
 - 3.1. Reintroduce natural fires and/or prescribed controlled burns. Dry prairies that have been degraded due to fire exclusion can be restored with prescribed burning. Each protected dry prairie site should have a fire management plan. Management plans should specifically include allowing natural, lightning-ignited fires to burn through the dry prairie landscape whenever possible, especially on the larger preserves, such as the Kissimmee Prairie State Preserve and the National Audubon Society's Ordway-Whittell Kissimmee Prairie Sanctuary. Burn plans for sites should specify fire type, intensity and frequency in order to mimic natural fires and to meet management objectives.
 - 3.2. Encourage maintenance and recovery of landscape-level ecological processes. Where possible, management efforts should strive to maintain and enhance ecological processes (natural fire regimes, natural hydrologic perturbations, biological interactions, ecosystem function, etc.) characteristic of the natural landscape. In particular, allowing natural lightning fires and other natural disturbances should receive special attention in management plans for areas with intact landscapes. Firebreaks and roads should be placed well away from ecotones. Ecotones that have been degraded by existing roads and fire breaks should be restored.
 - 3.3. Eliminate or control exotic and off-site species. The native ground cover of some dry prairies has been altered by past attempts to improve their livestock grazing potential and/or commercial forestry potential. Efforts to eliminate or control exotic plants should be implemented. In addition, total eradication of feral hogs should be a priority on dry prairie preserves.
 - 3.4. Continue to allow compatible public uses. Dry prairies acquired for conservation of biotic resources must be protected from inappropriate public use. However, compatible public uses are very valuable in public education about the ecosystem and the need for conservation. Off-road vehicle use and destructive commercial rare plant collecting are not compatible with preservation.
 - 3.5. Monitor for negative population trends among important dry prairie plant and animal

species. Each dry prairie preserve should have a specific monitoring plan that will alert land managers to extirpation or downward trends in populations of selected dry prairie species, including endemic species, listed species, and keystone species.

- 3.6. Monitor and eliminate hydrologic alterations. Recent hydrologic alterations created by adjacent landowners to control water flows on their properties present a real and current threat on Three Lakes WMA in Osceola County and the National Audubon Society's Ordway-Whittell Kissimmee Prairie Sanctuary in Okeechobee County. Vegetation sampling and monitoring of permanent vegetation plots is needed to determine the effects of hydrologic alteration on dry prairie vegetation.
4. Create dry prairie analogs where dry prairie has been destroyed by human activities such as mining. In Polk County, Callahan et al. (1990) report on preliminary results that suggest the costs of creating "moderate-quality" examples of "palmetto prairie" on a 60 ha parcel of mined land, although higher in initial cost than creating pastures, may not be as high as formerly reported. Callahan et al. (1990) report that while improved pastures can be created on mined land by seeding alone, actual restoration of prairies requires topsoiling, intensive planting of herbaceous species, direct seeding, or a combination of these methods, at a higher initial cost. However, Callahan et al. (1990) state that prairies might be nearly maintenance-free, while pastures are accompanied by higher land management expenses. Efforts to revegetate former strip mine lands using native species should continue (Callahan and Cates 1991).
5. Encourage ecosystem/landscape level research projects in dry prairie. Identify ecosystem processes (vegetation composition and structure, successional patterns, hydrologic regimes, burn regimes, herbivory, etc.) in dry prairie and use research findings to aid in development of management guidelines and strategies (Enge et al. 1997). Provide useful information on current research needs to IFAS Southwest Florida Research and Education Centers (SWFREC) Agro-Ecology and Natural Resources Advisory Committee (Enge et al. 1997).
 - 5.1. Determine the rangewide geographic variation in the dry prairie ecosystem. Conduct rangewide studies incorporating floristic surveys (considering species composition, phytogeographic patterns, relative frequency data, and vegetative physiognomy), faunal surveys and correlated environmental parameters (climate, hydrology, edaphic factors and regional landscape context) to recognize and differentiate regional variation in dry prairie. There is considerable regional diversity in peninsular Florida pine flatwoods and savannas (Orzell and Bridges 1997), and preliminary findings by Bridges and Reese (1998) suggest that there is also regional variation in dry prairie. In order to protect the biodiversity of dry prairie there need to be studies to determine the geographic variation within dry prairie.
 - 5.2. Fund and conduct research on the effects of livestock grazing on dry prairie. Since

much of the economic incentive to private landowners to retain dry prairie is derived from revenues generated from livestock grazing, it is important to fund studies evaluating the effects of livestock grazing on all components of the dry prairie ecosystem, including the effects on specific plants and animals. Funding to evaluate the effects of livestock grazing on dry prairie vegetation through establishment of permanent plots and grazing exclosures to monitor the long-term effects of livestock grazing should be encouraged. Funding should be secured to continue ongoing projects (*i.e.*, Bridges et al. 1998), initially funded by Avon Park Air Force Range, to evaluate the effects of grazing on dry prairie vegetation and the Florida grasshopper sparrow.

- 5.3. Encourage research on prescribed burning in dry prairie. As more dry prairie is purchased and/or protected, management knowledge about the effects of fire frequency, intensity and seasonality will become increasingly important to maintenance of the biodiversity of the dry prairie landscape. Recent trends of land managers to burn at times other than early spring and early summer, in order to avoid impacting any potentially listed birds needs to be studied (see section above in this account). In addition, the long-term effects of differing fire frequencies needs study, since recent trends indicate that many land managers of public properties are burning dry prairie typically on a 3-year rotation, rather than the more natural annual or biennial burn cycle. Knowledge about the natural fire season and research on fire intervals would lead to initiation of improved fire management programs (Dye 1997).
 - 5.4. Conduct research to determine the applicability and effectiveness of various mechanical treatments for restoration of severely degraded dry prairies. Former dry prairies that have been degraded due to fire suppression or other disturbances may benefit from controlled burns and some mechanical restoration treatments, such as rollerchopping. Work initiated by Tanner (1997) and Fitzgerald et al. (1995) should receive continuing funding to determine long-term effects and trends.
6. Increase awareness and knowledge of the dry prairie ecosystem.
 - 6.1. Provide support for a regional 1-3 day symposium on the Florida dry prairie ecosystem. The Florida Native Plant Society, Florida Department of Environmental Protection Division of State Land Management, Avon Park Air Force Range Natural Resources Flight, Florida Chapter of The Nature Conservancy, Florida Game and Fresh Water Fish Commission Non-game Wildlife Program, Florida Chapter of the National Audubon Society, FWS South Florida Office, and Southeastern Chapter of the Society for Ecological Restoration should sponsor, participate and support a symposium on Florida dry prairie. Ongoing and past research funded by the Department of Defense on rare dry prairies species and vegetation composition, along with research at Myakka River SP, the National Audubon Society's Ordway-Whittell

Kissimmee Prairie Sanctuary, and inventory efforts at the Kissimmee Prairie State Preserve could be highlighted. In addition, land managers of privately owned rangelands and other public lands should be encouraged to attend and make presentations on their management practices and results.

- 6.2. Provide technical advisory support to private landowners of dry prairie. Provide technical information on ecosystem management strategies and practices to private landowners willing and interested in protecting biodiversity of dry prairie.
- 6.3. Increase public awareness and understanding of the dry prairie ecosystem. Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Florida's Conservation and Recreational Lands (CARL) program and Preservation-2000. Environmental education programs in South Florida should be encouraged to distribute materials or develop lesson plans on dry prairie habitats, dry prairie species, and the importance of maintaining natural biodiversity. A recent article by Benshoff (1998), "Florida dry prairie, an endangered land," published in *Wildlife and Nature*, Florida's Outdoor Magazine is an excellent example for educational purposes. Develop a Wildlife Series, like others at GFC, and an education campaign on dry prairie (Enge et al. 1997).

Restoration of Cutthroat Grass Communities

Restoration Objective: Maintain and enhance the structure, function, and composition of cutthroat grass communities, protect cutthroat grass biodiversity to encompass the range of geographic variation, and increase the spatial extent of cutthroat grass habitat in South Florida.

Restoration Criteria: The restoration objective will be achieved when: (1) cutthroat grass communities are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression; (2) degraded areas are identified, acquired, and restored to suitable habitat; (3) appropriate ecosystem management plans (including monitoring and research) have been prepared, funded, and implemented for long-term perpetuation of the cutthroat grass landscape; (4) cutthroat grass is appropriately protected and managed to benefit community-dependent species; (5) ecological linkages to adjacent communities are restored; and (6) landscape-level habitat diversity is restored.

Community-level Restoration Actions

1. Determine the historical and current distribution and status of cutthroat grass communities in peninsular Florida. There is very little specific published or unpublished data on the rangewide distribution and status of cutthroat grass and cutthroat grass communities. Estimates of the current extent of cutthroat grass communities are known only for Archbold

Biological Station and Avon Park AFB.

- 1.1. Estimate the historical extent and location of cutthroat grass communities for all counties within the range of cutthroat grass. This would require interpretation of soil surveys, geomorphologic features, and historical aerial photography, in conjunction with mapping of known occurrences, to derive an estimate of potential range and extent of cutthroat grass and cutthroat grass communities.
 - 1.2. Determine the current distribution and status of cutthroat grass communities on both private and public lands in Florida. Some cutthroat grass communities could be located by interpretation of recent aerial photography. However, fire-suppressed examples and cutthroat grass flatwoods communities would be difficult to accurately locate on aerial photographs, and would require intensive ground-truthing to eliminate errors in interpretation.
 - 1.3. Identify, map and conduct ecological (plant and animal) inventories of remaining cutthroat grass communities to determine locations for the highest quality cutthroat grass community sites. Data from a systematic and comprehensive inventory would be used to develop, rank and prioritize a listing of the most ecologically significant cutthroat grass communities and to determine the degree of vulnerability of sites. Plant and animal inventories and de novo searches for rare taxa would uncover previously unknown sites and thereby provide updated documentation on the status and distribution of rare taxa. To date, these surveys have been conducted at few sites other than within Avon Park AFB.
2. Prevent further destruction or degradation of existing cutthroat grass communities.
 - 2.1. Secure protection for all of the remaining intact, high-quality cutthroat grass community sites. Develop a protection plan for all tracts identified in 1.2 and 1.3. Continue through land acquisition, landowner agreements, and conservation easements, land trades, or other conservation measures protection of cutthroat grass sites. Priority should be placed on preventing the loss of any remaining high-quality cutthroat grass community sites, with emphasis on protection of sites with intact landscapes and an intact, diverse native ground cover. Devise and negotiate interagency agreements (with Water Management Districts, Department of Environmental Protection, U. S. Fish & Wildlife Service, etc.) to improve mitigation procedures for loss of wetlands in cutthroat grass community landscapes. Sites identified as most threatened with destruction should be targeted and protected to prevent destruction. Once cutthroat grass communities have been converted to agricultural, commercial, or residential uses, there is no known way to restore cutthroat grass or associated species. The highest priority should be placed on preventing development of remaining cutthroat grass communities.

- 2.2. Prevent further degradation of disturbed, but recoverable examples of cutthroat grass communities by securing protection of such sites. This could be accomplished by conservation methods that prevent development, other than land acquisition, such as conservation easements, particularly on large cattle ranches where land acquisition is prohibitively expensive.
- 2.3. Ensure proper protection of existing protected areas. Fire-suppression and lack of sufficiently frequent or intense prescribed burning continues to be a problem in management of cutthroat grass communities even in protected areas. Drainage and other hydrologic alterations on private land adjacent to existing protected areas, and alterations in the source of seepage hydrology within the uplands adjacent to cutthroat grass communities could be a major long-term problem in maintaining protected sites. Federal and State agencies need to work more efficiently and closely together to solve problems that cross the jurisdictional boundaries of an agency.
- 2.4. Ensure proper management of existing protected areas. Staffing and budgetary constraints continue to present the greatest threat to proper management of existing protected areas. Other problems faced by land managers that hinder implementation of proper management strategies include lack of technical guidance information, insufficient equipment and manpower, and restrictions on the timing, size, and intensity of prescribed burning.
- 2.5. Develop private landowner protection incentives for cutthroat grass communities. Provide an economic or tax incentive to private landowners to prevent drainage and alteration of the watersheds supporting cutthroat grass communities. Federal, State and county governments should explore new and innovative ways to provide tax breaks or other economic incentives to private landowners that choose ecological stewardship of their lands. Economic opportunities for private landowners to retain native vegetation should be encouraged, including hunting, eco-tourism, low-intensity grazing of native rangeland, and harvesting of native grass seed for reclamation and restoration purposes. All of these help provide economic incentives to landowners to retain areas in natural cutthroat grass vegetation. Eliminate any tax incentives for silvicultural operations on cutthroat grass communities.
- 2.6. Connect existing cutthroat grass community preserves by acquiring lands for conservation between them. Land acquisition, landowner agreements or conservation easements should be used to prevent development of lands between existing conservation areas. Lands acquired as connectors between cutthroat grass community preserves need not be cutthroat grass communities. Much of this interconnection can be provided by designing preserves and connectors which encompass scrub and other xeric upland communities in association with the adjacent cutthroat grass communities.

- 2.7. Conduct vegetation monitoring of cutthroat grass communities to determine responses to various management strategies. Several potential results could come from vegetation monitoring of cutthroat grass communities which have implications for long-term management strategies. First, by considering the effects of management on a broader set of ecosystem components (e.g. all the plant species present) the possibility of misleading results (in the context of ecosystem management) based on a single species subject to possibly non-management related events is minimized. Secondly, because much more replication is possible in a vegetation study, the chances of uncovering statistically significant differences between treatments is increased. Thirdly, long-term trends in the abundance of conservative versus weedy or opportunistic species can be monitored within the plots, and can be used as input for management decisions.
 - 2.8. Encourage and support the efforts of the central and South Florida interagency prescribed fire councils. Without the ability and flexibility to use prescribed burning, management of cutthroat grass communities would be virtually impossible. The role of the prescribed fire councils in safeguarding, promoting and educating the public about the use of prescribed fire is essential to the future of prescribed burning.
3. Restore existing degraded cutthroat grass communities. Develop techniques for restoring modified or disturbed cutthroat grass communities.
 - 3.1. Reintroduce natural fires and/or prescribe controlled burns. Cutthroat grass communities that have been degraded because of fire exclusion may be restorable with prescribed fires. Each protected cutthroat grass community site should have a fire management plan. Management plans should specifically include allowing natural, lightning-ignited fires to burn through the cutthroat grass community landscape whenever possible, especially on the larger preserves. Burn plans for sites should specify fire type, intensity and frequency in order to mimic natural fires to meet management objectives.
 - 3.2. Encourage maintenance and recovery of landscape-level ecological processes. Where possible, management efforts should strive to maintain and enhance ecological processes (natural fire regimes, natural hydrologic perturbations, biological interactions, ecosystem function, etc.) characteristic of the natural landscape. In particular, allowing natural lightning fires and other natural disturbances should receive special attention in management plans for areas with intact landscapes. Firebreaks and roads should be placed well away from ecotones. Firebreaks at ecotones can greatly disrupt the hydrology of cutthroat grass communities. Ecotones that have been degraded by existing roads and fire breaks should be restored.
 - 3.3. Eliminate or control exotic and off-site species. The native ground cover of some

cutthroat grass communities has been altered by past attempts to improve the livestock grazing potential and /or commercial forestry potential. Effort to eliminate or control exotic plants should be implemented. In addition, eradication of feral hogs should be a priority on cutthroat grass community preserves.

- 3.4. Continue to allow appropriate public uses. Cutthroat grass communities acquired for conservation of biotic resources must be protected from inappropriate public use. However, public access is very important for educational purposes and to build public support for conservation efforts. Off-road vehicle use and commercial rare plant collecting are not compatible with conservation.
 - 3.5. Monitor for negative population trends among important cutthroat grass community plant and animal taxa. Each cutthroat grass community preserve should have a specific monitoring plan that will alert land managers to extirpations or downward trends in populations of selected cutthroat grass community species, including endemic species, listed species, and imperilled species.
 - 3.6. Monitor and eliminate hydrologic alterations. Artificial drainage from cutthroat grass communities should be minimized by plugging of ditches, and filling ruts associated with old firebreaks, fire plow furrows, and woods roads, particularly those which run downslope and serve to drain the community. Vegetation sampling and monitoring of permanent vegetation plots is needed to determine the effects of hydrologic alteration on cutthroat grass communities.
4. Encourage ecosystem/landscape-level research projects in cutthroat grass communities. Identify ecosystem processes (vegetation composition and structure, successional patterns, hydrologic regimes, burn regimes, herbivory, etc.) in cutthroat grass communities and use research findings to aid in development of management guidelines and strategies.
 - 4.1. Determine the rangewide geographic and local edaphic variation in the cutthroat grass community ecosystem. Conduct rangewide studies incorporating floristic surveys (considering species composition, phytogeographic patterns, relative frequency data and vegetation physiognomy), faunal surveys and correlated environmental parameters (climate, hydrology, edaphic factors and regional landscape context) to recognize and differentiate regional variation and local edaphic variation. This is of particular importance to determine if the cutthroat grass communities described for Avon Park AFR (mostly on the Bombing Range Ridge) are similar or dissimilar to communities on the Lake Wales Ridge, and if additional, as yet undescribed, cutthroat grass community types are present on the Lake Wales Ridge. Understanding local and regional variation is necessary in order to protect the biodiversity of cutthroat grass communities.

- 4.2. Fund and conduct research on the effect of livestock grazing on cutthroat grass communities. Since much of the economic benefit to private landowners of cutthroat grass communities is derived from revenues generated from livestock grazing, it is important to fund studies evaluating the effects of livestock grazing on not only the cutthroat grass community, but also on its flora and fauna. Funding to evaluate the effects of livestock grazing on cutthroat grass vegetation through establishment of permanent plots and exclosures to monitor the long-term effects of livestock grazing should be encouraged.
 - 4.3. Encourage research on prescribed burning in cutthroat grass communities. As more land with cutthroat grass communities is purchased and/or protected, management knowledge about the effects of fire frequency, intensity and seasonality will become increasingly important if we are to maintain the biodiversity of the cutthroat grass community and landscape. In addition, the long-term effect of differing fire frequency needs study, since recent trends indicate that many land managers of public properties are burning cutthroat grass communities typically on a 3-year rotation, rather than the potentially more natural annual or biennial burn cycle. Knowledge about the natural fire season and research on fire intervals would lead to initiation of improved fire management programs.
 - 4.4. Conduct research to determine the applicability and effectiveness of various mechanical treatments for restoration of severely degraded cutthroat grass communities. Former cutthroat grass communities that have been degraded because of fire suppression or other disturbances should benefit from controlled burns.
5. Increase awareness and knowledge of the cutthroat grass ecosystem.
 - 5.1. Provide technical advisory support to private landowners of cutthroat grass communities. Provide technical information on ecosystem management strategies and practices to private landowners willing and interested in protecting biodiversity of cutthroat grass communities.
 - 5.2. Increase public awareness and understanding of the cutthroat grass ecosystem. Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Florida's Conservation and Recreational Lands (CARL) program and Preservation-2000. Environmental education programs in South Florida should be encouraged to distribute materials or develop lesson plans on cutthroat grass community habitats, cutthroat grass community species and the importance of maintaining natural biodiversity. Develop a Wildlife Series, like others at GFC, and an education campaign on cutthroat grass communities.

Restoration of Freshwater Marshes and Wet Prairies

Restoration Objective: Restore natural water quality, increase the spatial extent, and restore natural hydropatterns and seasonal flows to freshwater marshes and wet prairies in South Florida.

Restoration Criteria: South Florida must restore and preserve the highly threatened Kissimmee River-Lake Okeechobee-Everglades drainage system, as well as freshwater marsh and wet prairie habitats that are associated with other lakes and creeks, and isolated freshwater marshes and wet prairies. The recovery of listed plant and animal species, and the continued existence of other species of concern, including the American alligator, apple snail, and migratory birds, depends upon the restoration of these communities. Restoration of freshwater marshes and wet prairies must also assure flood control and aquifer recharge for drinking water and agriculture.

The restoration objective will be achieved when (1) the Kissimmee River is restored to its natural basin; (2) Lake Okeechobee water quality and water storage are restored to more natural conditions; (3) the Water Conservation Areas, including the Arthur C. Marshall Loxahatchee NWR have water quality and sheet flow, and hydropatterns restored to more natural conditions; (4) Everglades NP and Big Cypress National Preserve have water quality, sheet flow and hydropatterns restored to natural conditions; (5) the Northeast Shark River Slough (NESRS) addition to Everglades NP and the eight and one half square mile area (8.5 SMA) of the East Everglades land purchases are completed and sheet flow is restored; (6) the lands currently identified by the COE, SFWMD and the National Audubon Society as Water Preserve Areas are added to the spatial extent of the system to provide additional natural wetlands, flood control, and aquifer recharge; (7) the SOR additions are made through the use of all possible conservation land funding methods (SOR, CARL and Federal financial assistance); (8) prescribed burning is restored to the management of the marsh and wet prairie systems; (9) exotic biota including Brazilian pepper, melaleuca, Australian pine, hydrilla, and water hyacinth are eradicated or controlled; (10) the integrity of the marshes and wet prairies are ensured and maintained through a sound water management program of delivery schedules, and water storage patterns to be derived from the Central and Southern Florida (C&SF) Restudy; and (11) the distinction between wet prairie and marsh habitat conditions, [sic]

Community-level Restoration Actions

1. Restore the maximum spatial scale to the natural ecosystems.
 - 1.1. Support and accelerate land acquisition programs by expanding funding and staffing for land transfers. Current land acquisition programs (P 2000, CARL, SOR, etc.) are guided by highly sophisticated gap analyses to set priorities (Cox et al. 1994, 1997), to improve core areas for listed species and reduce habitat fragmentation to increase the likelihood of long-term metapopulation survival. Combined Federal and State programs have been enacted to acquire the Northeast Shark River Slough (NESRS),

the Frog Pond, and the Addition Lands to the Big Cypress National Preserve. The Save Our Rivers Program (SFWMD 1998) has acquired or plans acquisition of lands associated with the Frog Pond, L31N, Corkscrew Regional Ecosystem Watershed (CREW), C-111, East Coast Buffer Strip (also called the Water Preserve Areas (see below), Kissimmee Prairie Ecosystem, Kissimmee River upper and lower lake basin watersheds, Kissimmee Chain of Lakes, Shingle Creek, Everglades Agricultural Area stormwater treatment areas (STAs), Indian River Lagoon, Lake Lizzie, Lake Walk-in-Water, and boundary modifications for the Southern Glades and Model Lands Basin, Loxahatchee Slough, and North Fork St. Lucie River. The Save Our Rivers program also includes completion of outstanding land interests in the water conservation areas (WCAs). Critical to the continuation and completion of these land acquisition programs at the State level is renewing the funding sources to extend a program similar to P2000 into the 21st century.

The acquisition of the remaining NESRS lands, Water preserve area (WPA) lands for a buffer strip and additional water storage capacity for implementation of the Modified Water Delivery plan to Everglades National Park has fallen behind schedule, and the current period of high waters (1994 to 1998) has created conditions that make it very clear that the SFWMD is beyond its capacity to store water. Massive amounts of water are being shunted out through the Caloosahatchee River, St. Lucie drainage system, and the remaining canals to the estuaries in the coastal areas. Also, the water deliveries to Everglades NP continue to be drained toward the west, which damages the wet prairies through flooding, and the eastern prairies and marshes by over-drying.

The high water levels in Lake Okeechobee endanger the Lake's natural marsh littoral zones, as well as the structural integrity of the Herbert Hoover Dike. An accelerated rate of purchase of peripheral wetlands for inclusion in the WATER PRESERVE AREA buffer system is recommended.

The GFC has developed a sophisticated set of documents to evaluate the criteria and priorities for land acquisition for federally and state listed species (Cox et al. 1994, 1997). The priorities are based on a complex effort that coordinates all available information on listed species, and critical habitats or vegetational community types to identify strategic habitat conservation areas (SHCAs) in relation to current managed lands, as well as lands identified as critical by other agencies, or institutions (e.g. CARL, SOR, P2000, FNAI). The results of these reports are of great significance in identifying the geographic gaps that need to be acquired or protected (e.g. by less-than-fee methods) to preserve listed species, vegetational community types, and ecosystems.

Cox et al. (1994, 1997) have pointed out that the land cover types most well represented in current publicly managed lands are wetlands, including marshes and

wet prairies. They point out that these cover types are, in a sense, over-represented in the current publicly managed land system, and made strong arguments for the need for land acquisitions in other cover types or vegetative communities, such as scrub, and pine flatwoods. But the high percentage of wetlands in public ownership, and the current and planned land acquisitions of additional wetlands are consistent with local State and Federal wetland protection legislation, and critical for a very large number of federally and state listed species associated with these cover types.

- 1.2. Manage acquired lands for ecosystem benefits. A major problem is not how many hectares of marsh and wet prairie are currently listed as managed areas or how many more hectares are acquired, but how they will be managed. Many land acquisitions do not end up being used to increase the spatial extent of the ecosystem, but rather are used for water treatment. A current example of this problem involves Miami-Dade County's Environmentally Endangered Lands and The Nature Conservancy lands between Biscayne NP and the Homestead Air Base. These lands may be used for stormwater retention and treatment with the planned privatization and commercial expansion of the airbase (SFWMD 1997b, U. S. Air Force 1994).

Some water management alternatives that are currently being discussed are counterproductive to maintaining water quality and natural system structure and function. For example, one option to implement a water control system around the eight and one-half square mile East Everglades residential area (8.5 SMA) will require back-pumping water that will lower water quality in the North East Shark River Slough.

In order to replace the pattern of rapid pulsed discharges and reversals of water levels with more natural attenuated sheet flow, land must be acquired to permit the wider areal extent of rainfall to drain off and water management releases to occur. The SFWMD stormwater treatment areas will also be used to redirect water flows from the northern Everglades EAA region. The releases will be designed to expand and enhance sheet flows to the water conservation areas (WCAs).

- 1.3. Restore existing freshwater marshes and wet prairies. The SFWMD (1998) in cooperation with other State, local, and Federal agencies should include the "Lower East Coast Buffer Plan" in the C&SF Restudy recommendations. The restudy is intended to develop water budgets and delivery schedules for all of southeast Florida. The projects under consideration include the Lower East Coast (LEC) buffer or water preserve areas as a series of wetlands along the development boundaries between the WCAs and Palm Beach, Broward, and Miami-Dade counties to serve as water preserve and storage areas. Some of the portions of this system of water preserve areas (WPAs) have been identified as having significant biological value (*e.g.*, the Pennsuco Everglades in Miami-Dade County), and will be considered as valuable areas for

ecological restoration of the spatial extent of the eastern peripheral freshwater marshes and wet prairies of the southeastern Everglades.

The Keys Environmental Restoration Trust Fund rehabilitated several acres of freshwater wetlands on Big Pine Key that are important to Key deer, Lower Keys rabbit, alligators, Key mud turtle (*Kinosternum bauri bauri*), wading birds, and other species. Restoration was achieved through fill removal and blockage of non-natural tidal influence.

Many other examples of laudable restorations exist and should be supported. The ecosystem restoration plan currently being enacted for Lake Trafford (Lake Trafford Task Force Conceptual Plan document, Gail Gibson, written communication 1998) is an excellent example of a plan to restore lake and marsh hydrology, reduce nutrient loadings, control phytoplankton blooms and Hydrilla, improve fisheries and wildlife habitat, and integrate the restoration into the Corkscrew Regional Ecosystem Watershed (SFWMD 1998). Another example is the restoration of short hydroperiod and marsh conditions on approximately 4,000 ha (9,880 acres) on former farmlands in the Hole-in-the-Donut of Everglades NP (Dalrymple 1994a, and Dalrymple and Doren (1998). This restoration prevents future germination of Brazilian pepper, and promotes wetland plant and animal re-colonization of the areas (Dalrymple 1994a; Dalrymple et al. 1993, Dalrymple and Doren 1998, Resources Management International 1998). All of these efforts will increase the spatial extent of functional wetlands for in a wide range of hydropatterns.

- 1.4. Support modeling efforts to evaluate plans and progress for ecosystem restorations. The USGS ATLSS modeling program (USGS 1997) is one of several initiatives to develop a landscape level model for evaluating future water delivery scenarios, as well as for evaluating impacts to single species, and entire trophic levels. This program should be supported because it is the only modeling program that incorporates both single species models and multi-species models in a spatially explicit landscape. Additional support for the Natural Systems Model and the modified water deliveries ("Modwaters") C-111 Project efforts are needed. Modeling efforts are needed for predicting rates of success of stormwater treatment of agricultural runoff (Moustafa 1997). Modeling efforts to develop the best possible program for use of the proposed Water Preserve areas and the WCAs must include assessments of studies of seepage rates from WCA2. Alternative water storage technologies including Floridan aquifer storage and retrieval methods should be supported.
- 1.5. Support reclamation programs that expand the spatial extent of marshes and prairies and lake and riverine littoral zones. The easiest way to begin improving on current conditions is to selectively modify current design characteristics that are most amenable to both water management and habitat enhancement. For example: besides

structural modifications for improved simulation of natural hydropatterns to regional lakes, rivers, and marsh systems, a number of additional actions should be considered for wildlife habitat improvement. Such actions include increased peripheral forested land, especially upland habitat, including native tree islands and littoral edge tree stands to improve ecotones between marsh and upland/forested habitat. Inclusion of island systems in artificial lakes and reclaimed rock mining pits, where native macrophytes and trees will be recruited, will promote water and wading bird foraging, roosting, and breeding habitat. Such areas would be isolated from human disturbance and mammalian predators (also see Hammond and Mann 1956, Sargeant 1982). King et al. (1985) have developed a series of guidelines for habitat reclamation on phosphate-mined lands, *e.g.*, Tenoroc FMA near Lakeland, Florida (also see King and Cates 1994). Effective plans have also been developed for restoration of the Peace River and especially the Upper Saddle Creek (DEP 1997, and King et al. 1994). Construction of points of land, isthmuses, or spits of land along shorelines will be beneficial to overall productivity, habitat diversity, and maintenance of upland-wetland species requirements (Newman and Griffin 1994).

- 1.6. Promote legislative initiatives that improve on water use practices. State of Florida reform legislation was enacted in the 1972 Water Resources Act (Chapter 373) including amendments to insure more appropriate water budgets to multiple users, including the natural systems (Gsteiger and Loftin, 1997). Most importantly, the legislation protects natural systems by requiring Florida's water management districts to ensure the sustainability of the natural systems and to establish minimum flows and levels for these systems. Scientific peer review for validating the data used in developing minimum flows was also required. The law should prevent wasting water by limiting the duration of water use permits, providing guarantees to current water permit holders when new users apply for limited water resources, providing equity in evaluation of water use permits, and providing certainty of water supply to existing and anticipated uses by requiring planning and water resource development technologies. While there are still some controversial issues to be resolved in finalizing the best legislation, including the role of agricultural users that have not required permits previously, the most important issue regarding protection and enhancement of the spatial extent of functional marsh and wet prairies is the identification of minimum flows and levels. This and future legislation must recognize that a range of flows and water levels are required to sustain the largest spatial extent and most diverse range of marsh and wet prairie conditions, and that no single minimum flow level will be adequate to ensure long-term health of the natural systems.

2. Restore natural water quality to the system.

- 2.1. Provide initiatives for water quality improvement in relation to agricultural practices.

SFWMD is developing six stormwater treatment areas (STAs) between the EAA and the WCAs in order to channel agricultural runoff away from Lake Okeechobee, and the WCAs. An experimental version, at a smaller scale, known as the Everglades nutrient removal project (ENR) has been operating since 1994. The ENR is a 1667 ha (4,000 acre) marsh retention area where runoff is held and phosphorus is absorbed by marsh plants. The ENR is experimental and intended to determine if the STAs will meet the Phase One goal of reducing phosphorus levels to 50 parts per billion (ppb) in water released into the WCAs. This is the largest constructed wetland designed for agricultural runoff in the country. To date, the SFWMD estimates (SFWMD 1997a) phosphorus reduction of 83 percent, estimated as a reduction to 22 ppb of phosphorus, which exceeds the expected Phase One level goal. SFWMD is continuing land acquisition and development of the full scale STAs. Debate remains over the actual success of the pilot nutrient removal. The agreement between the State and Federal agencies allows for continued acquisition and construction while these permitting and technical issues are clarified. STA 6 "section one" is operating now. STA-1 West, STA 2, and STA-5 are to be operating by early to mid 1999. The remaining STA element will not be operating until 2002 and later (SFWMD 1997a).

The ultimate goal is that water delivered to South Florida should not cause an imbalance of natural populations of flora and fauna. At the Phase Two level of this project agricultural phosphorus outflow concentrations should be down to 10 ppb or less when they leave treatment areas and enter the WCAs. The SFWMD is also proceeding with required evaluation of alternative technologies for phosphorus reduction, including chemical additives, STAs with chemical pre-treatment, and a method requiring passing STA water through an area of submersed vegetation with limerock for further filtration of phosphorus (SFWMD 1997a). The Miccosukee Tribe has promulgated water quality standards to protect tribal lands which include a large portion of the Everglades.

Similar efforts are underway in other portions of South Florida including the Kissimmee River drainage system. In Boney Marsh (Highlands County) a 0.48 sq. km (0.19 sq. mile) wetland was constructed to evaluate the role of overland flow in relation to phosphorus removal (Moustafa 1997). Much of this work is oriented to the development of larger projects throughout the SFWMD.

- 2.2. Support public education regarding proper disposal of hazardous wastes, and continue studies of the sources and effects of mercury and other contaminants and their relations to diseases and chronic sublethal effects in plants and animals in wetland food chains. The potential long-term food chain impacts from the wide range of contaminants and their relation to human activities may be the most underfunded and serious problem we face in the future.

3. Support and increase funding for eradication and control of exotic pest species. As reviewed above, funding and support is required to continue to control the expansion of exotic pest species of aquatic plants, trees, and animals in wetlands (Center et al. 1994, Jordan 1994, Schardt 1994, Thayer and Ferriter 1994). In particular, follow-up field studies of the effectiveness of biological control agents for melaleuca will require significant funding. Expanded quarantine facilities to permit more elaborate and detailed evaluations of other biological control agents are severely needed. Finally, some significant effort must be made to coordinate the agencies and inform the public regarding the elimination of exotic species of plants and animals.

Forested Wetlands

Restoration of Flowing Water Swamps

Restoration Objective: Prevent further reduction in area of flowing water swamps, protect all remaining high quality habitat, and restore and manage protected lands to maintain ecological processes and biodiversity, including normal hydroperiods and flow regimes.

Restoration Criteria: The recovery objective will be achieved when: (1) a reserve design incorporating all currently protected tracts and remaining high quality habitat has been developed and implemented; (2) flowing water swamps are protected through acquisition or cooperative agreements with landowners; (3) appropriate management plans have been prepared and funded for all lands within the reserve network; (4) restoration has been successfully initiated such that ecological processes are operating normally; and (5) natural succession and restoration actions through funded management programs can be expected to re-establish community structure and biodiversity on all significant degraded sites within the reserve network.

All systems within the reserve network must have adequate natural buffers and secure headwaters. Hydrological management for normal hydroperiods and flow regimes must be assured. Mature forests and core reserve swamps must be managed to achieve old-growth characteristics. Buffer zone swamps used for timber production must be managed sustainably.

Community-level Restoration Actions

1. Prevent further destruction or degradation of existing flowing water swamps.
 - 1.1. Acquire threatened flowing water swamps and their upland buffers and headwaters. Table 2 presents land acquisition proposals that incorporate important Flowing water swamps that should be protected. Other important areas that should be protected include: Bruner Cypress Swamp on Jane Green Creek in Osceola County (FNAI floodplain swamp EOR # 002). This is a stand of virgin cypress with trees up to 1.7 m (5.5 ft) dbh with swampbay, needle palm, and royal fern in the understory. Strand

swamp with virgin cypress in Hendry County, west of Cow Bone Island on Seminole Reservation lands (FNAI EOR #001). Floodplain swamp in Lee County (FNAI EOR #027). It is dominated by pop ash with abundant epiphytes and includes a slough with a 1.5 to 3.0 m (5 to 10 ft) waterfall at the upper end. There are many other flowing water swamps worthy of protection within local conservation systems. Natural landscapes, including healthy examples of such swamps, should be regarded as high priorities for local conservation efforts.

- 1.2. Promote conservation easements and landowner agreements to protect flowing water swamps and their upland buffers and headwaters. Telegraph Swamp in eastern Charlotte County is a particularly important site in need of a formal easement or landowner agreement.
 - 1.3. Enforce regulatory protection of forested wetlands. Lands are seldom adequately monitored to ensure compliance, and penalties and enforcement are often inadequate to motivate adherence to the law. Increased funding for regulatory monitoring and enforcement programs is needed at all levels.
 - 1.4. Prevent degradation of existing preserves. Conservation lands should be maintained according to management plans that ensure that flowing water swamps, along with their associated wetlands, upland buffers, and headwater systems, are protected from degrading land uses.
 - 1.5. Protect flowing water swamps from pollution. Flowing water swamps should be protected from both point-source and non-point-source pollution.
2. Manage flowing water swamps within the context of restoration objectives.
 - 2.1. Restore natural fire regimes. Emphasize landscape-scale burning that permits fires to burn into the edges of wetlands naturally. Minimize swamp-edge firebreaks. Recognize the need for occasional catastrophic fires to burn into the peat to rejuvenate sloughs within strand systems.
 - 2.2. Control exotic plants and animals. Control melaleuca invasion. Aggressively seek out and eliminate infestations of Japanese climbing fern and skunk vine. Control feral hog populations (with consideration for panther food base). Monitor other exotics in flowing water swamps and promptly initiate control programs for those that threaten to become problematic.
 - 2.3. Restore hydrology. Within the context of regional hydrological restoration, manage flowing water swamps to maintain hydroperiods, water levels, and flow regimes within the ranges found in natural systems.

- 2.4. Restore soils. Restore hydrological patterns and control fire to permit accumulation of peat in drained or burned swamps. In severely degraded systems, consider increasing water and nutrient levels on a temporary basis to accelerate the soil development process.
- 2.5. Restore ecosystem structure and composition by manipulating existing populations of native species, augmenting populations of native species, and reintroducing extirpated plants and animals.
- 2.6. Protect flowing water swamps from point-source and non-point source pollution. Acquire or otherwise monitor and control buffers.
3. Maintain flowing water swamps in a natural condition.
 - 3.1. Provide analogs for ecosystem functions such as fire regimes. Evaluate alternatives to catastrophic fire (dredging, etc.) for rejuvenation of sloughs within strand systems.
 - 3.2. Continue to control exotic plants and animals in perpetuity.
 - 3.3. Monitor for extirpations and extinctions and negative population trends of imperilled species, including pollinators, dispersers and soil organisms.
 - 3.4. Monitor and correct for both point-source and non-point-source pollution.
4. Re-create flowing water swamps where they have been destroyed by human activities. Use research conducted by the Florida Institute of Phosphate Research, the University of Florida Center for Wetlands, the National Audubon Society's Ecosystem Research Unit, and others to recreate flowing water swamps according to the guidelines of the Society for Ecological Restoration.
 - 4.1. Restore ecosystem structure, including soils and soil organisms, hydrology, plants, and animals.
 - 4.2. Restore ecosystem functions by controlling exotics and aggressive native weeds, restoring natural fire regimes, restoring natural biological interactions (food webs, nutrient cycling, etc.).
 - 4.3. Restore ecosystem composition for late-succession species and rare species.
 - 4.4. Protect flowing water swamps from both point-source and non-point source pollution.
5. Create flowing water swamp analogs where they have been destroyed by human activities to

the extent that a legitimate natural community can no longer be restored.

- 5.1. Restoration of ecosystem structure would need to consider physical landforms, drainage patterns, soils and soil organisms, and endemic flora and fauna.
 - 5.2. Restoration of ecosystem functions would include control of exotics and aggressive native weeds, restoration of hydrologic processes, restoration of fire regimes, and the creation of natural biological interactions (food webs, nutrient cycling, etc.).
 - 5.3. Restoration of ecosystem composition would need to consider late-succession species, rare species, and protection of the community from pollution.
6. Connect appropriate habitats.
- 6.1. Connect ecological systems. SFWMD's regional connection projects are especially important to flowing water swamps. The Myakka River project targets lands between the rivermouth Myakka SF and the Myakka River SP complex of public lands. The R.V. Griffin Reserve Addition tract (Toledo Blade) will maintain a natural corridor between the Myakka River SP complex and the lower Peace River floodplain. Although SFWMD's Bright Hour Watershed project includes only minor areas of forested wetland, its recent protection through less-than-fee acquisition will help to maintain a connection between the Fisheating Creek system and the Peace River corridor. The Charlotte 1 project could eventually preserve a critical connection between Telegraph Swamp/Cecil Webb and the Peace River corridor, if targeted lands on Shell and Prairie Creek are also acquired.

The Upper Lakes Basin Watershed project, while protecting much of the Reedy Creek and Lake Marion Creek basins, also encompasses the headwaters of the Kissimmee complex (Kissimmee-Lake Okeechobee-Everglades).

The Belle Meade project will provide a significant linkage between Collier-Seminole SP and the future Golden Gates Estates SF. The proposed Golden Gates Estates SF is part of the Save Our Everglades project that protects the headwaters of the Fakahatchee Strand State Preserve.
 - 6.2. Protect/restore landscape matrix. Preserve/restore flatwoods and prairies adjacent to and upstream of flowing water swamps wherever possible. Change wetland permitting regulations so that flatwoods buffers can be restored as wetland mitigation. Protection of remaining natural buffers and restoration of additional upland systems is especially needed along the Peace River, where much of the landscape matrix has been agriculturally altered.

- 6.3. Ensure maintenance of linkages critical to key species and functions.
7. Conduct Research.
 - 7.1. Determine distribution of remaining habitat.
 - 7.1.1. Develop strategies for gathering, synthesizing, and ground-truthing data to permit FNAI's floodplain forest, floodplain swamp, freshwater tidal swamp, slough, and strand swamp natural communities to be readily distinguished on GIS maps. In particular, clarify distinction between wet flatwoods and cypress on National Wetland Inventory maps.
 - 7.1.2. Assess and supplement available data.
 - 7.2. Improve reference ecosystem information regarding community composition, biodiversity, and site-to-site variability.
 - 7.3. Investigate roles of pollinators, mycorrhizae, seed dispersers, and other critical or imperilled species.
 - 7.4. Evaluate predator-prey relationships in landscape context.
8. Monitor community-level processes, community structure, and community composition including rare and imperilled species.
9. Increase public awareness for flowing water swamp communities

Restoration of Pond Swamps

Restoration Objective: Prevent further reduction in area of pond swamps, protect all remaining high quality habitat, and restore and manage protected lands to maintain ecological processes and biodiversity. Restoring and maintaining swamps within a healthy fire-maintained flatwoods and prairie landscape mosaic is critical.

Restoration Criteria: The recovery objective will be achieved when: (1) a reserve design incorporating all currently protected tracts and remaining high-quality habitat has been developed and implemented; (2) pond swamps are protected through acquisition or cooperative agreements with landowners; (3) appropriate management plans have been prepared and funded for all lands within the reserve network; (4) restoration has been successfully initiated such that ecological processes are operating normally; and (5) natural succession and restoration actions through funded management programs can be expected to re-establish community structure and

biodiversity on all significant degraded sites within the reserve network. Pond swamps within the reserve system must be adequately buffered from urban and agricultural runoff.

Community-level Restoration Actions

1. Prevent further destruction or degradation of existing pond swamps.
 - 1.1. Acquire threatened pond swamps. Table 2 presents land acquisition proposals that incorporate important pond swamps that should be protected. Other important areas that should be protected include: (1) cypress domes within flatwoods matrix on Sarasota County ranchlands and: (2) basin swamp in Collier County, 8.86 km (5.5 mi) northeast of Belle Meade (FNAI EOR #013). There are many other pond swamps worthy of protection within local conservation systems. Natural landscapes, including healthy examples of such swamps, should be regarded as high priorities for local conservation efforts.
 - 1.2. Promote conservation easements and landowner agreements to protect pond swamps. Appropriate agreements should be negotiated with landowners.
 - 1.3. Enforce regulatory protection. Lands are seldom adequately monitored to assure compliance, and penalties and enforcement are often inadequate to motivate adherence to the law. Increased funding for regulatory monitoring and enforcement programs is needed at all levels.
 - 1.4. Prevent degradation of existing preserves. Conservation lands should be maintained according to management plans to ensure that pond swamps, along with their associated flatwoods and prairie matrices, are protected from degrading land uses.
 - 1.5. Protect pond swamps from pollution. Pond swamps should be protected from both point source and non-point source pollution. Special measures should be developed to protect them from agricultural runoff from surrounding farmlands.
2. Manage pond swamps within the context of restoration objectives.
 - 2.1. Restore natural fire regimes. Emphasize landscape-scale burning that permits fires to burn into the edges of wetlands naturally. Minimize swamp-edge firebreaks.
 - 2.2. Control exotic plants and animals. Control melaleuca invasion. Aggressively seek out and eliminate infestations of Japanese climbing fern and skunk vine. Control feral hog populations (with consideration for panther food base). Monitor behavior of other exotics in pond swamps and promptly initiate control programs for those that threaten to become problematic.

- 2.3. Restore hydrology. Within the context of regional hydrological restoration, manage pond swamps to maintain hydroperiods and water levels within the ranges found in natural systems.
 - 2.4. Restore soils. Restore hydrological patterns and control fire to permit accumulation of peat in drained or burned swamps. In severely degraded systems, consider increasing water and nutrient levels on a temporary basis to accelerate the soil development process.
 - 2.5. Restore ecosystem structure and composition by manipulating existing populations of native species, augmenting populations of native species, and reintroducing extirpated plants and animals.
 - 2.6. Protect seepage swamps from point source and non-point source pollution. Design restoration projects to restore entire landscapes of integrated upland and wetland communities so that wetlands are buffered from agricultural and urban runoff.
3. Maintain pond swamps in a natural condition.
 - 3.1. Provide analogs for ecosystem functions such as fire regimes.
 - 3.2. Continue to control exotic plants and animals in perpetuity.
 - 3.3. Monitor for extirpations and extinctions, and negative population trends of keystone and rare species, including pollinators, dispersers and soil organisms.
 - 3.4. Monitor and correct for both point source and non-point source pollution.
 4. Restore pond swamps where they have been destroyed by human activities. Use research conducted by the Florida Institute of Phosphate Research, the University of Florida Center for Wetlands, and others to recreate pond swamps according to the guidelines of the Society for Ecological Restoration.
 - 4.1. Restore ecosystem structure, including soils and soil organisms, hydrology, plants, and animals.
 - 4.2. Restore ecosystem functions by controlling exotics and aggressive native weeds, restoring natural fire regimes, and restoring natural biological interactions (food webs, nutrient cycling, etc.).
 - 4.3. Restore ecosystem composition by introducing rare and late-succession species.

- 4.4. Protect pond swamps from both point-source and non-point-source pollution.
5. Create pond swamp analogs where natural communities have been destroyed by human activities to the extent that a legitimate natural community can no longer be restored.
 - 5.1. Restoration of ecosystem structure would need to consider physical landforms, drainage patterns, soils and soils organisms, and endemic flora and fauna.
 - 5.2. Restoration of ecosystem functions would include controlling exotics and aggressive native weeds, restoring hydrologic processes, restoring fire regimes, and creating natural biological interactions (food webs, nutrient cycling, etc.).
 - 5.3. Restoration of ecosystem composition would need to consider late-succession species, rare species, and protection of the community from pollution (point source and non-point source).
6. Connect appropriate habitats.
 - 6.1. Connect ecological systems. Pal-Mar, a project in northern Palm Beach and southern Martin Counties, is a critical connection between J.W. Corbett WMA and Jonathan Dickinson SP. When acquired, this will complete a 50,587 ha (125,000 acre) ecological greenway stretching from DuPuis Reserve close to Lake Okeechobee to Jonathan Dickinson SP. The Belle Meade project will provide a significant linkage between Collier-Seminole SP and the future Golden Gates Estates SF.
 - 6.2. Protect/restore landscape matrix. Preserve/restore flatwoods and prairies adjacent to pond swamps wherever possible. Change wetland permitting regulations so that flatwoods buffers can be restored as wetland mitigation.
 - 6.3. Assure maintenance of linkages critical to key species and functions.
7. Conduct research.
 - 7.1. Determine distribution of remaining habitat.
 - 7.1.1. Develop strategies for gathering, synthesizing, and ground-truthing data to permit better identification of pond swamps. In particular, devise ways to more readily distinguish FNAI's basin swamp in GIS mapping and clarify the distinction between wet flatwoods and dwarf cypress savanna (especially where the original community is obscured by melaleuca invasion) on National Wetlands Inventory maps.

- 7.1.2. Assess and supplement available data.
- 7.2. Improve reference ecosystem information regarding community composition, biodiversity, and site-to-site variability.
- 7.3. Investigate roles of pollinators, mycorrhizae, seed dispersers, and other critical or keystone species.
- 7.4. Evaluate predator-prey relationships in landscape context.
8. Monitor community-level processes, community structure, and community composition.
9. Increase public awareness of pond swamp communities.

Restoration of Seepage Swamps

Restoration Objective: Prevent further reduction in area of seepage swamps in South Florida, protect all remaining high quality habitat, and restore and manage protected lands to maintain ecological processes and biodiversity. Restoration and maintenance of water sources and hydrological regimes is critical.

Restoration Criteria

The recovery objective will be achieved when: (1) a reserve design incorporating all currently protected tracts and remaining high-quality habitat has been developed and implemented; (2) seepage swamps are protected through acquisition or cooperative agreements with landowners; (3) appropriate management plans have been prepared and funded for all lands within the reserve network; (4) restoration has been successfully initiated such that ecological processes are operating normally; and (5) natural succession and restoration actions through funded management programs can be expected to re-establish community structure and biodiversity on all significant degraded sites within the reserve network.

The reserve design must include appropriate linkages between major systems and incorporate the matrix of habitats necessary to maintain interactions between communities.

Appropriate water supplies and delivery must be assured for maintenance of normal hydrological conditions in all seepage swamps within the reserve system. Protection from unnaturally severe droughts and fires must be assured.

Community-level Restoration Actions

1. Prevent further destruction or degradation of existing communities.

- 1.1. Acquire threatened seepage swamps. Table 2 presents land acquisition proposals that incorporate important seepage swamps that should be protected. Other important areas that should be protected include:

Baygalls along the mangrove edge at Pelican Bay in Collier County (FNAI EORs # 007 and 008) and similar nearby sites, if any of these still exist. Such baygalls have southernmost extensions for northern plants like jack-in-the-pulpit and represent an unusual coastal variation of the community.

Baygall in Osceola County, east of Lake Davenport (FNAI EOR #016). This site also includes diverse xeric habitats.

Hydric hammock in Osceola County, parallel to Bull Creek (FNAI EOR #027). There are many other seepage swamps worthy of protection within local conservation systems. Natural landscapes, including healthy examples of such swamps, should be regarded as high priorities for local conservation efforts.

- 1.2. Promote conservation easements and landowner agreements. Appropriate agreements should be negotiated with landowners.
 - 1.3. Enforce regulatory protection. Wetlands are seldom adequately monitored to assure compliance and penalties and enforcement are often inadequate to motivate adherence to the law. Increased funding for regulatory monitoring and enforcement programs is needed at all levels.
 - 1.4. Prevent degradation of existing preserves. Conservation lands should be maintained according to management plans that assure that seepage swamps and their water sources are protected from degrading land uses.
2. Manage seepage swamps within the context of restoration objectives.
 - 2.1. Restore natural fire regimes. Emphasize landscape-scale burning that permits fires to burn into the edges of wetlands naturally.
 - 2.2. Control exotic plants and animals. Aggressively seek out and eliminate infestations of Japanese climbing fern and skunk vine. Control feral hog populations (with consideration for panther food base). Monitor other exotics in seepage swamps and promptly initiate control programs for those that threaten to become problematic.
 - 2.3. Restore ecosystem structure and composition by manipulating existing populations of native species, augmenting populations of native species, and reintroducing extirpated plants and animals.

- 2.4. Protect seepage swamps from point source and non-point source pollution. Design restoration projects to restore entire landscapes of integrated upland and wetland communities so that wetlands are buffered from agricultural and urban runoff.
3. Maintain seepage swamps in a natural condition.
 - 3.1. Provide analogs for ecosystem functions such as fire regimes.
 - 3.2. Continue to control exotic plants and animals in perpetuity.
 - 3.3. Monitor for extirpations and extinctions, and negative population trends of imperilled species, including pollinators, dispersers and soil organisms.
 - 3.4. Monitor and correct for both point source and non-point source pollution.
4. Restore seepage swamps where they have been destroyed. Use research conducted by the Florida Institute of Phosphate Research, the University of Florida Center for Wetlands, and others to recreate seepage swamps according to the guidelines of the Society for Ecological Restoration.
 - 4.1. Restore ecosystem structure including soils and soil organisms, hydrology, plants, and animals.
 - 4.2. Restore ecosystem functions by controlling exotics and aggressive native weeds, restoring natural fire regimes, hydrologic processes, and natural biological interactions (food webs, nutrient cycling, etc.).
 - 4.3. Restore ecosystem composition for late-succession species and rare species.
 - 4.4. Protect seepage swamps from both point-source and non-point-source pollution.
5. Connect appropriate habitats.
 - 5.1. Connect ecological systems. Pal-Mar, a project in northern Palm Beach and southern Martin counties, is a critical connection between J.W. Corbett WMA and Jonathan Dickinson SP. When acquired, this would complete a 50,587 ha (125,000 acres) ecological greenway stretching from DuPuis Reserve close to Lake Okeechobee to Jonathan Dickinson SP.
 - 5.2. Protect/restore landscape matrix. Preserve/restore uplands associated with seepage swamps. Change wetland permitting regulations so that upland recharge areas that feed seepage systems can be restored as wetland mitigation.

- 5.3. Assure maintenance of linkages critical to key species and functions.
6. Conduct research.
 - 6.1. Determine distribution of remaining seepage swamp habitat.
 - 6.1.1. Develop strategies for gathering, synthesizing, and ground-truthing data to permit seepage swamp types to be readily distinguished on GIS maps.
 - 6.1.2. Assess and supplement available data.
 - 6.2. Improve reference ecosystem information regarding community composition, biodiversity, and site-to-site variability.
 - 6.3. Investigate roles of pollinators, mycorrhizae, seed dispersers, and other critical or keystone species.
 - 6.4. Evaluate predator-prey relationships in landscape context.
7. Monitor community-level processes, community structure, and community composition including rare and keystone species.
8. Increase public awareness. Landowners need to be taught to recognize seepage swamps as wetlands subject to wetland regulations. Because these communities are rarely flooded, it may be difficult to understand that they are wetlands.

Restoration of Mangroves

Restoration Objective: Maintain the structure, function, and ecological processes of mangroves and prevent any further loss, fragmentation, or degradation of this habitat type in South Florida. Restoration Criteria: South Florida can contribute to the preservation of nationally significant wetlands, hydrology, aquifer recharge, and fish and wildlife habitat values by preserving the only geographic extent of this type of habitat within the continental United States. Benefits of restoring mangrove communities include: the conservation and recovery of listed plant and animal species, wide-ranging species, and neotropical birds; the recycling of nutrients and the nutrient mass balance of the estuarine ecosystem, including high primary and associated secondary biological production; the protection of the base arboreal, estuarine, and marine food web; the provision of physical habitat and nursery grounds for a wide variety of marine/estuarine vertebrates and invertebrates significant to sports and/or commercial fisheries; the protection of public and private lands and property by mangrove storm buffers and wind breaks; the stabilization of shorelines and fine substrates; the improvement of water quality and

clarity by filtering uplands runoff and trapping waterborne sediments and debris. Finally, preservation of mangrove systems contributes to the overall natural setting and visual aesthetics of Florida's estuarine waterbodies and the economy of the coastal counties of South Florida and the State of Florida.

The restoration objective will be achieved when (1) the geographic extent of mangrove habitat in South Florida is identified; (2) mangrove habitat is preserved through land acquisition or private landowner cooperative agreements consistent with the GFC's Closing the Gaps in Florida's Wildlife Habitat Conservation System and Preservation 2000 Act Study (Biodiversity Conservation Analysis), current State and Federal land acquisition proposals, and regional wildlife habitat protection plans; (3) the hydrology and exotic plant management of mangrove wetlands are regionally applied to enhance, restore, and maintain plant and animal biodiversity; and (4) State regulations are adequately enforced resulting in no-net loss of mangrove habitat.

Community-level Restoration Actions

1. Identify the extent of mangrove habitat. Although the existing GIS information, aerial photography, and ground-truthed land cover information are available for this community throughout South Florida, a comprehensive regional analysis has not been conducted.
 - 1.1. Detail the geographic extent of mangroves in South Florida. This task should integrate existing GIS and other databases on land cover, soils, and hydrology, to correctly identify and separate mangrove from other wetland types, particularly Brazilian pepper.
 - 1.2. Update the GIS database for mangroves to monitor cumulative impacts. As areas of mangroves are converted to other land uses, changes should be mapped to identify and analyze trends in habitat loss.
 - 1.3. Identify important habitat linkages. Important areas include connecting the mangroves of north San Carlos Bay to the Estero Bay Buffer Preserve; Rookery Bay National Estuarine Research Reserve north to Gordon Pass; Charlotte Harbor State Buffer Preserves north and south to other preserves.
2. Preserve remaining areas of mangrove habitat. Direct loss of habitat resulting from land conversion, habitat degradation, and fragmentation continues unabated in South Florida. However, some of the best remaining areas of intact mangrove have been identified for land acquisition.
 - 2.1. Identify and acquire mangrove habitat critical to the recovery of wide-ranging listed species. The acquisition and preservation of mangroves, including buttonwood forests, is critical to the recovery of federally and State listed species as well as for augmenting habitat for neotropical migrants.

- 2.1.1. Complete purchase of the following CARL projects: Cape Haze/Charlotte Harbor, Cayo Costa, Charlotte Harbor Buffer, Estero Bay Buffer, Myakka Estuary, Rookery Bay, Bear Point, Middle Cove, Blind Creek, King's Island.
- 2.1.2. Complete purchase and management implementation of mangrove habitat within 15 km (9.3 mi) of wading bird rookeries and 30 km (18.6 mi) of wood stork rookeries. This should include Lemon Bay, Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, Estero Bay, San Carlos Bay, Rookery Bay, the Ten Thousand Islands, the Florida Keys, Florida Bay, Biscayne Bay, Lake Worth Lagoon, and the Indian River Lagoon.
- 2.1.3. Protect coastal mangroves as raptor and bald eagle nesting habitat as well as neotropical migratory bird habitat. Bald eagles prefer nest and perch sites on the largest, tallest trees available near large, open waterbodies in coastal South Florida. Neotropical birds require available foraging habitat as close to the coast as possible to facilitate migration across the Gulf of Mexico and Caribbean. Coastal mangroves in urban areas are subject to hedging. Pine Island in Lee County is an example of a mangrove area that should be protected.
- 2.1.4. Complete purchase and management implementation of mangrove habitat within Priority I/II areas identified in the Florida Panther Habitat Preservation Plan.
- 2.1.5. Identify and acquire potential shoreline nesting habitat available to the American crocodile and mangrove terrapin in South Florida.
- 2.2. Complete purchase and management implementation of mangrove habitat in contiguous, connected, unfragmented patches for the conservation of biodiversity in South Florida. Acquiring and preserving mangrove habitat will benefit nongame species, rare and unique species, and keystone species such as the mangrove tree crab, mangrove rivulus, mangrove prairie warbler, and various owl and raptor species.
 - 2.2.1. Develop additions to existing Federal and State land acquisition proposals in areas identified as GFC Strategic Habitat Conservation Areas and in the 1990 Statewide Charrette, including the following: Estero Bay Watershed, San Carlos Bay, Cocohatchee River, West and East Charlotte Harbor, and the Imperial River drainage.
- 2.3. Use existing regulatory mechanisms to protect mangrove wetlands. Mangroves have significantly declined in areal extent, patch size, and quality in South Florida, primarily because of exemptions, inaccurate rules, lack of compliance review, and

inadequate mitigation practices.

- 2.3.1. Stress avoidance of impacts of this habitat type as a regional wetlands permitting concern. Both consultants and permitting entities need to be educated on the importance of this habitat to fish and wildlife resources and the economy.
 - 2.3.2. Re-evaluate the Federal and State permitting process and permit exemptions to assess impacts on mangrove habitat. Piecemeal development and speculative land clearing in urbanizing areas under exemptions results in fragmentation and loss of mangroves in the South Florida Ecosystem.
 - 2.3.3. Require in-kind on-site and off-site wetland mitigation when avoidance and minimization criteria have been exhausted. Both consultants and permitting entities often assess credit mitigation on the basis of the wetland depth, not the landscape importance or biodiversity value. This results in mitigation plans using red mangroves even when black, white and buttonwoods are being impacted.
- 2.4. Protect mangrove communities from point source and non-point source pollution.
 - 2.5. Implement cooperative habitat preservation and management programs with private landowners. Some mangrove habitat is in private ownership and some private landowners may not choose to participate in fee-simple land acquisition projects. Protection and management through alternate methods may conserve important ecosystems by providing landowners with economic incentives (*e.g.*, tax relief) and promoting good stewardship by ensuring that landowners view habitat as an asset, not a liability.
 - 2.6. Support and implement cooperative regional greenways programs with landowners and other agencies. Greenways planning has successfully developed cooperative, local conservation plans that will establish, maintain, and manage landscape connections between important resource areas.
 - 2.7. Promote the protection of mangroves by local governments. Use the GIS database to provide local governments with the location and areal extent of mangrove habitat to promote and improve resource planning within local comprehensive plans.
3. Manage and maintain mangrove habitat on public lands.
 - 3.1. Implement effective habitat management techniques to maximize the biodiversity of the mangrove community. Mangrove may benefit from alternate management

practices that are sensitive to hydrology, herbicide susceptibility, and subtropical vegetation. Diversification of management techniques may increase biodiversity of impounded and marsh managed systems. Management of mangroves on a landscape scale will benefit listed species, wide-ranging species, wading birds, neotropical migrants, and endemic bird species, including the mangrove cuckoo, black-whiskered vireo, and Florida prairie warbler. Effective management techniques should include controlling exotic plants and animals without impacting non-target native species and preventing collection of rare plant species, such as bromeliads and orchids, on public lands.

- 3.2. Ensure the continuance of habitat management on public lands. State and Federal land managers are faced with funding deficits that prevent or reduce management actions. Perpetual funding sources for staff and equipment should be secured.
 - 3.3. Maintain important habitat linkages. Public landowners should coordinate land acquisition and habitat management activities to ensure the protection of large, contiguous tracts of land that include a mosaic of native habitat types, including mangroves.
 - 3.4. Identify and prohibit incompatible public uses that degrade mangrove habitat. Incompatible public uses that disrupt hydrology, pollute, encourage exotic plant or animal invasion, overharvest resources, or destroy habitat beyond the ability for effective management should be identified and eliminated.
 - 3.5. Monitor compatible adjacent land uses to protect the ecological function of mangroves. Secondary and cumulative impacts to public lands can result from adjacent development, including loss of habitat, litter, chemical discharges, dumping, promoting exotic plant and animal invasion, alteration of adjacent hydrology, use of pesticides/herbicides, and noise/light pollution. Implementing land-use regulations to establish a wide buffer between mangrove habitat and upland development can eliminate or minimize these secondary and cumulative effects.
4. Restore and enhance mangrove habitat, where feasible.
 - 4.1. Identify locations of mangrove habitat that can be restored.
 - 4.1.1. Coastal areas where mangrove restoration efforts are either currently being conducted or should be considered include Indian River Lagoon, Lake Worth Lagoon, Biscayne Bay, Florida Keys, Charlotte Harbor, and Sarasota Bay.
 - 4.2. Restore the natural hydroperiod and tidal regime of mangrove communities.

- 4.3. Restore sheetflow hydrologic conditions by restoring the regional landscape to natural contour. Much of South Florida has been significantly altered by public and private drainage projects that have resulted in both overdrainage and flooding of natural systems. Where possible, off-site, regional hydrological restoration actions may be necessary to restore mangrove functions. Areas where restoration should occur include the South Golden Gate Estates and Camp Keais Strand in Collier County, the Estero Bay Watershed in Lee County, and the Babcock-Webb Wildlife Management Area in Charlotte County and the Charlotte Harbor Flatwoods CARL project in Lee and Charlotte counties.
 - 4.4. Re-establish important habitat links by constructing wildlife crossings. A wide variety of development and linear infrastructure projects fragment mangrove habitats. Future design and retrofit or rebuild of these projects should include culverts, undercrossings, overpasses, and other features that reduce wildlife mortality, preserve hydrology, and increase connectivity to adjacent habitat.
 - 4.5. Encourage mitigation banks that restore and enhance mangrove systems, not monocultures.
5. Perform additional research on mangroves.
 - 5.1. Continue and update studies on the utilization of mangrove communities by endemic and wide-ranging species, including the development of landscapescale management recommendations for the recovery of these species in South Florida.
 - 5.1.1. Inventory and characterize the importance of mangroves to avian populations, including neotropical migrants and wading birds.
 - 5.1.2. Survey mangroves in southwest Florida for the American crocodile. Updated surveys for the American crocodile have not been conducted. The complete range of this species should be documented in order to recover the population.
 - 5.1.3. Examine reptile and amphibian populations associated with ponded wetlands in mangrove ecosystems. Investigate the habitat requirements for the American crocodile and mangrove terrapin.
 - 5.1.4. Examine invertebrate diversity and life cycles in mangrove habitat.
 - 5.2. Monitor mangrove communities to evaluate biodiversity. Monitor community-level processes, structure, and composition, including rare and imperilled species. Improve reference information for community composition, biodiversity, and site-to-site variability.

- 5.3. Perform a hydrologic study of the flood attenuation and storm buffering potential of mangrove habitat under natural sheetflow conditions.
 - 5.4. Examine the population dynamics by invasive exotics in the understory of mangrove habitat.
 - 5.5. Examine the habitat value of buttonwood forests in South Florida.
 - 5.6. Identify historical and geological trends in mangrove distribution relative to hydrology and sea-level in the mangrove communities of South Florida.
6. Increase public awareness concerning mangrove habitat. Identify mangroves in text, maps, and on resource presentations to raise public awareness of the different types of mangroves. Stress the important ecosystem function of isolated and ephemeral wetlands included in the mangrove community. Establish the landscape-scale importance of this community to wide-ranging species and the significance of regional losses of this habitat in South Florida.
 - 6.1. Inform the public about the harm caused by marine debris, particularly monofilament line for fishing and polypropylene lines for lobster and stone crab traps, encouraging the use of biodegradable fishing line, proper fishing stewardship, and enforcement of marine dumping regulations.
 - 6.2. Inform the public about the need to maintain the off-shore drilling ban in Florida waters with mangrove estuaries, and the need for double-hulled transportation of petroleum products in mangrove estuaries.
 - 6.3. Inform the public about the need to not trim mangroves for view on public lands and on private waterfronts particularly in Aquatic Preserves.

Restoration of the Coastal Salt Marsh

Restoration Objective Restoration Objective:: Maintain the structure, function, and ecological processes of South Florida coastal salt marsh communities and increase their spatial extent in South Florida.

Restoration Criteria: South Florida can contribute to the restoration and preservation of coastal salt marsh ecosystems in Florida by restoring the natural structure, composition, and ecological processes of this community. The conservation and restoration of salt marsh habitat in South Florida will contribute to the recovery of several federally and State listed species, the protection and stabilization of other imperiled or rare species, provide additional nursery and breeding habitat, maintain or increase biodiversity, and restore hydrology to several coastal

areas.

The restoration objective will be achieved when: (1) salt marsh habitat in South Florida is identified and characterized; (2) salt marsh habitat is protected through land acquisition; Federal, State or local management actions; and/or private cooperative agreements; (3) salt marsh structure, composition, and ecological processes are restored and maintained; (4) policies are implemented to prevent further degradation and alteration of salt marsh habitat; (5) if mitigation is necessary, specific success criteria and compliance procedures are developed and implemented to ensure mitigation projects sufficiently replace the structure, composition, and ecological processes of salt marshes; (6) salt marsh habitat in the Lower Keys is preserved and enhanced enough to support self-sustaining populations of salt marsh-dependent species, such as the Lower Keys rabbit and rice rat; (7) the biodiversity of salt marshes is returned to natural levels; (8) salt marsh habitat is enhanced and maintained to provide important nurseries and breeding grounds; and (9) at least 90 percent of exotic vegetation is removed permanently from salt marsh habitat.

Community-level Restoration Actions

1. Identify and characterize the extent of remaining salt marsh habitat. Salt marshes are found throughout most of South Florida, but specific information on community types and extent is not known.
 - 1.1. Characterize habitat types. Characterize different community types and determine the condition of both protected and unprotected salt marsh habitats.
 - 1.2. Maintain and improve the GIS database for salt marsh habitat. Compile and maintain salt marsh distribution information through the FWS and GFC Geographic Information System (GIS) databases.
2. Preserve remaining salt marsh habitat. Develop a salt marsh habitat management plan that outlines priority habitat for acquisition and methods to protect, restore, and minimize impacts on salt marsh habitat.
 - 2.1. Identify suitable areas for acquisition. Develop a regional plan outlining priority salt marsh areas for acquisition, using a reserve design approach which takes such factors as connectivity, corridors, and fragmentation into consideration.
 - 2.2. Continue federal acquisition efforts. Continue salt marsh acquisition efforts within the National Key Deer Refuge, J.N. Ding Darling, Great White Heron, and Ten Thousand Islands, national wildlife refuges.
 - 2.3. Support State, local, and non-government organization acquisition efforts. Support entities in acquiring salt marsh habitat including State conservation easements, such as

CARL and The Nature Conservancy.

- 2.4. Protect salt marsh habitat on private lands. Protect salt marsh habitat on private land through acquisition, conservation easements and/or agreements. Develop agreements between the FWS and private landowners to minimize impacts such as alterations of hydrology and exotic plant invasion.
3. Manage and enhance salt marsh habitat. The main threats to salt marsh habitat are dredge/fill activities and alterations in hydrology. Over 66 percent of salt marsh habitat is presently in public ownership, but the remaining habitat is still highly vulnerable to man induced degradation and alteration. Identify areas in need of management and enhancement and implement appropriate management actions.
 - 3.1. Manage ecosystem function. Implement management actions that support or restore the structure, composition, and ecological process of salt marshes.
 - 3.1.1. Provide suitable structure. Implement management actions to ensure appropriate hydrology (*e.g.*, tidal inundation, wave force), elevation and slope, and sediment and soil composition.
 - 3.1.2. Manage salt marsh composition. Maintain native flora and fauna composition of salt marshes.
 - 3.1.3. Manage for ecological processes. Maintain water circulation and water quality, minimize contaminants, maintain or create transitional areas, and control non-native species.
 - 3.2. Coordinate with Federal, State and county agencies to develop guidelines to improve mitigation policies. Coordinate with various Federal, State, and local entities to develop policies that try to avoid the destruction or alteration of wetlands. If it is necessary to use mitigation as an alternative for offsetting wetland impacts, then develop specific mitigation standards that sufficiently replace the structural and ecological processes of natural, undisturbed systems. Enforce compliance with these success criteria.
 - 3.3. Support implementation of Federal management programs. Coordinate with and provide support for Federal management actions that maintain and benefit salt marshes such as those conducted by national parks, national wildlife refuges, and the National Estuary Program.
 - 3.4. Support the implementation of State management programs. Coordinate with and provide support for State management actions that maintain and benefit salt marshes

such as DEP and SWIM.

- 3.5. Support the implementation of local management plans that benefit salt marsh habitat. Coordinate with and provide support for local management actions to maintain and benefit salt marshes through various entities as county departments of environmental protection and parks and recreation.
 - 3.6. Support and encourage ongoing management efforts by mosquito control districts to restore salt marshes. Coordinate with and provide support for efforts by county mosquito districts to maintain and restore salt marshes.
 - 3.7. Restrict access to salt marsh habitat if necessary. Restrict access to sensitive salt marsh habitat to prevent damage caused by camping, homesteading, trash dumping, vehicular traffic, and detrimental recreational use.
 - 3.8. Establish buffers around sensitive salt marsh habitat. Establish buffers to provide transitional habitat and corridors for wetland species and insulation and protection from environmental and human influences.
4. Restore salt marshes. Residential and commercial construction, alterations of hydrology, mosquito ditching, fill excavation, illegal solid waste disposal, and invasive exotic vegetation have degraded or eliminated salt marsh habitat. Identify areas in greatest need of restoration and initiate restoration efforts.
 - 4.1. Identify salt marsh areas in need of restoration. Coordinate with Federal, State, local, and private entities to identify areas in greatest need of restoration and coordinate restoration efforts.
 - 4.2. Identify partners for restoration efforts. Support restoration efforts that have innovative partnerships and use cost-efficient, yet effective techniques to enhance or restore salt marshes. Many successful restoration efforts have incorporated volunteers to remove exotic vegetation and plant salt marsh species.
 - 4.3. Identify sources for planting materials and ensure genetic stock. Determine sources of plant material since the availability of salt marsh seeds and plants is limited in South Florida. Ensure growing conditions are compatible with restoration site conditions. Ensure transplantation of plant species from different areas does not disrupt or dilute gene pools.
 - 4.4. Restore ecosystem function. Implement restoration actions to restore the structure, composition, and ecological process of salt marshes.

- 4.4.1. Restore suitable structure. Implement restoration actions to ensure appropriate hydrology (*e.g.*, tidal inundation, wave force), elevation and slope, and sediment and soil composition.
 - 4.4.2. Restore salt marsh composition. Restore native flora and fauna composition of salt marshes.
 - 4.4.3. Restore ecological processes. Restore water circulation and water quality, minimize contaminants, maintain or create transitional areas, and control non-native species.
5. Identify, acquire, and manage salt marsh habitat to increase biodiversity, maintain important habitat for threatened, endangered, and imperiled species, and maintain nursery and breeding areas.
 - 5.1. Acquire, manage, and restore salt marsh habitat in the Lower Keys. Conduct management and restoration actions to ensure salt marsh areas are able to support self-sustaining populations of Lower Keys rabbits, rice rats, and Key deer.
 - 5.2. Acquire, manage, and restore salt marsh habitat used by other listed or imperiled species. Conduct management and restoration actions to ensure salt marsh areas are able to provide essential functioning habitat for species like wood storks, bald eagles, manatees, crocodiles, wading birds, and other salt marsh species.
 - 5.3. Manage and restore salt marsh to increase suitable habitat for nurseries and breeding grounds. Several commercially important fishes use salt marshes for nursery grounds. Protect and improve these areas to enhance nursery habitat.
 - 5.4. Manage and restore salt marsh habitat to increase biodiversity of native flora and fauna. Past human impacts have reduced species diversity in South Florida salt marsh habitat. Although salt marshes have lower species diversity than most terrestrial areas, they do support numerous transient species. Maintain these habitats to increase biodiversity.
 6. Conduct research on salt marshes in South Florida by examining their structure, composition, and ecological processes. Very little is known about the ecological processes of South Florida salt marshes. Additional information is needed to help restore and preserve these habitats.
 - 6.1. Inventory flora and fauna composition of South Florida marshes and determine any differences between regions.

- 6.2. Inventory and characterize the importance of salt marshes to threatened and endangered species.
 - 6.2.1. Investigate how threatened and endangered species use different habitat components of salt marshes for survival.
 - 6.2.2. Determine the effects of fragmented or degraded salt marsh habitat on endangered species, especially in the Lower Keys.
- 6.3. Characterize the importance of salt marshes to other flora and fauna, especially less-known taxa like insects and marine invertebrates.
- 6.4. Investigate the effects of hydrologic alterations on salt marsh processes.
- 6.5. Investigate salt marsh nursery grounds.
- 6.6. Continue to conduct genetic research of salt marsh vegetation.
- 6.7. Investigate the effects of non-native species on salt marshes.
- 6.8. Compare the ecology of marshes in different regions of South Florida, especially to the Keys.
- 6.9. Compare restored marshes to natural marshes.
- 6.10. Compare and evaluate salt marsh restoration techniques to determine the ability of different techniques to replace the structure, composition, and ecological processes of natural marshes.
7. Develop a long-term monitoring plan to evaluate status of salt marshes. Monitor the extent of salt marsh habitat by updating the loss or change of habitat due to residential or commercial construction through GIS databases.
 - 7.1. Monitor management and restoration activities. Establish plans for corrections or modifications to management and restoration activities.
 - 7.2. Conduct mitigation compliance and improve follow-up procedures. Monitor mitigation projects for compliance and evaluate the effectiveness of success criteria.
 - 7.3. Monitor biodiversity of salt marshes and use by fish and wildlife.
 - 7.4. Monitor the invasion/removal of exotic species in salt marsh habitat.

- 7.5. Hold annual workshops to evaluate salt marsh restoration efforts.
8. Increase public awareness of salt marsh habitat and instill stewardship. Conduct workshops with the public to educate private landowners on appropriate management practices to preserve salt marsh habitat. Encourage private landowners to remove exotics, maintain natural hydrology, refrain from destroying salt marsh habitat, and restore disturbed areas. Develop volunteer restoration programs; coordinate with local parks to increase awareness of salt marshes; and coordinate with local school programs to develop hands-on educational programs for students. Prepare literature to provide information regarding the importance of salt marsh habitat and its preservation and conservation.

Restoration of Seagrasses

Restoration Objective: Maintain and increase seagrass habitat in South Florida.

Restoration Criteria: South Florida can contribute to the protection, enhancement, and restoration of seagrass ecosystems in Florida by maintaining or improving water quality conditions necessary for seagrass growth within the region's estuaries. The protection, enhancement, and restoration of seagrass habitat in South Florida will contribute to the recovery of listed plant and animal species as well as maintain the ecological functions associated with this community, such as high primary and secondary production; enhancing water quality by stabilizing sediments and removing nutrients; and providing shelter, foraging, and nursery habitat for numerous invertebrates and vertebrates important to recreational and commercial fisheries. The reservation of this community will enhance the overall natural setting and visual aesthetics of Florida's coastal landscape and contribute significantly to the economy of South Florida and to the State of Florida.

The restoration objective for seagrass habitat in South Florida will be achieved when: (1) the spatial extent of seagrasses has been identified; (2) the condition of existing seagrasses has been assessed by monitoring specific locations; (3) the relationship between light and water quality to seagrasses has been determined from these monitoring sites; (4) predictive models have been developed that link light attenuation and nutrient loadings to water quality and to epiphyte abundance; (5) the models set pollution load reduction goals to improve or maintain water quality conditions necessary for seagrass survival and growth; (6) management actions have been implemented that result in protecting, enhancing, and restoring seagrasses; and (7) additional protective measures have been implemented to prevent further physical disturbance of seagrass habitat. Increased seagrass distribution and abundance will be used as measures of success to inform the public in recognizing the importance of this community to fisheries resources, wading birds, and listed species such as the Florida manatee.

Community-level Restoration Actions

1. Identify the extent of seagrass habitat. Using existing GIS databases, satellite/thematic images and aerial photographs (scales =1:12,000; 1:24,000; or 1:48,000) coupled with ground-truthing efforts, produce maps of seagrass distribution and abundance as an initial step in evaluating the extent of seagrasses in South Florida. Many of the region's estuaries have already been mapped or are currently being mapped for seagrasses (*e.g.*, Indian River Lagoon, Biscayne Bay, Florida Bay, and the Florida Keys).
 - 1.1. Conduct an inventory of seagrass habitat using available satellite/thematic imagery, aerial photographs, and ground-truthing efforts once every 3 years. Water clarity conditions for aerial photography are best during winter to spring; however, seagrass abundance is greatest in the summer. Ground-truthing verifies the interpretation of the large-scale aerial photographs.
 - 1.2. Maintain the seagrass data obtained/collected from the inventory in a GIS database. Digitize the data into a GIS database (*e.g.*, ARC/INFO) from which maps can be produced.
 - 1.3. Create a region-wide classification scheme of seagrass habitat. Classifying seagrasses as either dense continuous beds (seagrass beds with some sand patches; coverage > 50%) or patchy beds (sand areas with some patches of seagrass; coverage < 50%) improves the repeatability of determining seagrass coverage and is necessary to consistently map seagrass habitat.
 - 1.4. Map the distribution and abundance of seagrasses throughout the region. Mapping the abundance of seagrasses can identify both "problem" and "healthy" areas. Problem areas can be investigated to identify the cause of the problem. Healthy areas can be designated for protection. Mapping can plot changes in the amount and density of seagrass coverage, thereby providing a trend analysis of this community type.
2. Assess the status and condition of existing seagrass habitat. Monitoring selected areas within the region will be used to determine if seagrass beds are healthy or stressed and whether conditions are stable, improving, or declining and to what degree.
 - 2.1. Use low-level aerial photography to map the distribution and abundance of seagrasses in a selected area. Low-level aerial photography can record conditions and document changes in seagrass beds (0.1 to 10 m² [1.07 to 107.6 ft²] in size) at selected sites on a small scale (0.1 to 10,000 ha [0.3 to 24,710 acres]).
 - 2.2. Establish fixed transects to detect changes in depth distribution, abundance, and species composition of seagrasses. Sampling fixed transects can reliably detect fine-scale changes in depth distribution, abundance, and species composition over time.

3. Determine the relationship between light and water quality to seagrasses. Increases in turbidity and nutrients occur both in short pulses and over long periods of time. In order to determine the effects to South Florida's estuaries from episodic events, measurements (*i.e.*, monitoring) of photosynthetically active radiation, water quality, and seagrass cover and abundance need to be taken at the fixed transect sites. Implement site-specific monitoring protocols to identify causes of seagrass decline. Integrating these measurements should identify the effects light and water quality have on seagrasses.
 - 3.1. Implement sampling protocols to measure photosynthetically active radiation. The sampling methodology includes, but is not limited to, using quantum sensors to measure light at the water's surface and underwater.
 - 3.2. Implement monitoring protocols to sample water quality parameters. These parameters include, but are not limited to, temperature, salinity, dissolved oxygen, nitrogen, phosphorus, suspended solids, chlorophyll, turbidity, and color.
 - 3.3. Implement sampling protocols to measure seagrass parameters. These parameters include, but are not limited to, percent cover, biomass, shoot density, canopy height, species composition, productivity, and abundance of drift and epiphytic algae.
4. Develop predictive models that link light attenuation to water quality and to nutrient loadings and epiphyte abundance. The most critical factor affecting seagrass distribution and abundance is light availability, which is a function of water quality. Hence, identifying the water quality constituents regulating light availability in the water column is an initial step. Understanding how nutrients and epiphytes affect light availability is just as crucial. These predictive models will be linked to identify pollutant load reduction goals for specific estuaries or specific segments within estuaries.
 - 4.1. Develop a model that relates light attenuation in the water column to various water quality constituents. Light attenuation will be modeled based on various water quality constituents influenced by hydrodynamic (circulation) forces. Predicted effects on light in the water column, linked with the findings from the site-specific monitoring, will then provide a predictor of stress imposed on seagrass systems.
 - 4.2. Develop a model that relates nutrients to abundance of epiphytes and quantifies the resultant light attenuation. Epiphytes can reduce light reaching the seagrass blade by 50 to 80 percent. Two factors known to influence epiphyte abundance are dissolved nutrients in the water column and grazers (*e.g.*, snails, small crustaceans) on the blade's surface. If grazers are absent, epiphytes can grow unchecked. The epiphyte light attenuation model will address the balance between nutrient effects and grazing effects.

5. Implement management actions that will improve or maintain water quality conditions necessary for seagrass growth. Improving the management of potential sources for degradation will provide better water quality, which produces healthy seagrasses and maintains biological productivity.
 - 5.1. Based on seagrass light requirements, establish pollutant load reduction goals for a specific waterbody or even a segment within a waterbody. Setting the pollutant load reduction goals for a particular waterbody should result in reduced loadings as predicted by the models. The management actions required to reach the pollutant load reduction goals can include stormwater treatment, wastewater reuse, and best management practices for upland use (*e.g.*, landscaping options such as a reduction in fertilizers).
 - 5.2. Monitor these waterbodies or segments within them for the predicted responses to the implementation of management actions. Continue surveying the fixed transects to detect changes in seagrass distribution, abundance, and species composition.
6. Restore seagrass habitat, where feasible. Restoration of lost seagrass beds requires adequate mapping of sites known to have been vegetated with seagrasses in the past; reducing excessive nutrients and suspended particulates to allow seagrass beds to recover naturally; and possibly replanting candidate sites.
 - 6.1. Identify areas wherein stressed or lost seagrass beds are in need of restoration. Once the pollutant load reduction goals have been set and the management actions implemented, seagrasses should recruit naturally into the site. However, certain conditions may require a site to be replanted with donor specimens from another location.
 - 6.2. Rehabilitate seagrass communities where they have been destroyed by human activities (*e.g.*, prop scars) by replanting.
7. Preserve existing seagrass habitat. Most of South Florida's seagrass beds vegetate submerged land that is in sovereign ownership by the State. Much of this submerged land is under additional protection by the establishment of national parks, national wildlife refuges, a national marine sanctuary as well as the designation of a national estuarine research reserve and several aquatic preserves. Seagrass communities outside of these protective boundaries, especially those parcels in private ownership, require even greater attention. Such areas are often at risk from human activities simply because they do not have the unique resource designations that other areas have within South Florida.
 - 7.1. Use existing regulatory authorities to protect seagrass habitat. Seagrasses are currently protected by law from human activities on State-owned submerged lands within

designated aquatic preserves and within the boundaries of federally-designated areas, such as the Florida Keys National Marine Sanctuary, Biscayne NP, Everglades NP, and Rookery Bay National Estuarine Research Reserve. In those instances where seagrasses are damaged within these boundaries, enforcement of existing regulations is necessary.

- 7.2. Prevent the additional degradation of existing seagrass habitat. Implement a multiple approach management program to reduce prop scarring of shallow water seagrass beds. The management program should include increased boater education, installing channel markers, active enforcement, and establishing limited motoring zones. Over the long term, this comprehensive approach should reduce scarring to levels that do not significantly affect habitat quality and quantity.
- 7.3. Identify and acquire privately-owned submerged land vegetated with seagrasses. Public acquisition of these few tracts will preserve the seagrass habitat associated with them.
8. Promote research. Because of the problems experienced by Florida Bay, the effect of extensive phytoplankton blooms (*i.e.*, light availability, nutrient regimes) as well as slime mold disease (*i.e.*, *Labyrinthula*) on seagrass communities should continue to be investigated. In addition, the effects of freshwater flows (*i.e.*, quality, quantity, timing, distribution) on seagrasses should be investigated further.
9. Increase public awareness. Present literature, maps, and slide presentations on the importance of seagrass habitat in South Florida's coastal landscape. Emphasize the significance of the ecological functions and economic value associated with this community. Accomplishing this task will enlist support from the public at large to continue the protection, enhancement, and restoration efforts of seagrass habitat.

Restoration of Nearshore and Midshelf Reefs

Restoration Objective: To prevent further losses of nearshore and midshelf reef habitat values (primary and secondary production, refuge habitat, nursery habitat, biodiversity, educational).

Restoration Criteria: The primary threat to the health of Florida's nearshore reef system is the deposition of beach fill. Rock outcrops within the beach fill areas are buried, the epifaunal organisms associated with those outcrops are smothered, and the habitat which the reef provides to motile fishes and invertebrates is lost. The zone of direct burial increases in time as the fill material relaxes or is washed seaward by wave action and is transported to adjacent areas by littoral drift. Impacts extend beyond the fill zone when the fill material contains high amounts of silt and clay. Suspended fine material not only reduces light penetration but may settle out of

the water, degrading reef areas seaward of this zone. Midshelf reefs can similarly be affected by turbidity and sedimentation when the borrow site contains fine material. Midshelf reefs may also be damaged by direct contact with the dredge and dredge-related equipment.

A measurable criterion for meeting the stated restoration objective would be to prevent any further loss of nearshore reef (natural or artificial) acreage due to beach fill. That is, each acre lost by burial should be replaced by carefully designed and deployed artificial reefs. The above stated criterion is an interim criterion. The restoration objective of maintaining habitat values cannot be achieved until those values to threatened and endangered sea turtles, the vertebrate and invertebrate fisheries species mentioned in this report, and all other reef species which are of recreational or scientific importance, are understood. Life history information on the green sea turtle, for example, is incomplete (Ehrhart, et al. 1996). The value of South Florida's nearshore reefs to species which may only use nearshore reefs during a particular life stage, and for which basic life history information is lacking, cannot be measured with any confidence. The identification of factors which may limit a population is not possible. Degradation of nearshore reef habitat could have serious implications for populations of species if such habitat already represents a demographic bottleneck in the South Florida Ecosystem's carrying capacity for those species. The ultimate objective for restoration of the nearshore and midshelf reef systems would be to accomplish the basic research required to understand the value of the reefs to the species with which we are concerned, and to replace lost values through informed, responsible artificial reef design and deployment.

Community-level Restoration Actions

1. Prevent burial and degradation of existing habitat.
 - 1.1. Map the location and extent of vulnerable reef areas using aerial photography, where possible. Impact reduction can only be achieved once the area within the beach fill template and the sea floor within one thousand feet of the borrow site have been thoroughly mapped. The preferred method for mapping reefs within either zone is aerial photography. Ground-truthing of aerials is also necessary to eliminate false signatures, which are due to drift algae and schools of fish.
 - 1.2. Map vulnerable reef areas using side scan sonar. Borrow areas, unless they are located in the shoal of an inlet, are in deeper water and farther offshore than the fill zone. Thus, frequently, side scan sonar rather than aerial photographs, must be used to map nearby bottom features. Like aerial photographs, side scan sonographs must be ground-truthed to create a reliable map of the sea floor.
 - 1.3. Locate project fill and borrow areas away from reef areas. Once a project area has been thoroughly mapped, the project fill and borrow areas should be situated to minimize nearshore reef burial and sedimentation or mechanical damage to midshelf reefs.

- 1.4. Establish buffer zones. Establish minimum buffer area of 121.9 m (400 ft) between the dredge area and the reefs to help avoid excessive sedimentation and/or mechanical damage.
2. Prevent net loss of habitat.
 - 2.1. Mitigate for reef burial. Recommend compensation for beach nourishment and renourishment projects once the applicant has demonstrated that all efforts have been made to avoid and minimize adverse affects to the reefs.
 - 2.3. [sic] Deploy mitigation prior to project construction. Estimate the minimum acreage of natural reef expected to be buried by the project. At least half that acreage in artificial substrate should be deployed prior to project construction. This measure would provide refuge habitat for motile organisms displaced by the project.
 - 2.4. Measure impacts using aerial photography. A new set of aerial photographs or new side scan sonographs of the nearshore should be taken as close to 1 year after the project is completed as possible (when the fill has equilibrated or “relaxed”) and a measurement of the reef area buried by the project should be made. This is done through comparison with the aerial photograph taken before construction. The resulting acreage represents the acreage of artificial reef necessary to compensate for natural reef burial.
 - 2.5. Survey mitigation area. Survey the area chosen for the mitigation to ensure that there is a solid subsurface beneath the sand so that the newly placed structure does not sink into the bottom to the extent that its value as mitigation is reduced.
 - 2.6. Use clean sand. Use of sand with a silt content of 5 percent or less to reduce the resulting turbidity and sedimentation. Configure borrow areas based upon the goal of matching sand characteristics of the fill area as closely as possible.
 3. Monitor the effects of projects on nearshore and midshelf reefs.
 - 3.1. Monitor offshore reef impacts. Recommend that all applicants proposing to dredge for beach projects initiate and perform a thorough off-shore reef monitoring program.
 - 3.2. Improve monitoring capability. In addition to buffer zones around the offshore reefs near the borrow area, develop a sensitive monitoring system with a 24 hour response capability. The system should be developed by, or in collaboration with, an expert in the physiological effects of turbidity and sedimentation on South Florida offshore reef epibenthos, particularly the hard corals, octocorals and sponges. The system should provide advanced warning to the project sponsor and their contractors of an incident in

which turbidity or sedimentation damage to reef organisms could occur. An array of transmissometers in the vicinity of the potentially affected resources has been suggested.

- 3.3. Limit sedimentation. Within 1,000 feet of the affected reef/resources, install sediment traps both at the surface and near the bottom. Measurements should be taken during the construction phase. A sedimentation rate of 200 mg/cm²/day, particularly on coral reefs, should not be exceeded.
4. Restore areas to suitable habitat. "Restoration" of reef habitat which has been buried by beach fill is probably unfeasible. Nearshore ocean bottom areas which once had reefs which were buried by beach fill can be enhanced by deployment of artificial reefs. Most beach projects have not been constructed with the benefit of before and after aerial photographs to assist in assessing actual acreage of reef burial. To attempt to restore an area which may have sustained such impacts, a list of the locations of past nourishments and renourishments of those areas would have to be made and historical aerials obtained in the hope that any historical reef bottom would be visible in those aerials. Alternatively, deployment of nearshore artificial reefs could be made at appropriate nearshore sites around the southern half of the State to achieve ecosystem-wide enhancement. The reefs should mimic natural reefs in form and function. Restoration of some midshelf habitat values has been accomplished in Miami-Dade County. Artificial reefs were constructed to replace values lost due to the dredge denuding reef during construction of the Sunny Isles project. Palm Beach County has restored some reef habitat values by constructing four mitigation reefs and one enhancement reef in the nearshore area, and approximately 35 enhancement reefs in the midshelf zone.
5. Conduct Research.
 - 5.1. Research needs are varied and include gathering basic information on the life histories of reef inhabitants, population density studies of both natural and various artificial reef designs, and studies of the short- and long-term turbidity effects of beach construction and the effects of that turbidity on reef ecology. A standard protocol for censusing fishes and invertebrate populations on natural and artificial reefs should be adopted in order to allow comparisons from one reef type to another.
 - 5.2. Assess the value of reefs to sea turtles, other transient and resident inhabitants. Additional study of the value of nearshore reefs to sea turtles, fishes and invertebrate species, particularly during sensitive juvenile life stages or during reproduction, is needed. Basic information on the population densities of valued species on natural reefs is also desired to assist in determining the effects of reef loss on their populations.

- 5.3. Incorporate monitoring and annual reporting to the COE and resource agencies on the effectiveness of the mitigation as a project feature. After a project is constructed and artificial reef is deployed, a research opportunity is created. Monitoring should include qualitative measurement of the macroepibenthos per square meter. Comparisons should be made between total biomass, macroepifloral biomass and macroepifaunal biomass at the designed reef and at the natural reefs prior to burial. Fin fish communities at both reef types should be censused and compared in number, species and biomass (estimated). Fish community structure should also be compared at both reef types using multivariate analyses: classification and ordination. Sampling should take place once in each season for 3 years or until it is clear that population densities and community structure has stabilized.

Similarity indices between the natural reef data and the artificial reef data should be calculated to determine whether or not the target species are benefitting from the mitigation. The foregoing research should be done with a view toward promoting a better understanding of design effects on reef communities and to facilitate the development of an increasingly effective artificial reef strategy and better informed decision making for future civil works projects.

6. Inform the public about the value of Florida's reefs. Each artificial reef area should be placed near a public beach, if possible. A sign or display explaining why the reef was built along with a brief discussion of the ecological value of nearshore substrate and Florida's reefs in general should be included. Pictures of abundant reef inhabitants would enable the public to identify what they observe while snorkeling.

The Species

The Mammals

Recovery for the West Indian Manatee, *Trichechus manatus*

Recovery Objective: RECLASSIFY to threatened, then delist.

South Florida Contribution: Reduce human-related mortality in South Florida; control or reduce threats to essential manatee habitat in South Florida.

Recovery Criteria: The statewide manatee recovery plan states that the West Indian manatee can be considered for reclassification to threatened when data and population models are available to assess population size and trends; when analyses indicate that the population is growing or stable; when mortality factors are controlled at acceptable levels or are decreasing; and when critical habitats are secure and threats to them are controlled or decreasing (FWS 1996).

Species-level Recovery Actions

- S1. Support the investigation of the distribution and status of the manatee and its habitat in South Florida by continuing flying synoptic statewide aerial surveys. Aerial survey sighting data have provided and continue to provide useful data on manatee distribution and, in some situations, relative abundance. When combined with telemetry data, certain types of aerial sightings provide a sound basis for determining habitat use patterns. Aerial sightings also provide useful information on the proportion of calves. Because of uncertainty in the number of animals not seen in turbid water, uncertainty as to the proportion of the population within a survey area, and other problems, however, aerial sighting data generally do not permit scientists to estimate or detect trends in population size.
- S1.1. Continue flying synoptic statewide aerial surveys. In 1991, the Florida Marine Research Institute began flying coordinated statewide aerial surveys of all known winter manatee habitat. The surveys are flown following cold fronts when manatees aggregate at warm water refuges in greatest numbers. They involve large numbers of observers flying simultaneously over different segments of known winter manatee habitat. Although problems limit the use of this sighting data to measure population size or trends, the surveys have provided high counts that improve the lower bound of the range of the estimated number of animals. If correction factors for uncertainties noted above can be developed, the resulting data also may be used in the future to determine population trends. As appropriate, such surveys should be continued. For South Florida, aerial surveys should emphasize both manmade and natural warmwater sites; particularly the waterways of Florida Bay and Everglades NP.
- S1.2. Undertake regional or local aerial surveys. In some areas, aerial surveys are needed to improve information on local habitat use patterns. The information obtained through these surveys has been an important basis for developing and analyzing new speed zones and other management measures. As appropriate and possible, local aerial surveys should be undertaken or continued in the Indian, Miami, and Caloosahatchee rivers; Sarasota, Estero, and Rookery bays; Coral Gables Waterway, Ten Thousand Islands region, and Whitewater Bay as well as other areas to improve information on local habitat use patterns and trends in relative abundance.
- S1.3. Continue aerial surveys of aggregation sites after cold fronts. Florida Power & Light Company has supported aerial surveys of manatees at warm-water powerplant outfalls each winter since 1977. In addition to data on the numbers of animals sighted at these warm-water refuges, this long-term data set includes calf counts that provide valuable information on reproduction. If correction factors can be developed to account for sighting uncertainties, the data may be useful in the future for assessing past population trends.

- S1.4. Support a dedicated aerial survey specialist and convene an Aerial Survey Working Group. During a 1992 workshop on manatee population biology (O'Shea et al. 1992), participants reviewed aerial survey methodology and identified steps that might be taken to improve information generated by aerial surveys. Participants concluded that better interpretation of aerial data could help detect regional (though perhaps not statewide) trends in abundance. Improvements are needed in stratifying survey effort by type, refining information on diving behavior, defining acceptable sighting conditions, and testing strip transect methodology. A dedicated aerial survey effort by type, refining information on diving behavior, defining acceptable sighting conditions, and testing strip transect methodology. A dedicated aerial survey specialist should be supported to monitor progress on aerial survey research, improve survey methodology, and develop correction factors for sighting uncertainties. In addition, an Aerial Survey Working Group chaired by the specialist should be convened at least annually to provide further advice and assistance.
- S1.5. Analyze available aerial survey data. Re-evaluate the results of past aerial surveys to improve estimates of selected parameters and population trends. Aerial survey data sets should be evaluated regionally to determine whether they are sufficiently complete and up-to-date. Areas that need to be resurveyed should be identified. In addition, new methodologies and analytical techniques might be applied to ongoing aerial surveys. As possible, such analyses should be undertaken.
- S2. Protect and enhance existing populations by identifying and minimizing causes of manatee injury, mortality, and disturbance. Manatees are killed and injured as a result of interactions with boats, floodgates, navigation locks, marine debris, and fishing gear. In rare cases, manatees are killed by vandals and poachers. Additional mortalities, from natural causes such as severe cold weather or red tide, may also significantly affect the status of the manatee population. To permit growth of the manatee population and reach an optimal sustainable population level, such causes of mortality must be reduced. This section of the recovery plan identifies activities needed to monitor and reduce such sources of mortality.
- S2.1. Maintain and improve the salvage and necropsy program. The manatee salvage/necropsy program is fundamental to identifying causes of manatee mortality and injury. The program is responsible for collecting and examining virtually all manatee carcasses reported in the southeastern U.S., determining the causes of death, monitoring mortality trends, and disseminating mortality information. Program data help identify, direct, and support essential management actions (*e.g.*, promulgating watercraft speed rules and reviewing permits for construction in manatee habitat). The program was begun by the Sirenia Project and the University of Miami in 1974. Procedures and protocols to standardize

necropsies were developed in the early 1980s (Bonde et al. 1983) and expanded significantly early in the 1990s. Now part of the DEP's Florida Marine Research Institute, the major program duties include: receiving manatee carcass reports from the field; collecting and examining dead animals; maintaining accurate mortality records; and carrying out special studies to improve understanding of mortality causes, rates, and trends. Program staff also coordinate rescues of injured or distressed manatees.

S2.1.1. Ensure prompt and complete reporting of manatee carcasses. To obtain manatee carcasses for necropsy, the carcass recovery and necropsy program relies on reports of carcasses from members of the public. These reports are usually provided through the Florida Marine Patrol, officers in the GFC, or local officials. To provide the best possible understanding of manatee mortality causes and trends, it is important not only to obtain as many reports as possible, but also to assure that reports are received promptly so that carcasses are as fresh as possible when necropsied. The following tasks will facilitate reporting from the field.

S2.1.1.1. Provide training for law enforcement officials on carcass reporting procedures. Most manatee carcasses are found by the public and reported to the Florida Marine Patrol or local law enforcement officials. To ensure that program staff are notified of all reported carcasses, officials likely to receive such reports need to be advised and reminded of the data needs and procedures for reporting carcasses to the salvage and necropsy program staff and the importance of doing so promptly. Periodic presentations by program staff and/or mailings should be made to the Florida Marine Patrol Academy, to Florida Marine Patrol officers in the field, and to other law enforcement groups, such as the GFC, the U.S. Coast Guard, local police departments, and county sheriffs. To maintain interest and involvement, efforts to provide feedback to law enforcement officials on the results of necropsies and program findings should be undertaken routinely.

S2.1.1.2. Encourage public reporting of carcasses. Most manatee carcasses are found by boaters, shoreline residents, and other members of the public frequenting waterways and shorelines. To increase public reporting, information on procedures for reporting carcasses and the importance of doing so promptly should be included in posters and appropriate public education materials. Periodic mailings and/or presentations and public

service announcements targeting appropriate groups such as homeowners associations, boating, diving, and fishing groups, and others should be prepared and sent.

S2.1.2. Maintain salvage and necropsy field stations and staff. The salvage and necropsy program includes a central necropsy facility operated by DEP at Eckerd College in St. Petersburg, three field stations on the east coast located at Jacksonville, Melbourne, and Tequesta, and one field station on the west coast at Port Charlotte. The stations collect, examine, and dispose of carcasses, and record, analyze, and distribute mortality data. Support must be provided to maintain an adequate program staff and provide the necessary equipment.

S2.1.2.1. Provide support for salvage and necropsy program staff and equipment. Salvage and necropsy program staff are part of DEP's Florida Marine Research Institute. Field station personnel are responsible for promptly collecting dead animals and related data in the field and transporting the carcasses to the central necropsy facility. The central facility's staff is responsible for conducting all necropsies; collecting, examining, and archiving tissue samples; distributing tissue samples to other researchers; photo-documenting wounds and scars on all salvaged carcasses; recording and analyzing data; performing special studies; preparing monthly and annual mortality summary reports; and administering and coordinating all salvage and necropsy program work. Staffing must be continued to properly conduct this program. In addition, annual funding is needed to repair, replace, upgrade, and otherwise maintain such equipment and supplies necessary to carry out necropsy work.

S2.1.2.2. Develop and coordinate out-of-state salvage efforts. During summer, some Florida manatees migrate north into Georgia, South Carolina, North Carolina, and Virginia or west into Alabama and Louisiana. To maintain accurate mortality data, arrangements are needed to collect carcasses and data from animals that die in these areas. This requires (1) alerting State and local officials in these areas of the importance of reporting dead manatees, and (2) supporting travel and other expenses associated with collecting carcasses and mortality data. The FWS and the salvage and necropsy program staff should cooperate in contacting appropriate officials outside of Florida to alert them as to reporting needs and procedures for manatee

carcasses found in their respective areas, and ensuring funds are available for collecting manatee carcasses and mortality data promptly.

S2.1.3. Undertake special studies and analyses to improve understanding of mortality causes and trends. Special studies are needed to better define and explain various factors, phenomena, or events influencing poorly understood mortality trends.

S2.1.3.1. Assess manatee carcass reporting rates. While it is believed that most dead manatees are found and reported, an unknown proportion go unreported, resulting in an under-representation of annual manatee mortality totals. To assess the number of manatee carcasses that go unreported, studies of carcass detection and reporting rates should be undertaken.

S2.1.3.2. Undertake a workshop and/or studies to identify the proximal cause(s) of perinatal mortality. In recent years, perinatal mortality has increased at a rate greater than any other mortality category and now constitutes approximately 25 percent of the total annual mortality. The causes of increased perinatal mortality are uncertain. It may be related to pollution, injuries and stress from increased vessel traffic and other human activities, changes in the age structure of mature breeding females, habitat changes, or some combination of these and other possible causes. It also may be due to a greater number of births. A workshop should be held to investigate available information on perinatal mortality, research needs, and mitigation measures. Possible contributing factors and any regional differences should be examined.

S2.1.3.3. Undertake routine and periodic tissue analyses. To obtain maximum information from carcasses and wild and rescued manatees, it is necessary to examine and analyze tissues for contaminant levels, reproductive status, age at death, etc. In addition, to improve understanding of disease and immunotoxicological processes, salvaged tissues, organs, and organ systems should be studied. Serum from wild and rescued manatees should also be screened to assess the incidence of exposure to various viral, bacterial, parasitic and other pathogenic organisms. A centralized serum bank should be established to analyze diseases.

S2.1.3.4. Investigate and respond to potential unusual mortality events.

From time to time there are unusual mortality events in which large numbers of manatees die or become moribund. For example, over 45 animals died in association with a severe cold front in late December 1989, and at least 149 animals died in association with a red tide event that struck southwest Florida populations in 1996. A plan for responding to such an event has been prepared by the FWS as required by the Marine Mammal Stranding Act of 1992. If a large-scale mortality event occurs, the FWS and the salvage and necropsy program will need to coordinate response efforts using contingency plans and funding specifically designed for these events.

S2.2 Minimize collisions between manatees and watercraft. The largest source of human-related manatee mortality is collisions between manatees and watercraft. Known watercraft deaths now constitute at least 20 to 22 percent of the total known annual mortality. Watercraft may cause additional deaths or reduced population growth due to indirect effects of injuries and stress on the reproductive success of mature females (Marine Mammal Commission 1993). Actions to address specific needs are discussed below.

S2.2.1. Develop and refine State waterway speed and access rules. The State of Florida has begun promulgating waterway speed and access rules to reduce the number of collisions between manatees and watercraft. The rules seek to create a system of speed and access zones tailored to local manatee habitat use-patterns and boating needs. Rulemaking is an intensive process that requires compiling and reviewing voluminous site-specific environmental data, particularly on manatee habitat-use patterns and boating activity; extensive coordination between county and DEP officials to develop rule provisions; public hearings and review; and approval by the Secretary of DEP. As directed by the Florida Governor and Cabinet in 1989, priority attention has been focused toward 13 key counties. Rules for 12 of the 13 key counties are complete. Over the next 5 years, the need for manatee protection measures in the remaining key county and some 20 other counties with important manatee habitat should be considered. Also, rule refinements likely will be needed to increase rule and sign uniformity and to reflect new information on manatee habitat-use patterns and boating activity.

S2.2.2. Develop and refine Federal waterway speed and access rules. For certain Florida waterways, particularly those in or adjacent to NWRs, the FWS has promulgated Federal rules regulating vessel speed and access. These

rules, which complement State rules, are issued under authority of the ESA, the Marine Mammal Protection Act, and/or the NWR System Administration Act. Federal rules issued by the COE to control vessel speeds adjacent to navigation locks also may enhance manatee protection. Although the principal purpose of the latter rules is vessel safety around navigation locks, they also reduce the risk of manatee-vessel collisions and should be encouraged for both reasons at locks used by manatees along the Okeechobee Waterway, Cross Florida Barge Canal, and elsewhere. As necessary and appropriate, such Federal rules should be modified and new rules promulgated in cooperation with the State of Florida and other concerned parties.

- S2.2.3. Post and maintain regulatory signs. To advise watercraft operators of speed and access restrictions, regulatory signs are posted strategically along waterways. As proper posting is a prerequisite for enforcing and prosecuting violations, signage is as important as the rules themselves. The extensive new rules necessitate posting thousands of new signs along thousands of miles of waterway. On the east coast, the Florida Inland Navigation District is responsible for sign posting and maintenance. Elsewhere the task is shared by the DEP, the West Coast Inland Navigation District, and the counties. Once county rules are adopted, the DEP's Office of Protected Species Management develops or reviews signage plans, the Florida Marine Patrol issues permits for sign placement, and the entity responsible for printing and posting then proceeds with actual posting. As rules are completed or modified, signs should be posted promptly by the responsible agency. Once posted, they should be inspected periodically and repaired or replaced as needed. Signage changes may be warranted based on enforcement or navigation needs or efforts to make sign messages clearer and more uniform.
- S2.2.4. Enforce and encourage manatee protection regulations. The Florida Marine Patrol is the principal agency in Florida responsible for enforcing speed and access rules as well as other manatee protection rules. Federal and State officers assigned to selected parks, refuges, and reserves, the GFC, and the U.S. Coast Guard also assist with enforcement. Effective enforcement requires training to ensure that officers are aware of the purposes and provisions of the rules and how to enforce them. It also requires cooperation among various Federal and State enforcement officials, and the judiciary.
- S2.2.4.1. Focus and increase officer time dedicated to enforcing manatee protection rules. Manatee protection rules are but a few of the

myriad of rules which law enforcement officers must enforce. To maximize the effectiveness of enforcing rules concerning manatees, steps should be taken to: (1) concentrate efforts at times and areas where boat and manatee densities are greatest; (2) increase the amount of time dedicated to enforcing manatee protection rules; and (3) provide speed guns and training to appropriate field officers. The Florida Marine Patrol, GFC, the Office of Protected Species Management, and the FWS should periodically review needs and strategies for concentrated enforcement efforts.

- S2.2.4.2. Develop and implement a strategic plan to strengthen cooperative interagency enforcement. Enforcement of manatee protection rules involves field officers in various Federal, State, and local agencies as well as judicial, legislative, and regulatory support. Although waterway speed and access rules demand the greatest time and effort to administer, rules for poaching, incidental take in fisheries, harassment, etc., also require attention. A strategic enforcement plan should be developed and implemented to establish a cooperative interagency field enforcement network that is backed by a supportive judiciary and legislature. The strategic plan should address interagency agreements as may be needed for effectively cross-deputizing and coordinating Federal, State, and local field officers; develop and update officer training programs and explanatory materials on manatee protection rules and enforcement needs; conduct periodic training and refresher courses for enforcement units at all levels; coordinate interagency enforcement exercises; make regulations as clear and as uniform as possible; educate the judiciary and otherwise facilitate prosecutions of manatee-related rule violations; and work with the legislature to ensure fines, penalties, and other statutory provisions are clear and as effective as possible.
- S2.2.4.3. Conduct surveys to assess compliance with rules. Field surveys should be done to monitor the extent to which watercraft comply with regulatory measures. Periodic surveys on selected waterways in each key county should be undertaken.
- S2.2.4.4. Encourage and cooperate with efforts to develop unified statewide boating safety measures. Proposals for state-wide speed limits, boat operator licenses, and mandatory boater

education have been considered in the past. Such measures would complement and enhance efforts to reduce watercraft-related manatee deaths by offering opportunities to educate boaters about manatees. Although such boating safety measures have been rejected to date, similar measures may be proposed and adopted in the future. To the extent possible, new proposals to establish statewide boating safety measures should be encouraged. Particular efforts should be made to integrate manatee protection concerns into any new boater education programs.

- S2.2.5. Establish policies for authorizing boat races and other water sport events. Certain organized water sports events, such as boat races, waterski contests, and fishing tournaments, involve boats traveling at high speed. In certain areas and times, these activities pose threats to manatees. Permits for such events typically are required from the U.S. Coast Guard. The U.S. Coast Guard considers advice from the FWS and DEP on whether a permit should be granted, denied, or granted conditionally given possible effects on manatees. To help planning for boat races, representatives from DEP, the FWS, and boat racing organizations developed guidelines on when, where, and under what conditions such events could be held consistent with manatee protection objectives. The guidelines are used by the FWS and DEP to review permit requests and by event organizers to plan events. The FWS and DEP should keep such guidelines under review and modify or expand them as needed to address other types of water sport events. The FWS, and the U.S. Coast Guard should continue to consult on the issuance of permits for sporting events that involve high speed boats in manatee habitat.
- S2.2.6. Indicate speed and access zones on nautical charts. NOAA publishes nautical charts and a “Coast Pilot” to help vessel operators navigate in coastal waters. As new speed and access rules are adopted, NOAA and other organizations publishing navigation charts should update their publications.
- S2.2.7. Assess and reduce mortality caused by large vessels. Large slow-moving ships (*e.g.*, tugs and cargo vessels) are known to kill manatees. Some animals appear to be pulled into propeller blades by the sheer power of generated water currents and others are crushed between the bottom and the hull of deep-draft ships. When moored, large vessels also can crush manatees between their hulls and adjacent wharves or ships. To prevent the latter problem, some ports (*e.g.*, the Mayport Naval Station) have

begun using fenders to maintain minimum stand-off distances between moored vessels and wharves. To address the threat of propellers on large tugs operating at the Kings Bay Naval Base, the Navy recently designed and installed propeller shrouds on its C-tractor tugs. These approaches may be useful in other areas.

To consider applying such measures more widely, a study should review mortality data for evidence of deaths attributable to large vessels; examine barge, tug, and other large vessel traffic patterns relative to manatee distribution; assess the feasibility and cost of installing propeller guards or shrouds on large vessels or tugs routinely plying waterways used by manatees; consider rules to require fenders when mooring large vessels in manatee habitat; evaluate ways to educate harbor pilots about the threats large vessels pose for manatees; and identify other possible mitigation measures. Actions to implement appropriate measures should be taken based on study findings.

- S2.2.8. Evaluate the feasibility of propeller guards or alternative propulsion technology for small watercraft. In the past, propeller guards have been examined as a possible solution to recreational watercraft-related manatee mortality. They also have been considered for improving human safety and protecting seagrass beds. While new designs are developed periodically, their effect on vessel speed and steering have discouraged general use. Broad use of propeller guards should reduce propeller-caused manatee injuries; however, it may only marginally reduce overall injuries and deaths since the impact of a propeller guard on a fast-moving boat is as injurious to manatees as the wounds from propellers. Nevertheless, as new designs are developed, they should be tested and evaluated. Once efficient and effective guards are available, incentive-based programs should be explored to encourage greater use of propeller guards.
- S2.2.9. Continue section 7 and State reviews of boating facilities and watersport events. Marinas, boat ramps and other boating facilities increase local boat traffic. They can therefore influence the frequency of watercraft collisions with manatees in areas where manatees are common. Facility construction and the resulting traffic also can degrade habitat features, such as seagrass beds, which are important to manatees. Such facilities require permits from the COE, environmental resource permits from the DEP, and submerged land leases from Florida's Board of Trustees. As noted above, watersport events also may affect manatees and require permits from the U.S. Coast Guard. Under section 7 of the ESA and other Federal regulations, the FWS reviews and comments on permit applications

whenever they may affect endangered species and other natural resources. This formal review process is a fundamental part of the manatee recovery program and must be continued.

- S2.3. Minimize manatee deaths in water control structures. Late in the 1970s, eight to nine manatees per year were killed in floodgates and navigation locks. To reduce this mortality, steps were taken to modify gate opening procedures. Annual mortality initially decreased in the early 1980s. The number of deaths subsequently increased and in 1994, 16 deaths were recorded. An ad hoc interagency task force was established with representatives from the SFWMD, the COE, the FWS, and DEP to examine other steps to prevent such deaths. Support the development, testing, and implementation of new alternative measures at water control structures to reduce the number of manatee injuries and deaths. Coordinate with the South Florida Ecosystem Restoration Task Force to ensure alterations in the quantity or quality of water flow do not negatively affect the manatee and its habitat (*i.e.*, effects of alterations of water flow in the C & SF, Caloosahatchee River, St. Lucie Waterway, and Whitewater Bay).
- S2.3.1. Develop, test, and implement new alternative measures. The interagency task force has identified several possible alternatives to reduce floodgate and navigation lock deaths. They include adjusting gate opening sequences, installing slotted gates or gates with new top-flow designed structures, adding detection devices to alert gate operators when manatees are present, and/or installing automatic door reversing mechanisms similar to safeguards on elevator doors. A pressure-sensitive unit has been designed and tested on two water control structures by the SFWMD with inconclusive results. The COE is preparing a Section 1135 Project Modification Report on Manatee Protection at Select Navigation and Water Control Structures. The devices and techniques that resulted from this study should be installed, tested for effectiveness, and implemented in a timely manner.
- S2.3.2. Promptly investigate structure-related deaths. Gate-and lock-related manatee mortality should be kept under continual review by FWS, DEP, and the agencies directly responsible for the structures. Structures at which multiple deaths occur should be investigated immediately to identify and correct contributing factors.
- S2.4. Assess and minimize manatee injuries and deaths caused by fisheries. In some years, as many as six manatees have been killed in commercial fishing gear. Most are caught and drowned in nets of inshore shrimp boats in northeast Florida; others are entangled in float lines for crab traps. Commercial fisheries in coastal Florida

are managed cooperatively by the Florida Marine Fisheries Commission and the DEP. To minimize adverse interactions between fisheries and manatees, the following steps are needed.

- S2.4.1. Minimize manatee drownings in shrimp nets. The Florida Marine Fisheries Commission has completed portions of a statewide shrimp fishery management plan. The Commission, DEP, and FWS should review and, as necessary, update measures to prevent manatees from being caught and drowned in shrimp nets. As an initial step, DEP has printed and distributed brochures to advise shrimp fishermen of the problem and the steps they can take to minimize drownings (*e.g.*, reducing tow times and immediately retrieving nets when heavy objects are encountered). If such education efforts do not resolve the problem, other measures (*e.g.*, gear, season, and/or area closures) should be considered, incorporated into the plan, and implemented.
- S2.4.2. Minimize injuries and deaths in crab pot lines and other fishing gear. Manatees are entangled in crab pot float lines, various types of fishing nets, and monofilament line used by recreational fishermen. Information on interactions with such fishing gear should be kept under review by DEP and FWS. Steps should be taken to improve reporting of animals caught in fishing gear, particularly those that are released or escape alive. Steps to identify and implement measures to reduce or avoid such interactions should be taken, if needed.
- S2.4.3. Identify locations where fishing gear impacts manatees and implement measures to mitigate impacts. In certain areas where commercial and recreational fishing is particularly heavy and/or where manatees tend to aggregate, interactions with fishing gear may be particularly common. At some east coast aggregation sites, manatees are snagged by lines, lures, and treble hooks of recreational fishermen. These sites should be identified and, as warranted, steps should be taken to assess and implement actions to prevent potentially threatening interactions with fishing gear.
- S2.5. Investigate and prosecute all incidents of poaching and malicious vandalism. Poaching, shooting, butchering, and other malicious vandalism against manatees are rare occurrences. All reports and evidence regarding such incidents should be turned over to the FWS's law enforcement agents for investigation and prosecution to the fullest extent of the law. As appropriate, a reward system should be established to help investigate and prosecute violations.

S2.6. Rescue, rehabilitate, and release distressed manatees. Reports of injured or distressed manatees are frequently received by officials in the manatee recovery program. While many prove false, some form of rescue action is deemed necessary in about 15 to 25 cases per year. In some cases, animals are treated and released immediately. In others, rehabilitation in captivity is needed and marine zoological parks make facilities, resources, and expertise available to transport and care for animals prior to their release back into the wild. Such actions help reduce manatee mortality but require extensive cooperation among Federal and State agencies, zoological parks, and other institutions and organizations. The FWS, with the assistance of an Interagency/ Oceanaria working group, maintains oversight of work to rescue, rehabilitate, and release animals. The Florida Marine Research Institute's manatee salvage and necropsy program has agreed to coordinate rescue response work on a day-to-day basis. The FWS's Jacksonville field office coordinates captive program activities and manatee releases. In addition, under state law, DEP has been authorized and directed to provide partial reimbursement to cooperating parks and organizations to help defray rescue and rehabilitation costs. This program should continue.

S2.6.1. Authorize cooperative participation in the manatee rescue/ rehabilitation network. The FWS has overall responsibility for work to rescue, rehabilitate, and release injured or otherwise distressed manatees. To meet this obligation, the FWS's Office of Management Authority issued an endangered species/marine mammal enhancement permit to authorize related work by cooperating facilities and organizations. Letters of authorization under this permit are issued by the FWS to qualified groups interested in participating in the rescue/rehabilitation network. The letters set forth the scope of their respective involvement in (1) verifying, (2) rescuing and transporting, and/or (3) treating and maintaining distressed animals. Activities under letters of authorization need to be reviewed continually. Every effort should be made to provide training opportunities to members of authorized groups to ensure continuous improvement in local rescue assessment and logistic capabilities. The FWS should update or modify the terms of existing letters and/or issue new authorization letters to additional qualified facilities or organizations as such needs are identified.

S2.6.2. Coordinate and oversee day-to-day rescue operations. To assure prompt, effective responses to distressed manatees, a rescue coordinator has been designated to receive initial reports of such animals and to mobilize and coordinate rescue network teams. The Director of the Florida Marines Research Institute's manatee salvage and necropsy program currently serves as the rescue coordinator. Reports of distressed animals should

continue to be directed to the rescue coordinator who in turn contacts authorized rescue network teams to organize a response for verification, rescue, and transport to available treatment facilities as necessary, and notifies the FWS of ongoing rescue operations, and unusual or significant incidents as necessary.

- S2.6.3. Ensure adequate rehabilitation facilities. In the past the number of captive manatees has ranged from about 40 to 50 animals. Three “Pre- Act” animals (animals brought into captivity prior to enactment of the ESA) have been in captivity for several decades. Some captives have been judged unreleasable due to the nature of their injuries or concern about their ability to adapt to the wild (*e.g.*, long-term captive animals that were born in captivity), and the remainder are animals in varying stages of rehabilitation.

Captive Florida manatees are held at eight marine facilities and zoological parks:

1. Sea World of Florida* - Orlando, Florida
2. Miami Seaquarium* - Miami, Florida
3. Lowry Park Zoo* - Tampa, Florida
4. Homosassa Springs State Wildlife Park - Homosassa Springs, Florida
5. Epcot’s Living Seas - Lake Buena Vista, Florida
6. South Florida Museum -Bradenton, Florida
7. Sea World of California - San Diego, California
8. Mote Marine Laboratory - Sarasota, Florida

(* = Critical Care Treatment Facility)

Space for captive animals is limited and maintenance costs to feed and care for them are relatively high (at least \$ 25-40,000 per animal per year). To assure space is available to maintain animals rescued in the future, steps are being taken to return rehabilitated animals to the wild as quickly as possible. To provide additional options for management, captive maintenance facilities at the Homosassa Springs State Wildlife Park and elsewhere should be expanded and improved, as needed.

- S2.6.4. Convene periodic meetings of the Interagency/Oceanaria working group and the Captive Manatee Planning Committee. The FWS convenes periodic meetings of an Interagency/Oceanaria working group to help coordinate rescue, rehabilitation, and release work and to manage captive maintenance activities in ways that will best meet manatee recovery objectives. Among other things, the working group reviews the status of manatee rescue and rehabilitation work; maintains records of captive

manatees; charts the progress of animals towards their release; assists the FWS in developing and reviewing protocols and criteria for the rescue, transport, rehabilitation, maintenance, and release of animals; and exchanges information and expertise with respect to rescue, rehabilitation, maintenance, and release procedures.

Captive manatees also provide unique opportunities to study physiological processes and other aspects of manatee ecology that may add to the information base on habitat requirements and recovery needs. Such work, however, should not impede rehabilitation and release of captive animals. To help evaluate and direct research on captive animals the FWS has established a Captive Manatee Planning Committee. In part, the Committee is responsible for reviewing all research proposals and management options involving captive manatees and making recommendations to the FWS's manatee coordinator. At least two meetings per year of both the full working group and its planning committee should be held.

S2.6.5. Facilitate and evaluate animal releases. As soon as animals taken into captivity for rehabilitation or care are judged suitable for release back into the wild, steps should be taken to do so. Decisions on releases should be made by the FWS in coordination with the facility maintaining the animal and the Interagency/Oceanaria working group following established criteria.

S2.6.5.1. Develop protocols and criteria to govern releases and evaluate the manatee's readaptive success. To assure that released animals will readjust to the wild, criteria and protocols need to be developed and kept under review for assessing the physical health of animals in release pens and their fitness to be released. The guidance in these criteria and protocols should be modified as necessary based on the success or failure of animals with different histories and medical records to adapt to wild conditions. Veterinarians in the Interagency/Oceanaria working group, in coordination with the FWS, should develop and keep such protocols and criteria under review. Similar guidance also should be developed to help with decisions on whether and when to recapture animals not satisfactorily acclimating to the wild.

S2.6.5.2. Radio-tag and track released manatees. To help assess readjustment and survival of rehabilitated manatees returned to

the wild, certain released animals should be followed by telemetry upon release and all released animals should be tagged with Passive Integrated Transponders (PIT) tags. This will aid in assessments of whether animals adopt normal habitat-use patterns, interact with other manatees, and readapt successfully to the wild. If problems arise, it also may help in locating and recapturing animals. Over the next five years, 5 to 10 animals are expected to be released annually. Telemetry tags, staff, and other support needed to track about 5 to 7 released animals annually will be required.

- S2.7. Minimize other human-related disturbances and harassment. Disturbance and harassment by boaters, divers, fishermen, and others can alter manatee behavior and reduce the suitability of some areas as manatee habitat. Waterway speed and access restrictions partially address causes of disturbance and harassment. However, general guidance and advice for certain user groups and the general public also are needed on ways to minimize or avoid interactions that alter natural behavior and movement of manatees. The following tasks are needed to develop regulations, guidelines, and/or practical principles that define proper conduct by divers, boaters, and others with respect to feeding, watering, approaching, viewing, or otherwise interacting with manatees.
- S2.7.1. Prepare and adopt guidelines for the development of manatee viewing areas. Interest in developing facilities to allow members of the public to view wild manatees is increasing. While such facilities offer public education and awareness opportunities, they also increase the potential for harassment of animals and perhaps even malicious injuries. Proposals for such facilities need to be examined carefully. To respond to future proposals to create manatee viewing facilities, guidelines should be prepared for determining when such facilities would be consistent with manatee recovery objectives and what design features or other conditions should be required.
- S2.7.2. Prepare and adopt guidelines or regulations on feeding and watering manatees. Even when well-intentioned, public feeding or watering of wild manatees may alter natural behavior in ways that ultimately change manatee distribution patterns or place individual animals at risk. It may condition animals to approach boats or areas that are hazardous, or encourage them to remain in areas during times that could expose them to thermal stress. The development of guidelines and public education programs and, if necessary, regulations to discourage such activities should be evaluated and implemented. Enforcement policies must be

adopted by responsible agencies. Special attention is needed at areas where feeding or watering by the public is done routinely.

- S2.7.3. Develop and keep under review guidelines governing close approaches to manatees. At times, manatees and people, particularly divers, come in close and even direct physical contact with one another. While manatees occasionally invite such contact, people often chase after manatees that are trying to avoid them. This constitutes harassment, which is a violation of Federal law and may cause animals to leave preferred habitats. The latter is an issue of particular concern at the Crystal River NWR. The FWS has prepared a brochure advising divers at Crystal River on proper conduct when encountering wild manatees. Current policies and provisions governing close encounters between manatees and people in the wild should be kept under continuing review and their form and content modified if they are found to afford inadequate protection for manatees.
 - S2.7.4. Coordinate with the FWS' Contaminant Program and other entities to minimize contaminant effects on the manatee in South Florida. Investigate contaminant effects on the manatee, including red tide, nutrients, and heavy metals. Support the development and implementation of management actions to minimize negative effects from contaminants.
- S3. Support research on the physiology, life history, and ecology of the manatee. Studies of physiology, life history, and ecology are needed for understanding population status and trends, and to help assess what habitats are most important to manatees and why. Collect additional biological information on number of individuals, age-class structure, habitat use, reproductive viability, food use and availability, and threats.
- S3.1. Maintain and analyze manatee "scar catalog" data. Many manatees have scars from boat strikes or other sources. When carefully photographed, they provide a means of identifying individual animals. Photographs of distinctively marked animals collected by researchers in the field are compiled in a manatee scar catalog held by the Sirenia Project with support from the Florida Power & Light Company. The catalog has been expanded and improved and is now a computerized system of photos on compact-disc, the Manatee Individual Photo-identification System. The Florida Marine Research Institute now assists in maintaining portions of the catalog. The data provide valuable information on movements, site-fidelity, age at first reproduction, calving intervals, and other vital parameters. Recent analyses indicate resighting data can be used to derive survival rates. This database should continue to be maintained and analyzed.

- S3.1.1. Continue to collect photographs of individually identifiable manatees in the field. Photographs of individually identifiable manatees should be routinely collected from the field. In particular, photographs should be obtained at winter aggregation sites. The routine collection of photographs from the field and their incorporation into the catalog will ensure that information on movement patterns, site-fidelity, reproductive histories, survival rates, and related databases remains current.
- S3.1.2. Maintain staff support to collect, enter, check, retrieve, and analyze scar catalog data. Some 6,000 new photographs are submitted annually by field researchers for inclusion in the catalog. Comparison of photographs with previously identified animals, proper entry of new data, and retrieval of data for analyses requires a dedicated staff member who is proficient and familiar with both the classification system and the identified individuals. Continued support, including a dedicated scar catalog archivist, to maintain and upgrade the scar catalog for both the east and west coasts should be provided. Standardized protocols for describing and coding data collected by photographers have been distributed for use by all cooperators submitting photographs to the catalog. Distribution of photographs of carcasses must continue so that dead manatees can be removed from the active catalog files.
- S3.1.3. Upgrade and maintain computer/camera equipment for the scar catalog. The scar catalog is presently maintained as a computer-based system that uses a CDROM. The catalog now includes over 1,000 animals and nearly 15,000 sighting and resighting records (Beck and Reid 1995). Computer and camera equipment to store, sort, and retrieve photographs and sighting data must be purchased, maintained, and upgraded to facilitate and enhance use of the catalog's data.

Photographs of carcasses taken by the Florida Marine Research Institute should be shared with the Sirenia Project so that dead animals can be removed from the active scar catalog. It will also provide information on minimum ages of manatees in the system, permitting analysis of age-specific reproduction and survival. Carcass recovery data may also be combined with resighting data in some recently developed survival models to further enhance the accuracy and precision of survival estimates.

- S3.2. Analyze scar catalog data to determine annual survival rates and other population parameters. One of the most important parameters for estimating trends in

population status is age-specific survival. Scar catalog data on animals at Crystal River, Blue Spring, and along Florida's east coast are now sufficiently extensive to estimate survival rates in those areas (O'Shea and Langtimm 1995). Analyses of survival rates, as well as calving intervals, age of first reproduction, and other parameters should be undertaken and/or refined as new records are entered.

- S3.3. Continue and expand long-term studies of individual animals. Long-term studies of the reproductive traits, behavior, and life history of individual females provide data on age-specific birth rates and success in calf rearing. Such data, in turn, are important for assessing potential population growth rates. Although long-term records on individual females are best from Crystal River and Blue Spring, useful data also have been collected at other locations. Relevant data are included in the scar catalog, in long-term telemetry results for individual females through routine monitoring programs at major warm-water refuges, by long-term telemetry studies on selected manatees, and through reports from various researchers. Efforts to gather and analyze data on the reproductive history and behavior of known females should be continued and expanded to other study areas. Research should address the behavioral/ environmental causes of perinatal mortality by focusing on cow-calf behavior and interaction with conspecifics, especially during the perinatal period.
- S3.4. Analyze data on calf production. The total number of calves produced is uncertain and may vary regionally. Calf counts from research at Crystal River and Blue Spring and from aerial surveys and data on the reproductive status of females recovered in the salvage necropsy program should be analyzed to estimate and identify possible regional differences in reproductive rates.
- S3.5. Continue aerial photogrammetry analyses. Aerial photographic techniques to estimate the size, and hence age class, of individual animals are being investigated as a way to determine the age-structure of manatee populations. If the results suggest that further work is needed, studies should be designed, and equipment and support should be provided to collect and analyze aerial photogrammetric data.
- S3.1.4. Continue opportunistic deployment of passive integrated transponder (PIT) tags. PIT tags are small tags inserted under the skin of animals to identify them if they are recaptured or recovered in the salvage and necropsy program. By comparing data on an animal's size, reproductive status, and general condition between time of tagging and recovery, one can increase the amount of information obtained on life history parameters. PIT tags are applied opportunistically by the Florida Marine Research Institute, the Sirenia Project, or an authorized veterinarian whenever animals are caught for radio tagging or rehabilitation or released

from captivity. PIT tags should continue to be applied as opportunities arise and PIT tag readers should be purchased and made available to individuals and groups likely to handle manatees.

- S3.6. Conduct additional physiological studies of thermal tolerances. Although it is known that manatees are sensitive to cold stress, precise information on thermal tolerances and the effects of cold on physiological processes of different manatee age and sex classes is not known. Such information may be useful for assessing the percentage of the manatee population likely to aggregate at warm-water refuges at different ambient water temperatures, when different age/sex groups are likely to arrive at and depart from refuges, when emergency situations are likely to arise from unexpected changes in thermal discharges, etc. Studies to assess thermal tolerances and physiological effects of cold stress should be designed and undertaken.
- S3.7. Conduct additional studies to assess hearing capabilities. Manatees, particularly mothers and calves, communicate vocally. Noise from boats or other sources may interfere with such communications or be a source of stress. Hearing capabilities, however, have been poorly understood. Recent studies indicate that manatees may have a wider range of hearing than previous studies suggested (Gerstein 1994). There is a need for further research on hearing capabilities and the effects of noise on manatees.
- S3.8. Complete and conduct additional studies of manatee food habits. Nutritional characteristics of manatee food plants and the importance of different food sources for different age and sex classes in various regions are poorly understood. Such information is needed to help assure that adequate food resources are protected in different portions of the population's range. Ongoing studies should be completed to identify manatee food habits and feeding patterns, the nutritional value of different aquatic plants important to manatees, and the regional food resources most in need of protection and management.
- S3.9. Continue genetic analyses from manatee tissue samples. New molecular techniques to examine genetic material provide an opportunity to update information on the genetic sub-structure of manatee populations, male mating success, paternal contributions, and frequencies of kinship that vary within social groups. This genetic analysis also identifies regional homozygosity and possible effects due to localized matrilineages, etc. Such information could improve understanding of the structure and social interactions of populations, influencing management objectives for different groups of manatees.

These studies should also be interrelated to physiological findings; management

efforts should reflect an accurate assessment of the influence that the existing gene pool may have on lowered reproductive potential, enhanced susceptibility to disease, and other factors. Research to examine a number of these points has already been initiated. In addition, a number of researchers are interested in conducting other analyses. For some questions, the genetic data alone will not yield insights into manatee biology without a simultaneous field effort to collect the appropriate behavioral data. To determine the role of kinship in social interactions it will be necessary to collect data on association patterns and interactions among known individuals. Likewise, assessment of paternity for a large number of males will provide data on variance in male reproductive success but will not shed light on factors affecting male success. Associated data on male physical characteristics (*e.g.*, size, body condition, age) and behavioral traits (*e.g.*, movement patterns, “dominance” in a mating herd), as well as extended observations of mating herds will be important for understanding reproductive activity among males. Tasks that facilitate and coordinate research related to manatee genetics should be initiated.

- S3.10. Conduct additional studies to identify requirements for fresh water. In estuarine and marine areas manatees are attracted to, and drink from, freshwater sources. While this attraction is well known, the physiological need for fresh water is not clear. Studies have been initiated to examine processes by which manatees regulate internal salt levels and the physiological role of drinking fresh water. The results of these studies should be reviewed and, if warranted, further research should be undertaken.
- S3.11. Convene a population status working group to develop methodology, data and models to assess population size and trends. Information on trends in the size of Florida manatee populations is essential for assessing the effectiveness of manatee recovery actions. It also is needed to develop objective, measurable criteria required by the ESA for determining when manatee populations may be reclassified as threatened or removed from the endangered species list. Given the present difficulty in measuring population size and trends directly, assessments of these parameters in the foreseeable future will benefit from information derived from population models. Models should use estimates of mortality, reproduction, survivorship, age/sex structure that stem from various other research tasks. Models should be developed, evaluated, and improved as needed.

As more information on manatee life history parameters is obtained, population models will tend to become highly complex. It is important for those developing manatee population models to coordinate their activities, and interact directly with biologists who have collected manatee life history data or who are authorities on manatee ecology. Biologists will better understand how models were derived, and

the modelers will obtain feedback on the validity of their assumptions and interpretation of their results. The working group should be convened at least once every 2 years chaired by the staff of the Sirenia Project.

- S3.12. Conduct research to better understand manatee-boat interactions. More data is needed to assess how manatees respond to a variety of boat types and traffic patterns. Innovative research techniques such as remote observations using airships should be investigated. Research should be conducted to develop various devices, such as propeller guards, in an effort to minimize manatee injury or death caused by passing boats.
- S4. Support the monitoring of manatee populations in South Florida. The success of efforts to develop and implement measures to minimize manatee injury and mortality and to protect manatee habitat will depend on the accuracy and completeness of data on manatee life history and ecology, population status, and habitat condition. Good data in these areas are needed to identify and define problems, make informed judgments on appropriate management alternatives, establish an information base to justify selected actions, and provide a basis for determining whether or not the actions taken are achieving the desired result.
- S4.1. Maintain a manatee telemetry program. Telemetry programs are currently the only reliable means by which to generate detailed information on manatee movement and habitat-use patterns. Manatees are netted, belted, and tagged with transmitters for remote and visual monitoring. These monitoring programs provide information used to identify key use areas and travel corridors, and to tabulate reproductive histories, monitor use of powerplant effluents, and trace the progress of re-introduced captive manatees. This information is used to develop specific recommendations for manatee protection and to support habitat management initiatives.
- S4.1.1. Maintain adequate telemetry capabilities. Telemetry studies require personnel, tags, tag attachments, receivers, boats, vehicles, airplanes and other equipment to capture and tag animals and to retrieve or replace transmitting units. They also require computer hardware and software and personnel to process the data and funding for the cost of satellite data retrieval. Presently the Sirenia Project and the Florida Marine Research Institute can track up to 20 and 15 animals, respectively. This level of capability should be maintained exclusive of telemetry needs for tracking released rehabilitated animals, work in Puerto Rico (see the Puerto Rican manatee recovery plan), or cooperative studies in other countries.
- S4.1.2. Enter telemetry locations into the manatee Geographic Information

System (GIS) database. Accurate information on manatee habitat-use patterns provides a sound scientific basis for identifying and supporting management decisions on waterway speed and access rules, permits for facility construction in manatee habitat, etc. To assure access to new data by managers, telemetry data should be processed by researchers for entry into the Florida Marine Research Institute's GIS. A standardized methodology to interpret and display telemetry data should be developed with the results distributed to the appropriate management agencies and cooperating groups annually through the Manatee GIS Working Group.

- S4.1.3. Prepare and distribute monthly updates, annual progress reports, and final summaries of telemetry results. To keep managers and researchers involved in the recovery program abreast of progress and new findings from manatee tagging and tracking studies, monthly updates on the status of tagged manatees should be compiled and distributed. Summary progress reports should be circulated annually and final research findings and conclusions should be made available as soon as possible following the completion of regional study elements.
- S4.1.4. Develop regional atlases of telemetry location data. Telemetry research has proceeded as a series of regional studies with tracking work concentrated in different areas over time. To date, studies have been conducted or are underway in the upper St. Johns River, along the east coast of Florida and southeastern Georgia, in the Crystal River area, Lee County, Tampa Bay area, and along the southwest Florida coast. Upon the completion of a regional study, an atlas of telemetry results should be compiled to summarize habitat-use patterns of different age and sex classes by season.
- S4.1.5. Develop a long-term strategy for telemetry studies. Presently, telemetry studies are being done on the east coast by the Sirenia Project and along the west-central Florida coast by the Florida Marine Research Institute. In the future, telemetry work may be needed in areas of the State not well studied (*i.e.*, Everglades, Okeechobee Waterway and Lake Okeechobee) as well as in areas that have been previously studied. The latter is important to identify possible shifts in habitat use patterns over time. To ensure telemetry capabilities address recovery program data needs as effectively as possible, a set of goals with a long-term strategy for telemetry work in Florida should be developed. The goals and strategy should be reviewed by FWS, the Sirenia Project, and the Florida Marine Research Institute and updated as needed. A working group composed of FWS, Sirenia Project, and the Florida Marine Research Institute should be

formed to develop the long-term strategies for telemetry studies.

S4.2. Maintain and improve the GIS for data on manatees and manatee habitat. The Florida Marine Research Institute has developed a GIS to store, synthesize, and retrieve large volumes of data on manatees and manatee habitat. This data management system can store, manipulate, analyze, and display site-specific data on manatee carcass recovery sites; manatee sighting data from aerial surveys, ground research, telemetry studies; water depths, vegetation coverage, waterway speed and access zones, shoreline characteristics and development patterns, etc. The hardware, software, and database are used by Federal, State, and local officials for scientific analyses, permit reviews, developing waterway speed and access rules, and preparing county manatee protection plans.

S4.2.1. Maintain the hardware, software, and expertise to operate the GIS. Hardware, software, personnel, and training to access the GIS should be provided and maintained by involved agencies. GIS work stations already exist at the DEP's Florida Marine Research Institute and Office of Protected Species Management, and the FWS's Jacksonville field office, and Sirenia Project. Other work stations should be established and maintained at appropriate agency offices (*e.g.*, COE District Office and other divisions of DEP). These agencies should assign trained staff to serve as GIS operators and analysts responsible for providing maps and data summaries needed by staff planners, managers, and scientists. DEP and/or FWS should provide sufficient staff support to respond to requests for needed information from cooperating agencies and organizations which lack the hardware, software, or expertise necessary to use the database (*e.g.*, some county planners).

S4.2.2. Convene regular meetings of the Manatee GIS Working Group. Optimum use of the GIS database requires that the staff of agencies, offices, laboratories, and organizations responsible for key research and management tasks have access to GIS databases pertinent to their analytical needs. To promote interactions between system users and system curators, a GIS Working Group composed of representatives from governmental agencies and interest groups wanting to use manatee GIS data should be convened on a regular basis. The Working Group should meet to review data processing needs, access procedures, and available data; encourage and organize cooperative efforts to acquire ancillary data sets that would contribute to the manatee GIS; and provide opportunities to instruct users in the use of available data and new technologies. Working Group members should be responsible for overseeing their agency's participation in manatee GIS-related work. Funding to convene

this group should be provided as needed.

- S5. Increase public awareness. Develop curricula and educational materials for schools and host public workshops to increase awareness about the manatee and instill a sense of stewardship for the protection of this endangered species. Increase the availability of manatee education services and materials in South Florida to provide better technical assistance to the public. Design and implement a program to evaluate the effectiveness of education in recovering the manatee. Initiate and implement a standard education program for marinas and develop standards for evaluating the effectiveness of this education program. It is essential that the public be made aware of the manatee and the efforts to protect and maintain the population.
- S5.1. Develop curricula and materials for schools. Most manatee protection and conservation measures need to remain in place indefinitely. To provide a sound base of understanding and support for conservation measures by future generations of Floridians and Georgians, materials and curricula on manatees and manatee conservation should be updated periodically and made available for use at various academic levels from elementary to high school.
- S5.2. Develop and update materials for target user groups. Information important to achieve manatee conservation objectives differs for different user groups (boaters, divers, fishermen, commercial ship operators, shoreline owners) and different areas (people using a particular protected area, residents of coastal areas in Florida, tourists). By the same token, appropriate media (films, posters, brochures, public service announcements, personal presentations) also differ according to user groups and areas. Agencies and organizations carrying out public education and outreach programs should cooperate in assuring that pertinent information in appropriate formats is made available to relevant sectors of the public.
- S5.3. Maintain avenues to encourage and direct voluntary contributions in support of needed recovery work. A significant amount of the funding to support the State of Florida's manatee recovery work is obtained from voluntary contributions in the form of a special state license plate and an optional contribution on boat registration applications as authorized by the Florida Legislature. Some equipment and funding also are provided from donations to the Save the Manatee Club and other environmental organizations. These voluntary contributions form a significant part of the funding base for the recovery program and permit much work to be done that would not otherwise be possible. Innovative approaches to obtain and direct voluntary support to needed program work should be tested and maintained.
- S6. Coordinate recovery activities, monitor and evaluate progress, and update/revise this

narrative. The actions necessary to support and implement recovery are beyond the abilities or scope of any one agency. They require the participation and cooperation of many Federal, State, and local agencies, as well as public, private, and industry organizations. To ensure that the work of involved agencies and groups is carried out in a timely, cost-effective manner that addresses priority recovery needs, the following administrative and coordination tasks should be carried out.

- S6.1. Maintain Federal and State manatee coordinator staff positions. Given the central role of the FWS and the DEP, each agency should designate a full-time manatee coordinator and provide basic support staff. The level of support must be adequate to carry out administrative functions for which each is responsible and to work directly with involved agency and organization officials on a day-to-day basis. The primary responsibility of the FWS' manatee coordinator and support staff is to provide Federal oversight, guidance, and support for the overall manatee recovery effort as outlined in the recovery plan. Additional responsibilities include preparing rules for Federal Manatee Sanctuaries; reviewing and providing guidance on development permits and section 7 consultations; assisting and monitoring recovery-related work by participating agencies and organizations; developing a die-off response plan; overseeing efforts to rescue, rehabilitate, and release distressed manatees; assisting and coordinating manatee land acquisitions; helping develop state waterway speed and access regulations and county manatee protection plans; assisting in the development of manatee-related provisions, programs and facilities at NWRs; updating the manatee recovery plan and preparing annual status reports; and chairing and convening meetings of the manatee recovery team.

Tasks for the State manatee coordinator and support staff include developing state waterway speed and access rules and overseeing efforts to post and enforce established zones; reviewing environmental resource permits and state submerged land leases; providing advice and assistance to responsible agencies on resolving mortality caused by flood gates and fishing gear; assisting and coordinating manatee-related land acquisition; assisting in the development of manatee-related provisions, programs, and facilities at state parks, reserves, and aquatic preserves, and other State lands; assisting counties in developing county manatee protection plans; serving as staff for the Manatee Technical Advisory Committee; and carrying out relevant public education and awareness work.

- S6.2. Convene periodic meetings of the Florida Manatee Recovery Team and Manatee Technical Advisory Council. The FWS has constituted and periodically convenes meetings of a Manatee Recovery Team composed of the principal involved agencies and groups. Chaired by the FWS's manatee coordinator, the team reviews progress on the recovery program tasks; develops advice on program priorities and

needs; and helps coordinate work and support on recovery tasks among involved agencies and groups. In addition, DEP has established a Manatee Technical Advisory Council. The Council provides advice to the Secretary of this agency on progress and priority needs with respect to DEP involvement in the manatee recovery program. Both groups complement each other. They meet at times when advice and assistance is most timely and have become an important means of reviewing, guiding, and coordinating ongoing activities. The FWS's manatee coordinator provides staff support for the recovery team and DEP's manatee coordinator serves as staff for the Advisory Council. Support to convene periodic meetings of both groups should be provided.

- S6.3. Develop an annual progress report. As a means of documenting and monitoring progress on recovery tasks, the FWS, with the assistance of involved agencies and groups, prepares annual progress reports reviewing activities on all identified tasks. The annual reports provide a means of tracking ongoing work, identifying areas in need of further attention, and projecting priorities for the coming year. The preparation of annual status reports should continue.
- S6.4. Update the Florida Manatee Recovery Plan. The Florida Manatee Recovery Plan identifies and interrelates fundamental recovery tasks. It also identifies task priorities, agency involvement, and funding needs for a 5-year period. Agency involvement and funding projections are included as guides rather than commitments and are provided solely for planning purposes. In this regard, it is used by the FWS and other agencies as a principal reference to develop annual budget requests for manatee-related work. Given progress on listed tasks, new information on manatees, environmental changes, changes in agency administration, and other factors that are difficult or impossible to predict accurately more than a few years in advance, the plan is limited to a 5-year period and should be updated at least once every 5 years. Responsibility for doing so rests with the FWS, with assistance from the Florida Manatee Recovery Team.
- S6.5. Convene a panel or workshop to evaluate the effectiveness of the manatee recovery program. The revised recovery plan assumes that more extensive boat speed regulations will minimize the major source of human-related mortality, and that local manatee protection plans, land acquisition, and development permit reviews will achieve adequate manatee habitat protection. While these assumptions seem reasonable and appropriate, it remains to be demonstrated that they will in fact be successful. A workshop or panel should be convened prior to the next revision of the recovery plan to identify and evaluate fundamental issues in the Florida Manatee Recovery Program, to evaluate whether present strategies and assumptions prove ineffective. To obtain a fresh, independent assessment of options, the panel or workshop should be heavily weighted toward expert scientists

and wildlife managers not directly involved in the manatee recovery program.

S6.6. Share experience and expertise developed through the manatee recovery program. The Florida Manatee Recovery Program is a model for potential or evolving manatee recovery programs in other countries. The experience and expertise that has been gained in Florida should be applied to other southern states and U.S. territories with sirenian populations to encourage conservation efforts.

S6.6.1. Develop cooperative agreements with other states and countries. Manatees also occur in Georgia, occasionally in other southeastern states, and in Puerto Rico. Research and management techniques developed to protect manatees in Florida could be applied to protect manatees in those areas as well. Steps should be taken to establish working relationships with appropriate officials in other states or territories to transfer expertise and experience.

Similarly, other countries developing manatee conservation programs should be encouraged to enter into agreements with the FWS and the Sirenia Project to facilitate the transfer of information, experience, and expertise related to manatee research and management. Such agreements might involve the exchange of personnel for training purposes or cooperation in carrying out specific projects. Where opportunities arise to establish such agreements, they should be pursued and supported.

S6.6.2. Participate in and assist with manatee-related work under the Caribbean Environment Program. Under a regional SEAS program sponsored by the United Nations Environment Program, nations in the wider Caribbean region, including the U.S., cooperate in the Caribbean Environment Program. The program is guided by provisions set forth in an action plan and the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean (*i.e.*, the Cartagena Convention). In 1991, parties to the Convention signed a Protocol on Specially Protected Areas and Wildlife. Convention members have an interest in the development of national or regional recovery plans for manatees. Participants in the Florida manatee recovery program should assist in recovery programs envisioned under this protocol and the Caribbean Environment Program.

S6.6.3. Participate in national and international manatee conservation and research activities. Results from the manatee recovery program are of interest not only to scientists and managers involved in manatee conservation, but also to other scientists and resource managers. In

addition, the experience of other wildlife scientists and managers may provide insights of value to the manatee recovery program. Agencies should encourage individuals involved in the recovery program to present papers or otherwise participate in national and international activities involved in wildlife research and management, including conferences, training, and technical assistance.

Habitat-level Recovery Actions

H1. Prevent degradation of existing manatee habitat in South Florida. In addition to controlling direct sources of manatee injury and mortality, manatee recovery depends on maintaining the availability of habitat suitable to support a larger manatee population. Manatee habitat requirements include adequate sources of aquatic vegetation for food; sources of fresh water; secluded areas in which to mate, bear and nurse their young, and rest; warmwater refuges during cold periods; and safe travel corridors between these areas. Availability of these habitat features may be affected by coastal development and human activity patterns along waterways used by manatees. The challenge for managers is to provide for human needs while, at the same time, protecting the availability and quality of a network of essential habitat components. These essential habitat components reflect seasonal manatee movement patterns and maintain a full complement of habitat needs throughout the principal range of both the east and west coast manatee populations. This section of the recovery plan identifies the tasks needed to protect essential manatee habitat.

Ongoing dredge-and-fill and water quality permit review programs involving the FWS, the COE, the NMFS, and the EPA at the Federal level (section 10 of the Rivers and Harbors Act, section 404 of the Clean Water Act, and section 7 of the ESA), DEP and water management districts and Georgia Department of Natural Resources at the State level, and local environmental permitting agencies, should continue to review and comment on permit applications that have the potential to adversely impact manatees and/or their habitat.

H1.1. Support the acquisition of manatee habitat in South Florida. Federal and State systems of refuges, reserves, preserves and parks in Florida contain important manatee habitat. Management of those areas offers assurance that habitat will be maintained so as to protect the features (*e.g.*, grassbeds, quiet secluded waterways, warm-water springs, etc.) important to manatees. In the last 10 years, considerable cooperative effort has been devoted to acquiring essential manatee habitat and adding it to Federal and State protected area systems. These efforts are beginning to form regional protected area networks that contain many important habitat features essential for the long-term survival of manatee populations. These efforts need to continue as well as efforts to manage key protected areas in ways that enhance achievement of manatee recovery objectives.

- H1.1.1. Support the acquisition and incorporation of essential manatee habitats to the NWR, park, and preserve system. Several NWRs managed by the FWS contain essential manatee habitat and are adjacent to other essential manatee habitat that is not similarly protected. Expanding refuges to add these areas would significantly improve protection not only for manatees, but also for many other species. Particularly important areas in this regard are along the Crystal River near the Crystal River NWR; Homosassa River near the Chassahowitzka NWR; and St. Johns River and associated waterways in and adjacent to the Lake Woodruff NWR. As possible, the FWS should pursue acquisitions, in cooperation with the State of Florida, to expand these and other refuges.
- H1.1.2. Support the acquisition and incorporation of essential manatee habitats to state reserve, preserve, and park systems. Florida's Conservation and Recreation Lands (CARL) Program and the Save Our Rivers Programs administered by the five regional water management districts have acquired many areas that will further manatee habitat protection. They also have many important acquisition projects in varying stages of development. As possible, administrators of the two State programs, in cooperation with the FWS, should place special emphasis on completing acquisition projects important to manatees.
- H1.1.3. Review and provide advice on priority habitat acquisitions relative to manatees. The CARL trust fund provides a significant source of funding for manatee habitat acquisition projects. In allocating these funds, the Office of Protected Species Management in the DEP provides comments and advice to the Division of State Lands and the Program's Land Acquisition Advisory Council on listed acquisition projects of particular importance to manatees. DEP and the FWS should continue to provide advice to this program and the Save Our Rivers program. Particular efforts should be made to solicit acquisition advice from manatee biologists with the DEP's Florida Marine Research Institute and field research biologists with the USGS/BRADEED's Sirenia Project.
- H1.1.4. Identify and propose new land acquisition projects. As new information on manatee habitat-use patterns and essential habitat becomes available, new areas for acquisition may be identified. New land acquisitions can connect areas of essential manatee habitat to create regional protected systems. Periodic efforts should be undertaken to review manatee distribution and movement patterns to identify and propose new land acquisition projects. A task force to undertake this work should be created and convened as necessary.

H1.1.5. Encourage and coordinate Federal, State, and private land acquisition efforts. Manatee-related land acquisitions that help create regional networks of essential manatee habitat are particularly important. In this regard, identification of priority areas must include regional manatee habitat requirements and relationships among essential manatee habitats. To promote and guide complementary projects, the FWS and the DEP should designate an individual to convene meetings, act as a clearinghouse on the status of manatee acquisition projects, and otherwise help coordinate relevant land acquisition by Federal and State agencies, The Nature Conservancy, and others.

H1.2. Protect and manage habitat in South Florida.

H1.2.1. Support the designation, management, and maintenance of Federal manatee sanctuaries and refuges in South Florida. Under authority of the Marine Mammal Protection Act and the ESA (50 AFR Part 17), the FWS may designate certain waters as manatee sanctuaries (areas in which all waterborne activities are prohibited) or manatee refuges (areas in which certain waterborne activities may be regulated). Six seasonal manatee sanctuaries have been designated by the FWS (FWS 1995). Established areas must be posted and enforced. As necessary, the FWS should modify existing rules and designate other sanctuaries or refuges.

H1.2.2. Support the maintenance of safe, reliable artificial warm-water refuges in South Florida. Many Florida manatees have come to rely on warm-water outfalls from certain power plants and other industrial facilities to avoid thermal stress during periods of extreme winter cold. If warm-water discharges used regularly by manatees are disrupted or otherwise fail to provide needed warmth during the winter, animals which have learned to use them may be exposed to cold stress and perhaps die before they can find or reach alternative heat sources. In addition, water intake canals, pipe openings, etc. could trap manatees attracted to these facilities. Management agencies should conduct a review of these artificial warm-water discharges and develop recommendations based on the importance of each outfall to the long-term survival of the manatee. For those discharges that are determined to be essential for the survival of the manatee, written agreements should be established between the FWS and relevant industries on appropriate courses of action. To minimize discharge interruptions and other threats to artificial refugia, National Pollution Discharge Elimination System permits issued by the EPA or the DEP should be reviewed by the FWS pursuant to its authority under the ESA and the Clean Water Act. Manatee site protection plans should be

developed by permittees as requirements of issued permits and should address such issues as: (1) disruptions to warm-water outflows during winter; (2) inadequate discharge temperatures to sustain manatees during extreme cold events; (3) precautions to minimize hazards to manatees at intake and outfall areas; and (4) timely communication to manatee recovery program personnel of any long-term changes in the availability of warm-water discharges and/or unanticipated problems that may affect manatees in outfall areas.

- H1.2.3. Protect and promote regeneration of seagrass beds in South Florida. Implement new measures to protect and recover seagrasses. Particular attention should be given to establishing monitoring procedures and standards for water clarity in areas of existing or historic seagrass beds. In addition, guidelines should be established to assist in the review of applications for state environmental resource permits issued by the DEP and requests for state submerged lands leases issued by the Florida Board of Trustees that may affect the quality of seagrass beds important as manatee feeding areas. Assess threats to seagrass habitats and develop protection strategies. Develop and implement alternative measures to mitigate threats to, and promote regeneration of, seagrasses. Primary areas in need of protection include Lee, Collier, and Miami-Dade counties.
- H1.2.4. Support the review and implementation of aquatic plant control programs. Essential freshwater food supplies for manatees outside of protected areas may be damaged by dispersal of herbicides to control exotic aquatic plants. The FWS and the DEP Office of Protected Species Management should routinely review treatment plans developed by aquatic plant control programs to ensure that neither manatees nor their essential food sources are adversely affected by these herbicides. Mechanical or biological plant control alternatives should be considered, if possible. Such alternatives may not always be appropriate. For example, mechanical plant removal may be inadvisable in some areas when manatees are present in large numbers.
- H1.2.5. Incorporate manatee protection measures into management systems for protected areas and State-owned submerged lands. Depending on local conditions and human activity patterns, management measures may be needed to ensure that activities and development projects within protected area boundaries or affecting state-owned submerged lands do not adversely affect manatees or their essential habitat.
- H1.2.5.1. Include manatee protection and monitoring measures in

management plans for Federal and State protected areas. As appropriate and possible, managers of Federal and State refuges, reserves, parks, etc. should adopt measures to develop and enforce waterway speed and access rules to avoid vessel traffic patterns that threaten manatees; manage aquatic plant control programs to avoid impacts to manatees or their food supplies; protect and monitor the quality and quantity of water flowing from natural warm-water springs used by manatees; and identify and avoid uses incompatible with protection of manatees and manatee habitat. They also should carry out programs to monitor and record manatee habitat-use patterns in and around unit boundaries. Such measures should be developed, reviewed, and modified periodically with the assistance of the FWS's manatee coordinator and the State's Office of Protected Species Management. Needed measures should be incorporated into unit management plans.

H1.2.5.2. Develop policies and provisions to guide decisions on leasing State-owned submerged lands. Most essential manatee habitat in Florida overlies publicly owned sovereignty submerged lands. Private use of these lands to construct marinas, docks or other facilities potentially affecting manatees requires a lease from the Florida Board of Trustees. To ensure that the use of such areas is consistent with manatee recovery objectives, there is a need to develop policies, guidelines, and/or other provisions to help review lease requests involving activities or projects that may directly or indirectly affect manatees and manatee habitat.

H1.2.6. Develop, implement, and update county manatee protection plans. To develop effective, fair manatee protection schemes, site-specific conditions and information should be reviewed and protection measures should be integrated into local policies and ordinances. Comprehensive, multi-faceted county manatee protection plans are considered appropriate and vital. It is anticipated that such plans would be implemented as amendments to local government comprehensive plans required by the State's Comprehensive Growth Management Act of 1985 and reviewed for consistency by DCA. Steps to encourage manatee protection plans already have been taken for the 13 key counties where manatee mortality has been greatest and manatees occur most frequently. Two of the most important components of these plans are county waterway speed zones and measures to balance plans for new boating facilities with manatee protection needs. Regarding the latter point, the Governor and Cabinet

have directed that limits be placed on the construction and expansion of boating facilities pending the implementation of more comprehensive plans. Eventually, such plans should be prepared for all counties with important manatee habitat.

- H1.2.6.1. Assist counties to develop manatee protection plans. To develop and approve manatee protection plans, county planners and DCA need reliable information on local manatee habitats and habitat-use patterns. To varying degrees, counties also may need help to identify and evaluate appropriate planning provisions. Such information and assistance should be provided by DEP's Office of Protected Species Management, FWS's Jacksonville Field Office, and USGS's Sirenia Project. The staff of these agencies should cooperatively synthesize and provide accurate, up-to-date data on manatee distribution and habitat within county boundaries to county officials and work closely with them to develop appropriate planning measures. DEP and FWS should coordinate with DCA to draft local, county or State manatee protection programs. Once completed, the plan should be approved and implemented. DEP, FWS, and the Sirenia Project must allocate the staff and resources needed to provide such assistance.
- H1.2.6.2. Assist in implementing manatee protection plans. Approved manatee protection plans should be provided to Federal and State agencies to aid in decision making with regard to permitting, leasing submerged lands, project review, or other activities that may have an affect on manatees. Of particular importance in this regard are DEP, the COE, and FWS.
- H1.2.6.3. Periodically assess, review, and modify manatee protection plan provisions. As new information becomes available, there may be a need to modify manatee protection plans. One of the most critical needs in this regard is data on boating activity patterns. While efforts are underway to gather these data in the 13 key manatee counties, it should be collected state-wide. Accordingly, the Office of Waterway Management and the Office of Protected Species Management in DEP should cooperate in developing a state-wide database that includes data on: (1) boat traffic patterns; (2) areas of concern for boating safety; (3) the location of existing marine facilities; and (4) proposed sites of future marine facilities. Based on this and

other relevant data, county officials and staff of DCA, the Office of Protected Species Management, and FWS should periodically review county manatee protection plans. Modification of county plans may be called for in the future, based on changes in available information. Plans would need to be strengthened as needed should human-caused mortality increase. Similarly, modifications to accommodate boaters may be warranted where manatee use of speed zone areas is demonstrated to be significantly less than previously documented.

H2. Restore and create manatee habitat in South Florida.

H2.1. Support the maintenance and restoration of water quality in freshwater sources. Coordinate with the South Florida Restoration Task Force to restore natural tidal flow and hydrology in manatee habitat. Maintain minimum flows and levels in manatee use areas.

H2.2. Enhance manatee habitat in South Florida. Improve habitat by planting or encouraging native plant species, such as seagrasses and mangroves. Wetland restoration in the Indian River Lagoon area may significantly benefit the manatee. Coordinate with the FWS's Coastal Program and other pertinent groups to conduct manatee habitat restoration efforts.

H3. Support research on manatee habitat in South Florida and how it affects the manatee's persistence. Ongoing research on manatee-seagrass grazing interactions should be continued and completed. Investigations of manatee grazing effects and seagrass recovery, using both exclosures and enclosures, have been conducted in the Banana River in Brevard County. Results from these studies should provide information useful in design of monitoring studies, estimation of manatee carrying capacity of seagrass beds in key areas, and better understanding of the manatee's role in maintaining healthy, diverse seagrass communities.

H3.1. Investigate how manatees use different habitat components for survival. Investigate the effect of habitat change in South Florida on the manatee. Determine how manatee distribution and abundance is affected by increased mortality, habitat degradation, and hydrological changes.

H3.2. Determine an index of habitat fragmentation in South Florida.

H3.2.1. Investigate movement patterns and the spatial use of habitat to identify important core areas and corridors in South Florida.

- H3.2.2. Determine if the amount and configuration of habitat is sufficient to support a stable or increasing population of manatees in South Florida.
- H4. Develop and implement a manatee habitat monitoring program. In addition to efforts to monitor the status of manatee populations, work should be undertaken to monitor the condition and status of manatee habitat. Information from such a program could provide an early warning of future threats to manatee populations and help explain observed manatee population trends. Presently, there is no systematic approach to monitoring the condition of key manatee habitats.
- H4.1. Develop methodology and expertise to monitor the condition of essential manatee habitats. While basic manatee habitat requirements have been identified and many, if not most, of the essential areas providing those requirements are known, there is no systematic approach for monitoring the condition of those habitat features. For example, the condition of essential grassbed feeding areas and the discharge rates and water quality at natural warm-water refuges are not routinely monitored. To provide a means of detecting potential problems in the capacity of such areas to support manatee populations, methodologies and expertise to monitor the condition of essential manatee habitat features should be identified and tested.
- H4.2. Coordinate and implement a long-term habitat monitoring program. A longterm program should be initiated to monitor key parameters, such as the species composition and extent of aquatic plant species at vital feeding areas and the discharge rates and water quality at warm-water refuges. To the extent possible, such efforts should rely on habitat monitoring programs and research already undertaken by Federal and State agencies or academic institutions.
- H5. Establish effective manatee management programs at Federal and State protected areas. After essential manatee habitats are acquired and added to Federal and State holdings, the agencies responsible for administering those areas should incorporate manatee protection and public awareness measures into unit administration programs.
- H5.1. Develop and maintain public education programs at selected protected areas. Because Federal and State protected areas attract thousands of visitors each year, those containing essential manatee habitat offer valuable opportunities for interpretive programs on manatee conservation. Visitors to refuges, preserves, and parks with essential manatee habitat must be made aware of special measures to protect manatees within these areas.
- H5.2. Develop public awareness/education programs at other parks and refuges. FWS and the State should develop and maintain displays and education programs explaining manatee conservation issues at other refuges, reserves, preserves, and

parks that include essential manatee habitat. This should also be a priority at manatee aggregation sites where managed public viewing and education opportunities exist.

Recovery for the Florida Panther, *Felis concolor coryi*

Recovery Objective: Establish three viable populations within the historic range.

South Florida Contribution: The narrative in this multi-species recovery plan is being prepared in advance of the range-wide Florida panther recovery plan revision which will be undergoing complete revision beginning in late 1997. Therefore, recovery tasks identified in this plan should be considered tentative and subject to change based on the results of the range-wide recovery plan revision. The multispecies plan will focus on the South Florida population, while recognizing that full recovery of this species is dependent upon the establishment of additional populations within the historic range of the species. The FWS will ensure the two plans complement one another in effecting recovery of the Florida panther.

Recovery Criteria: The present range-wide recovery objective for the Florida panther is to achieve three viable, self-sustaining populations within the historic range of the animal. First priority will be to secure the population in South Florida. A viable population level will be determined when enough data are available to develop a panther population model. An essential criteria for recovery of the panther needs to ensure 95 percent probability of persistence of the South Florida population over a minimum of 100 years. Re-established populations may require separate population goals. Population objectives will generally be based on the size of the respective areas, prey base, and other ecological factors important to panthers.

This narrative will only address the existing population in South Florida. The range-wide recovery plan revision will incorporate the needs in South Florida with population re-establishment and the many other tasks deemed necessary to recover the panther.

Species-level Recovery Actions

S1. Refine the current distribution of the South Florida panther population. Delineate areas inhabited or frequented by panthers. Radio-collared panthers have been documented in 12 of 19 counties in South Florida. The breeding population is centered in Collier, Hendry, and Miami-Dade counties. Uncollared panthers may still reside on private lands in Charlotte, Collier, Hendry, Lee, and Glades counties.

S1.1. Conduct field surveys on all newly acquired public lands. As State or Federal conservation lands are added to the public trust field surveys should be conducted to determine the presence or absence of Florida panthers. Uncollared panthers encountered should be added to the research population.

S1.2. Conduct field surveys on private lands to document panther presence. Potential

sites would include areas identified in the HPP, other areas comprising panther habitat, and areas associated with reliable reports of panther observation/sign. Special emphasis should be placed on developing cooperative partnerships with private landowners for access. Private landowners currently involved in telemetry research studies should be commended for their participation. As in S1.1, uncollared panthers encountered should be added to the research population.

S2. Protect and enhance the South Florida panther population.

S2.1. Enhance the panther population through genetic and demographic management. Plans for genetic and demographic management should anticipate the circumstance under which translocation would be appropriate, and should distinguish the advantages and disadvantages of using males, females, pregnant females, animals of various ages, soft- and hard-release techniques, etc.

S2.1.1. Translocate animals for genetic management. Eight female western cougars (*F. c. stanleyana*) were translocated from Texas to Florida for genetic introgression in 1995. The approved genetics management plan calls for the translocation of one female western cougar about every 6 years thereafter. Animals selected for translocation must be screened in the field for cowlicks and kinked tails and screened in quarantine for atrial septal heart defects or disease using established protocols.

S2.1.2. Formulate plan for humane disposition of surplus animals. Female western cougars may need to be removed once F1 kitten recruitment goals (two per female) are met. A female western cougar/male F1 kitten pairing (backcross) is undesirable. Contraception, translocation, and removal are techniques by which undesirable pairings can be prevented. Develop a protocol for removal of these surplus animals from the population and attach it to the recovery plan as an appendix.

S2.2. Translocate animals for demographic management. It may be necessary, on occasion, to translocate panthers or intercross progeny to minimize or prevent undesirable pairings, to balance gender representation, and to fill home range vacancies in marginal habitat (i.e. southern Big Cypress).

S2.3. Reformulate plan for captive propagation of Florida panthers. Ten kittens, representing 11 adult panthers, were removed from South Florida during 1991 and 1992. Two died in captivity in 1992. Two died after being released to the wild in 1997. The other six panthers remain in permanent captivity. A population reestablishment study showed that there were advantages to using wild-caught versus captive-raised animals. Wild-caught western cougars are being used for

genetic management rather than captive-raised animals. Consequently, the role of captive propagation in panther recovery would seem diminished. However, the fate of panthers remaining in captivity, and the role of captive propagation for education, genetic management, demographic management, or population re-establishment has not been determined. These issues need to be addressed.

S2.4. Identify causes of injury and mortality. Florida panther mortality (n=67) averaged 3.5 deaths per year from 1978 through June 30, 1998. Specific causes of panther mortality include: road kill (37.9 percent), intraspecific aggression (21.2 percent), disease and old age (18.2 percent), causes unknown (12.1 percent), shootings (9.1 percent), and capture related (1.5 percent). Other than disease, only those causes of panther injury or mortality attributable to humans can be minimized.

S2.4.1. Continue to minimize injury and mortality from panther/vehicle collisions. Florida panther injury and mortality (n=30) from vehicle collisions averaged 1.5 per year between 1978 and June 30, 1998. Panther/vehicle collisions were greatest in Collier County (76.7 percent), Hendry County (10 percent), and Lee County (10 percent); and on S.R. 29 (33.3 percent) and Alligator Alley (16.7 percent) in Collier County. Reduced nighttime speed limits are in effect, and enforced, on S.R. 29. Underpasses and fencing have eliminated panther mortality on Alligator Alley and certain stretches of S.R. 29. Panther/vehicle collisions continue on other rural roads.

S2.4.1.1. Complete installation of underpasses on S.R. 29. Four of six underpasses have been installed concurrent with the widening and realignment of S.R. 29. Two underpasses remain to be constructed in the Sunniland, Florida vicinity.

S2.4.1.2. Establish an underpass on S.R. 80 east of LaBelle, Florida. The Caloosahatchee Ecoscape was added to the Conservation and Recreation Lands acquisition list in 1998 and serves as the last remaining link between panther habitat in Glades County and Hendry County. S.R. 80, which runs from Ft. Myers to West Palm Beach, bisects the project, is heavily traveled, and likely to be four-laned. An underpass or underpasses will be required to maintain this important landscape link.

S2.4.1.3. Identify and prioritize other underpass needs in South Florida. Panther/vehicle collisions continue on rural two-lane roads in eastern Collier County, Hendry County, and in rapidly developing eastern Lee County. Underpass needs should be

identified prior to future road maintenance or improvement projects on appropriate roads in South Florida counties. It is more efficient to construct wildlife underpasses concurrent with road improvements.

- S2.4.2. Minimize the risk of disease outbreaks. Disease is a threat to small, inbred populations. All Florida panthers undergo an examination to assess general health and physical condition at the time of capture. Panthers greater than 8 weeks of age are dewormed and vaccinated for feline viral rhinotracheitis (FVR), feline calicivirus (FCV), feline panleukopenia (FPV), and rabies. Biomedical samples collected include whole blood, skin biopsy, hair, and feces. Bacterial cultures are taken as needed. Panther kittens less than 6 weeks of age are also given injections of iron, vitamin B, and penicillin. This protocol should continue--subject to periodic review, and amendment as needed.
- S2.4.3. Minimize the risk of shootings. Education, self-policing among hunters, and regulation are the tools by which shootings are minimized. All free-ranging puma in the southeastern U.S. are protected by a “similarity of appearance” provision in the ESA.
- S2.4.4. Minimize the risk of capture-related mortality. The only capture-related panther mortality occurred in 1983. Captures are confined to cooler months (November through March) to minimize heat stress. Crash bags and safety nets are used to cushion the impact of panthers that fall from the tree after immobilization. Anesthetic drugs have been changed and doses reduced through experience to minimize adverse reactions to the drugs. Advances in pharmacology have also made anesthesia safer.
- S2.5. Enforce available protective measures. Implement local, State and Federal regulations and guidelines to protect Florida panthers and their habitat.
 - S2.5.1. Initiate section 7 consultation when applicable. All Federal agencies must consult with the FWS on any of their activities (authorized, funded, or carried out) that might adversely affect Florida panther populations. Such activities include (among others) land clearing, road construction, and military training exercises.
 - S2.5.2. Implement on-site minimization, habitat compensation, and mitigation on private lands through section 10 when needed. Where adverse effects cannot be avoided, measures must be taken to minimize on-site disturbance, and compensate or mitigate for the impacts that remain. The

FWS generally recommends that areas used as habitat compensation be located in the vicinity of the affected habitat, where appropriate, and avoid further fragmentation and isolation of existing habitat.

- S3. Continue Florida panther life history and ecology research.
- S3.1. Conduct research on biology, ecology, and population demographics. Although considerable work has been done on the biology and ecology of the Florida panther, biological studies should continue to increase information on population viability, and relationship of demographic factors to habitat quality and availability.
 - S3.2. Conduct risk assessment and population viability analyses to determine the probability of persistence of panthers in South Florida, using current demographic data. Conduct periodic workshops to update population viability projections.
 - S3.3. Continue research on effects of mortality on the Florida panther.
 - S3.3.1. Assess the current state of knowledge of the effects of environmental contaminants on the Florida panther. Compile the latest available information from published and unpublished literature, and from scientists, to determine the direction for future research.
 - S3.3.2. Continue to research effects of environmental contaminants that could be affecting the Florida panther. Other environmental contaminants, such as endocrine disruptive chemicals, should be researched to assess any possible effects to the Florida panther.
 - S3.3.3. Continue to gather and evaluate data on feline-associated viruses, parasites and other potentially debilitating agents. Management recommendations should follow guidelines resulting from these data.
 - S3.3.4. Develop health indicator matrix. Presence or absence of disease and contaminants (estrogen mimics, mercury) for each animal would be indicated in the matrix. An index of health would be established by noting the number of animals affected by disease or contaminants, the extent to which the animal is affected, the age, sex, and breeding condition of the animal, and comparing that to a desired index.
 - S3.3.6. [sic] Conduct research to determine the effects of road density and development (human density) on white-tailed deer and feral hog

distribution and abundance.

S4. Monitor the South Florida panther population.

S4.1. Continue and expand the radio-telemetry/monitoring program. The radiotelemetry/monitoring program within the core population area has been underway since 1981. Continue to track locations of collared panthers, and maintain all data on a GIS database. Expand the program by radio-instrumenting individuals in under-studied segments of the population and monitoring outside of the core area (*i.e.* CREW, Okaloacoochee Slough area, areas north of the Caloosahatchee River, etc.).

S4.2. Continue to monitor translocated animals and offspring. All western cougars used for genetic introgression are radio-collared and monitored. All intercross kittens will be implanted with transponder identification chips, radio-collared prior to dispersal, and monitored. Four F1 kittens implanted with transponder identification chips have dispersed without being radio-collared. These animals, now old enough to breed, will be collared when encountered. DNA analysis will be required to establish the identity of F2 kittens sired or reared by the four uncollared F1 kittens.

S5. Refine statewide education and outreach programs for Florida panther. A 1995 public opinion survey indicates that Floridians are remarkably positive in their opinions and attitudes toward panther conservation (92 percent support, 2 percent oppose). The challenge now is to turn this support into tangible conservation efforts. Educators need to identify specific ways Floridians can become involved in panther protection. The action items should be simple and need to be effectively and constantly communicated to the public.

S5.1. Emphasize basic facts about the Florida panther in outreach materials. Awareness of the panther among respondents of the 1995 survey was high (90 percent) but knowledge levels were limited. Surprisingly, only 44 percent of the people aware of panthers in Florida knew that the panthers were confined to South Florida and only 14 percent knew that there were less than 50 remaining. Public relations efforts and materials must continue to reflect these basic facts.

S5.2. Tailor outreach efforts and materials to non-residents. Tourism, which brings about 40 million people to Florida annually, was not a focus of the 1995 survey. Agencies are only now beginning to understand the relationship between tourism, development, and wildlife conservation. Another way to increase panther awareness levels and support is to tailor outreach efforts and materials to tourists.

S5.3. Publicize Florida panther website. A website has been developed by Florida State

University and the Florida Advisory Council on Environmental Education with funding derived from the sale of panther license plates. Education and outreach materials should include the web address (www.panther.state.fl.us).

- S5.4. Establish South Florida education and outreach programs for Florida panther. Informing the public about the life history of the panther, land management practices that benefit the panther, and interagency efforts to prevent the extinction of the panther are important components of the panther recovery program. Listed below are tasks specific to South Florida as identified in the Florida Panther National Wildlife Refuge Comprehensive Conservation Plan.
- S5.4.1. Develop multi-agency visitor center. Use high-quality, conventional exhibits and progressive interactive media displays to inform public. The center will serve as an outdoor classroom in the Big Cypress Watershed for students in Collier County, Hendry County, Lee County, and all of South Florida.
- S5.4.2. Hire three new personnel at Florida Panther National Wildlife Refuge. A media specialist is needed to coordinate news events, press releases, and information transfer to local, State, and national news outlets. A public use specialist is needed to coordinate visitor center activities, refuge interpretive displays, school outreach, and refuge volunteer activities. An administrative assistant is needed to support the media specialist and public use specialist.
- S5.4.3. Increase membership of “Friends of the Panther Refuge” support group. The target is to have 100 members. The group will assist with education programs on and off the refuge. Quarterly evaluations will assess the effectiveness of the group’s support efforts.
- S5.4.4. Collaborate with partners to support outreach activities. Partners include but are not limited to local, State, and national non-profit organizations, and State and Federal agencies. Participate with partners in at least two events per year (National Wildlife Refuge Week, International Migratory Bird Day, Earth Day, etc.).
- S5.4.5. Develop lesson plans for local school teachers and community organizations. The lesson plans should focus on the panther, public land management, South Florida ecosystem issues and restoration efforts. An annual workshop will be held for teachers from school districts in Collier County, Hendry County, Lee County, and all of South Florida.

- S6. Continue to participate in the Florida Panther Recovery Program.
- S6.1. Reconstitute the Florida Panther Interagency Committee. The Florida Panther Interagency Committee (FPIC), established in 1986 to coordinate panther recovery efforts, is comprised of the FWS, NPS, GFC, and DEP. However, other State and Federal agencies and tribal governments have much to contribute to panther recovery. Consideration should be given to expanding FPIC membership.
 - S6.2. Convene periodic meetings of the Florida Panther Recovery Team. The Florida Panther Recovery Team should convene periodically to discuss interagency relations, ongoing research, research results, new literature relevant to panther recovery, and to assess panther recovery program accomplishments and needs.
 - S6.3. Convene periodic meetings of the Florida panther Technical Advisory Council. The Florida Panther Technical Advisory Council should continue to convene biannually.
 - S6.4. Update and revise the range-wide Florida panther recovery plan. The range-wide recovery plan, first approved in 1981, then revised in 1987 and 1995, is currently undergoing its third revision, which should be complete in 2000. The range-wide plan details the status of the recovery program and the myriad of tasks necessary for panther recovery. The plan should be updated and revised every 5 years. Progress reports on recovery plan implementation should be published annually.
 - S6.5. Convene periodic conferences for recovery program partners and general public. The Florida Audubon Society sponsored the first Florida Panther Conference in Orlando, Florida in 1978. A second conference sponsored by Florida Defenders of the Environment was held in Gainesville, Florida in 1986. A third conference sponsored by the Florida Panther Interagency Committee was held in Ft. Myers, Florida in 1994. The conferences have all focused on the issues of, and progress towards, panther recovery. Conferences held about once a decade for recovery program partners and the general public seem appropriate.

Habitat-level Recovery Actions

- H1. Preserve and protect Florida panther habitat. The Florida Panther Habitat Preservation Plan (HPP) identified 374,868 ha of occupied and potential habitat considered essential to maintaining a minimum viable population of 50 breeding adult panthers in South Florida. Fifty-seven percent of these lands are classified as Priority 1 (highest quality and/or most frequently used) and 43 percent as Priority 2 (lower quality and/or less frequently used). The HPP also identified habitat threats, and the means by which habitat could be protected: land acquisition, conservation easements, exchanges, donations, voluntary management agreements, landowner incentives, and landowner disincentives.

- H1.1. Complete acquisition projects comprised of Priority 1 and Priority 2 habitat. Nearly 190,000 ha of priority panther habitat have been proposed for State (75 percent) or Federal (25 percent) acquisition. Thirty-three percent of these lands have been preserved using fee-simple acquisition and conservation easements. The remainder should be preserved in a timely manner.
- H1.2. Initiate new acquisition projects comprised of Priority 1 and Priority 2 habitat. The FWS has initiated a proposal to expand the Florida Panther NWR in Collier County and Hendry County by about 150,000 ha. Other proposals are being developed. Appropriate agencies should continue to identify landowners interested in panther recovery from whom land and conservation easements may be purchased.
- H1.3. Complete public protection of Big Cypress Area of Critical State Concern. The Big Cypress Conservation Act of 1973 designated 347,228 ha of the 634,561 ha Big Cypress Watershed as an Area of Critical State Concern (ACSC). Today, 93 percent of the ACSC is in public ownership. The 7 percent remaining in private ownership, all Priority 1 habitat, extends from Florida Panther NWR north to Okaloacoochee Slough SF, serves as a large mammal corridor between Collier County and Hendry County, and should be protected.
- H1.4. Establish, restore, and maintain important corridors. Corridors are necessary for population expansion and for facilitating gene flow between subpopulations. The Caloosahatchee Ecoscape, added to the CARL acquisition list in 1998, is a 4,047 ha corridor connecting panther habitat in Glades County and Hendry County. Camp Keais strand links Florida Panther NWR with the CREW. A recent 20,695 ha conservation easement acquired by the SWFWMD could link panther habitat in DeSoto County and Glades County. The Florida Greenways Coordinating Council adopted in 1998 a five-year implementation plan for a statewide system of greenways and trails that could benefit the panther long-term.
- H2. Use landowner incentive programs to conserve, restore, and manage panther habitat. The USDA-NRCS and FWS administer several landowner incentive programs capable of preserving Priority 1 and Priority 2 panther habitat on farms and ranches in South Florida. Each of the programs is briefly discussed below. Some examples of how the program can be used for panther recovery are given.
- H2.1. Environmental Conservation Acreage Reserve Program. The Environmental Conservation Acreage Reserve Program (ECARP) encompasses the Conservation Reserve Program, Wetlands Reserve Program, and the Environmental Quality Incentives Program. The purpose of these programs is to help farmers and ranchers conserve and enhance soil, water, and related natural resources, including grazing

land, wetlands, and wildlife habitat. Program objectives are achieved primarily through short-term or perpetual retirement of marginal agricultural land and changes in land management practices.

H2.1.1. Conservation Reserve Program. The Conservation Reserve Program (CRP) makes annual rental payments and pays 50 percent of the cost of eligible conservation practices implemented by the landowner. Two types of CRP are recognized. The Traditional CRP allows irregular, periodic enrollment of large acreages and can quickly provide measurable benefits to wildlife species requiring expanses of contiguous habitat. For example, traditional CRP should be used to establish tracts of pine flatwoods 250 ha or greater to reverse a historic pine flatwoods decline of 88 percent in central South Florida. Forest tracts 250 ha or larger are a constituent element of occupied panther range and pine flatwoods can account for about 30 percent of individual panther radio-locations. The Continuous CRP allows year-round enrollment of small acreages with an emphasis on strip-type water quality practices. The continuous CRP should be used to plant pine or hardwood buffers around isolated cypress domes or along cypress strands to provide cover for panthers, cover for panther prey, and to increase average forest patch size in a given area, thus reversing fragmentation. Trees planted in strips of sufficient width along ditches, canals, interior access roads or similar landscape features could serve as cover for panther prey and provide nominal travel corridors for the panther.

H2.1.2. Wetlands Reserve Program. The Wetlands Reserve Program (WRP) pays farmers and ranchers to restore former and degraded wetlands. Restoration of forested wetlands would reverse forest declines and would be somewhat beneficial to the panther given its preference for forested habitats. Wetland restoration would also benefit panther prey, which can be found feeding in, or around the edge of, herbaceous wetlands. The options available include the following: (1) permanent easements, where the easement payment is generally 100 percent of the agricultural value or a predetermined area cap, and NRCS pays 100 percent of the restoration costs; (2) 30-year easements, where the easement payment is generally 75 percent of the agricultural value or a predetermined area cap, and NRCS pays 75 percent of the restoration costs; and (3) restoration cost-share agreements, where there is no easement payment but NRCS pays 75 percent of the restoration costs. The minimum duration for the agreement is 10 years.

- H2.1.3. Environmental Quality Incentives Program. The Environmental Quality Incentives Program (EQIP) provides educational, technical, and financial assistance to help farmers and ranchers comply with State and Federal environmental laws. Fifty percent of the annual appropriation is allocated to livestock-related natural resource concerns and cattlemen owning land inhabited by the panther are ideal applicants. This program can be used to fence hardwood hammocks that have been degraded by mechanical manipulation or overgrazing. Hardwood hammocks can account for 30 to 40 percent of individual panther radio-locations and are the most productive white-tailed deer habitat.
- H2.2. Wildlife Habitat Incentives Program. The Wildlife Habitat Incentives Program (WHIP) helps farmers and ranchers to plan and pay for improvements that benefit threatened and endangered upland and wetland species. NRCS will pay up to 75 percent of the cost of implementing the conservation practice. A minimum 10-year contract is required. Annual food plots are not eligible. The program was designed to promote habitat management compatible with active agricultural operations and can be used to develop, restore, or enhance many habitat types. All of the examples given above could be accomplished using this program. Use of prescribed fire to manage pine flatwoods and to stimulate the growth of understory browse for deer is also possible.
- H2.3. FWS Partners for Fish and Wildlife program. The Partners for Fish and Wildlife (PFW) program provides technical and financial assistance to private landowners to restore and enhance fish and wildlife habitat on their property. The FWS will pay up to 100 percent of the cost of habitat restoration projects and up to 50 percent of habitat improvement projects. The funding is limited to \$10,000 per landowner per year and the minimum duration of a PFW contract is 10 years. The PFW program can work in conjunction with any of the USDA-NRCS programs to help implement the conservation practices discussed above.
- H3. Optimize habitat management techniques for panther and prey. Optimal management of habitat suitable for panther and prey on public and private lands is second only to habitat preservation. Prescribed fire should be used to maintain fire-adapted vegetation communities and provide browse for white-tailed deer. Chemical, biological, and mechanical control methods can eradicate invasive exotic plants. Hunting and access restrictions can be used to manage prey and minimize human activities that might disturb panthers. Research and education are key to optimizing habitat management for panther and prey.
- H3.1. Continue research on panther, panther prey, and habitat relationships. The USGS-BRD, University of Tennessee is conducting a study on the response of

panthers to prescribed fire and a study on panther movements in response to recreational hunting. The University of Florida, Institute of Food and Agricultural Sciences, Southwest Florida Research Center is conducting a deer forage study. Staff at Florida Panther NWR are conducting experiments on food plots for white-tailed deer. Other studies are underway or being planned. Land management programs will be refined as research results dictate.

H3.1.1. Determine properties best suited for habitat restoration using landowner incentive programs. Using most recent low-level aerial photography and land ownership data available, determine which ownerships best fit the ideal for panther habitat.

H3.1.2. Host annual seminar for South Florida land managers. The seminar will provide an interactive forum for farmers, ranchers, and public land managers to discuss management techniques, current research, research needs, public/private partnerships, and other topics pertinent to panther habitat management and panther recovery.

H4. Develop and implement a habitat monitoring program. Data exist for habitat changes in the Immokalee Rise physiographic region from 1900 through 1989. Low-level aerial photography should be acquired every 10 years to ascertain positive and negative changes in habitat quantity. The analysis should focus on upland and wetland forest fragmentation, *i.e.*, gaps between forest patches, forest patch size and abundance per patch size, etc.

H5. Publicize habitat management techniques and research results to increase public awareness. Publish a periodic newsletter, via print and the internet, on panther habitat management issues and relevant research results. The newsletter should be sent via direct mail to all South Florida land managers (public and private) and distributed through local county extension and USDA-NRCS offices to landowners.

The Birds

Recovery for the Audubon's Crested Caracara, *Polyborus plancus audubonii*

Recovery Objective: DELIST the species once recovery criteria are met.

Recovery Criteria: This objective will be achieved when any further loss, fragmentation, and degradation of habitat in south-central Florida has been prevented; when the number of Audubon's crested caracara territories in the historic range increases from 200 to 300; when Audubon's crested caracara have maintained or exceeded this number of territories for at least 10 years; when these territories are well-distributed throughout the core counties of Glades, DeSoto, Highlands, Okeechobee, and Osceola; when additional breeding pairs have established

territories on unoccupied or restored habitat; when those lands have been protected through land acquisition, conservation easements, or cooperative agreements; and when the Audubon's crested caracara population in Florida exhibits an intrinsic rate of increase (r) equal to or greater than 0.0, sustained as a 3-year running average over at least 10 years.

Species-level Recovery Actions

- S1. Determine the distribution, status, and abundance of Audubon's crested caracaras. Dry prairie habitats throughout the Kissimmee River valley should be targeted for surveys. Other areas that might support populations of the Audubon's crested caracara should be determined through the use of satellite imagery to locate search areas and other aggregation areas important to juvenile caracaras.
 - S1.1. Locate active caracara territories in Glades, DeSoto, Highlands, Okeechobee, and Osceola counties. Active territories in these counties should be mapped using digital, spatial information; this information should be maintained as part of a database to facilitate land protection and monitoring efforts for the caracara.
 - S1.2. Locate and map potential habitat within the former range of the caracara that might be rehabilitated for reintroduction purposes. Caracaras once occurred in prairie habitat from northern Brevard County south to Collier County. Caracaras were once reported from as far north as Nassau County and as far south as the lower Keys in Monroe County but have been extirpated over much of their former range. Efforts should be made to locate and map these formerly inhabited areas, to determine if it is feasible to restore habitat and expand the range of the caracara.
 - S1.3. Develop standardized, systematic censusing procedures. The census should use active territories as a variable.
- S2. Protect and enhance existing populations of Audubon's crested caracara.
 - S2.1. Protect and enhance existing populations of Audubon's crested caracara on public and private land. Caracaras currently occur on several properties managed by the SFWMD in the Kissimmee River valley as well as other publicly owned land in south central Florida; however most pairs occur on private lands. Territories on private lands are critical to the survival and recovery of the caracara.
 - 2.1.1. Inform landowners of the presence of caracaras on their property. Appropriate State and Federal authorities should inform landowners that their property contains resident caracaras. Encourage landowners to protect caracara nesting sites by providing incentives (awards, credits for mitigation, special recognition, etc.). Inform landowners of the amount of habitat needed around each nest and the level of human activity tolerated

by each pair during nesting.

- 2.1.2. Encourage landowners to adhere to guidelines derived from item S3.1.4. Investigate options for monetary or tax incentives to encourage lower intensity farming operations or preservation of native habitats in occupied and restorable areas. Encourage the media to focus on these land protectors. Also, provide public recognition for proper land management.
- S2.2. Develop and implement a plan to reintroduce Audubon's crested caracaras into suitable habitats within their historic range. Caracaras once occurred in prairie habitat from northern Brevard County south to Collier County. Caracara sightings were once reported from as far north as Nassau County and as far south as the lower Keys in Monroe County. Efforts should be made to locate and map these formerly inhabited areas, to determine if it is feasible to restore habitat and expand the range of the caracara. This plan must identify the specific areas that are suitable for such reintroductions, protocols for determining when habitat is suitable for a reintroduction, the size of a reintroduced population, monitoring protocols for reintroduced populations, and land management prescriptions for reintroduction areas.
- S2.3. Encourage natural colonization of restored habitats by Audubon's crested caracaras. Many areas within the historic range of the caracara are being restored as part of the COE and SFWMD's restoration projects in the South Florida Ecosystem. Other areas are being restored because of a change in land use in the Kissimmee River valley (such as the expansion of Three Lakes WMA). Dispersal of the caracara into restored areas from occupied sites should be encouraged by enhancing areas adjacent to active territories.
- S2.4. Introduce rehabilitated birds into expanded or restored areas whenever and wherever possible. When caracaras are taken into captivity for rehabilitation purposes, those without permanent disabilities should be considered for release into expanded or restored areas when they have recovered. Myakka River SP has been recommended as a possible location for reintroducing caracaras that have been rehabilitated.
- S2.5. Establish rehabilitation centers for injured or sick caracaras found in the wild. Lyons (1984, 1985) had considerable success in rehabilitating sick and injured caracaras in Texas. Traumatic injuries in Texas usually involve leg or foot injuries (from leg-hold traps) and gunshot wounds. Lyons found that caracaras quickly adapt to captive conditions, and respond well to medical treatment. By establishing a center in Florida, sick or injured caracaras could be rehabilitated and returned to the wild. This could also be accomplished by developing agreements with a local

veterinarian, bird rehabilitation center, or university.

- S2.5.1. Develop an emergency program for removing injured or sick caracaras from the wild including a hotline number for notification of responsible individuals. When a sick or injured caracara is located, it may be necessary to place the bird into a rehabilitation center where it can receive proper medical treatment. A rehabilitation center should consider such factors as housing, equipment, veterinary expertise, proximity to the present core distribution of caracaras, etc. Key individuals should be appointed to pick up sick or injured birds and transport them to the rehabilitation center. The phone numbers of these individuals should be provided to all wildlife officers within the core range of the caracara.
 - S2.5.2. Establish a caracara rehabilitation team, made up of rehabilitation experts, raptor biologists, veterinarians, etc.
 - S2.5.3. Maintain accurate and detailed records on individuals brought in for rehabilitation.
 - S2.5.4. Determine where recovered birds should be released into the wild. When sick or injured birds have recovered to the point that they can return to the wild, they should be released in expanded or restored habitat areas.
 - S2.5.5. Monitor the health and status of Audubon's crested caracara that have returned to the wild. Monitor rehabilitated birds through radiotelemetry to determine whether they survive. If the introduction of rehabilitated caracaras is successful, more widespread reintroductions could be accomplished with juvenile birds.
 - S2.5.6. Conduct section 7 consultations on all Federal activities that may affect caracaras and their habitat. Federal agencies shall consult with the FWS on any activities (authorized, funded, or carried out) that may affect caracaras. Such activities include: pesticide use, road building, construction of new facilities, training exercises, wetland fill, clearing for new runways, etc.
- S3. Conduct research to determine the basic biological needs of the caracara. Although considerable research has been done on the biology and ecology of the Audubon's crested caracara, more information is necessary before this species can be properly managed and effects of habitat management actions assessed. Biological studies should be continued to complete our knowledge of the demographics of caracara populations (survivorship, fecundity, mortality, dispersal) and the relationship of these demographic variables to

habitat availability and quality, particularly water regimes and fire management.

- S3.1. Determine habitat requirements of the caracara in Florida. Habitat loss is believed to be the primary cause of caracara decline in Florida. Research to determine precise details are ongoing, but more information is needed on nesting and feeding habitat requirements, the percentage of forest or agricultural encroachment caracaras will tolerate, and their need for water. Precise details are also needed on the extent of caracara movement into other habitats for feeding and drinking purposes.
 - S3.1.1. Determine essential habitat components. Identify all the components that make up prime habitat. Prime habitat is the sum of all essential components, where their absence would make the habitat suboptimal or result in abandonment of the area for nesting and/or feeding. Determine the habitat components necessary for successful nesting and roosting. Determine the need for water in proximity to nests, and the level of tolerance to human disturbance during early and late reproductive stages. This action should involve the use of Geographic Information Systems and remote mapping since much of the occupied caracara territories are present on private lands.
 - S3.1.2. Determine the minimum amount of nesting and feeding habitat needed to support a population of caracaras. Determine the amount of nesting and feeding habitat needed to support a single pair of caracaras. Nesting habitat is relatively restricted, but territories extend over large areas. Therefore, maintaining nesting habitat might be the crucial factor in protecting the birds. Protection of nest sites from predators may be necessary at some nesting sites.
 - S3.1.3. Formulate estimates of habitat carrying capacity under optimum conditions. Determine the carrying capacity of nesting and feeding habitats of the Florida population of Audubon's crested caracara. This will allow scientists to evaluate which habitats are underutilized or overutilized. This knowledge is essential for management of the birds.
 - S3.1.4. Establish habitat management guidelines to protect the nests and nesting pairs of Audubon's crested caracaras. These guidelines should be modeled after the "Habitat Management Guidelines for the Bald Eagle in the Southeast Region" (FWS 1987). Their purpose will be to assist land owners, land managers, and regulatory biologists in avoiding impacts to caracaras.

- S3.1.5. Utilize current information and conduct additional research to develop a Population Viability Analysis for the caracara. This analysis would be used to evaluate management and regulatory actions as well as other conservation strategies, including the development of reintroduced populations. It would also aid in determining which ecological factors are most critical for the survival and recovery of the species.
- S3.2. Compile caracara data into a central database at one location. Gather historic data from all researchers. This data would be an important element in determining recovery of the population.
- S4. Develop and implement a program to monitor the status and trends of wild Audubon's crested caracara populations. It will be necessary to continually monitor the stability and health of existing wild populations to assess recovery efforts.
 - S4.1. Develop monitoring protocols and techniques for the Audubon's crested caracara. Develop a set of monitoring protocols that are able to identify small changes in the size and distribution of Audubon's crested caracara populations over time.
 - S4.2. Monitor Audubon's crested caracara populations on public lands to evaluate management actions. Establish monitoring programs for the Audubon's crested caracara on public lands in south-central Florida to determine if fire management, water management, and other management actions are consistent with the recovery needs of the caracara.
 - S4.3. Monitor the success of reintroduced Audubon crested caracara populations. To determine whether recovery efforts are successful, it will be necessary to conduct periodic censuses and surveys of all introduced populations.
- S5. Increase public awareness of the biology, ecology, status and trends of the Audubon's crested caracara. The public must be made more aware of the status and trends of the Audubon's crested caracara, its recovery needs, and opportunities to participate in the caracara's recovery. This public awareness program must include an effort to contact owners of lands that support populations of Audubon's crested caracaras; it must also include development and distribution of materials developed specifically to inform the public about the Audubon's crested caracara.
- S6. Assess reclassification criteria based on the results of research projects; revise as necessary. One condition required to reach the recovery objective for the caracara is to ensure that the amount of nesting and feeding habitat needed to maintain stable or expanding populations remains stable or increases over a 10-year period.

Habitat-level Recovery Actions

- H1. Protect and enhance currently occupied habitat. Alteration and habitat loss are primary threats to prairie species. As much of the remaining prairie habitat as possible must be secured. State and COE efforts to restore the Kissimmee River floodplain may provide habitat for prairie dependent species.
- H1.1. Protect privately owned, occupied lands wherever possible. Particular effort should be made to acquire or protect lands on which prairie species reside.
- H1.1.1. Encourage the purchase of unprotected lands that support caracaras. State, county, and local governments and private organizations can purchase lands. The FWS can consider purchase of land to protect endangered or threatened species through its Land Acquisition Planning System.
- H1.1.2. Use conservation easements and other non fee-title ownership options to maintain habitat. Conservation easements, recognized under both Federal and State law, may protect habitat while allowing it to remain in private ownership. Non-binding conservation agreements with landowners may also prove useful. Investigating tax and monetary assistance or incentives should be a high priority for willing landowners.
- H1.1.3. Where private lands cannot be acquired, or protected through conservation easements, encourage landowners to maintain suitable habitat for the benefit of prairie species. The private landowner must be informed of the needs and value of caracaras in order to obtain their cooperation in providing protection.
- H1.1.4. Maintain and enhance habitat on acquired lands or lands under conservation easements or agreements. Conduct prescribed burns, selective thinning, or mechanical manipulation at periodic intervals to maintain dry prairie and pasture habitat and prevent forest encroachment. Plant scattered cabbage palms, where needed, to serve as nesting sites for caracaras. Intensive rangeland improvements should be discouraged in prairie areas to maintain as many native vegetative species as possible.
- H1.2. Protect and enhance habitat on public lands. Occupied caracara territories present on public land should be protected and enhanced for this species. Public lands that are occupied by caracara include Avon Park AFR in Polk and Highlands counties, and the Latt Maxcy property (Kissimmee Prairie State Preserve) in Okeechobee County. Federal land management agencies should try to protect, maintain, and enhance occupied habitat on all lands they manage. Habitat must be maintained in an early stage of succession through selective thinning and prescribed burning.

Since caracara nesting is minimal on Avon Park AFR and this site is essential for the survival of the Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), grazing should not be increased in this area, and prairie management should focus on the grasshopper sparrow. Other public lands should utilize the recommendations obtained from habitat component research on the caracara to determine which management actions are compatible with the survival of this species and the Florida grasshopper sparrow.

- H1.2.1. Conduct prescribed burns at periodic intervals. Occupied areas should be burned in a mosaic fashion on a periodic rotational basis to maintain early stages of succession.
 - H1.2.2. Maintain pastures in native vegetation to the extent possible. Prairie species may be adversely affected if pasture lands are improved to the point where native vegetation is totally removed.
 - H1.2.3. Do not allow reforestation of prairies. Prairie species prefer unforested areas. Small patches of cabbage palm areas should be maintained to afford nesting sites for caracaras.
 - H1.2.4. Establish appropriate burn seasonality. Fire management should be conducted in all seasons although the majority of natural fire occurs in summer.
- H2. Create, restore, or expand occupied habitat wherever possible. Habitat loss has occurred throughout the range of the caracara, and has been the primary factor threatening the survival of these animals. Conversion to higher intensity agricultural uses (e.g. sugar cane) may reduce the amount of useable habitat within a territory to the point that caracaras are unable to survive and reproduce. These areas can be enhanced to become suitable again. Mosaics of agriculture and native prairie may afford the landowner best use of their land while maintaining enough suitable habitat for caracaras.
- H2.1. Expand habitat in currently occupied areas. Wherever possible, enhance prairie habitat in the vicinity of occupied habitat. Use prescribed burning and mechanical treatment or planting of cabbage palms to enhance areas to attract caracaras.
 - H2.2. Restore habitat in currently unoccupied areas. Delineate areas which once supported the caracara but are no longer suitable and restore them to a suitable condition. This may involve cabbage palm plantings and fire management.
- H3. Conduct research on caracara response to habitat modifications. Little is known concerning the level of tolerance or the extent to which habitat within caracara home

ranges may be modified before the birds abandon the site. The response to habitat modification from rangeland to a higher intensity agricultural use should be investigated. A study employing radiotelemetry should be designed and implemented.

H3.1. Determine why certain habitat areas are not used. Certain areas are apparently unsuitable for caracaras since they are not used. The cause(s) for the lack of use should be investigated.

H3.2. Determine which elements need to be modified to make unused areas suitable for the caracara. The unoccupied habitat may lack suitable nest trees or be too wooded. Pesticide contamination, especially in agricultural areas, may be a factor. Water quality analysis should be conducted to determine whether agricultural chemicals are making water unsuitable for caracaras. Blood sampling of individual caracaras should be used to determine levels of various chemicals present in the population. Adverse conditions present on potentially suitable habitat must be recognized and corrected before caracaras can expand their range, or be reintroduced.

H4. Use satellite imagery and updated aerial photographs to monitor changes in land use in the core of the caracara population. This information may be essential in determining the probability of recovery of caracaras, especially in response to agricultural development pressure.

H5. Inform the public. Prairie communities are unique to central Florida and both the caracara and Florida grasshopper sparrow are only found in this community. The general public needs to be informed of the value of prairie, and its management needs.

Recovery for the Bald Eagle, *Haliaeetus leucocephalus*

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: South Florida's contribution to meeting this recovery objective will be achieved by maintaining or increasing the number of successful nests and the average annual productivity.

Recovery Criteria: Delisting criteria for the bald eagle in the southeast region are currently being developed. Until this species is delisted, South Florida's contribution to recovery of the bald eagle in the southeast is in accordance with the recovery criteria as indicated in the current approved Southeastern States Bald Eagle Recovery Plan. Specifically, South Florida can contribute to the recovery of the bald eagle in the southeast by furthering the goals of: nesting productivity of at least 0.9 chicks per occupied nest, greater than 1.5 young per successful nest, and at least 50 percent success in raising at least one young. These criteria must be accompanied by three years of data.

Species-level Recovery Actions

- S1. Determine distribution of the bald eagle in South Florida. This task is covered by the bald eagle monitoring program performed by GFC described below in task 3.
- S2. Protect and manage bald eagle populations in South Florida.
 - S2.1. Prevent or mitigate the effects of behavioral degradation. Behavioral degradation is the modification of normal eagle activity by any disturbance which reduces an area's ability to support eagles. These disturbances may result in increased energy expenditures, decreased feeding efficiencies, reduced reproductive potential, or decreased habituation by eagles.
 - S2.1.1. Identify and quantify effects of disturbance on nesting eagles and incorporate into management plans. Quantifying disturbance effects must focus on increases or decreases in annual productivity.
 - S2.1.2. Identify and quantify the effect of disturbance on bald eagle feeding sites and incorporate into management plans as indicated in task H1.2.5. The impact of disturbance to foraging eagles is not clear, but reduced feeding efficiency and increased energy expenditures are likely. The effect of these factors on productivity must be examined.
 - S2.1.3. Continue to require permits for all research activities which have the potential to negatively impact eagles. The effects of disturbance from research projects should be evaluated against the information to be gained and the project's enhancement of the recovery potential of eagles.
 - S2.1.4. Help the Department of Defense develop and implement bald eagle guidelines for use on Military Areas of Operation in South Florida.
 - S2.2. Reduce bald eagle mortalities in South Florida. Minimizing mortality will involve documenting the type, amount, source, and location of mortality and providing effective enforcement of existing laws.
 - S2.2.1. Enforce laws protecting bald eagles. Maintain and/or augment active enforcement of existing laws and preventive actions designed to reduce the number of violations. Law enforcement personnel at the State and Federal levels should be made aware of the potential sources of harm to bald eagles.
 - S2.2.2. Establish and maintain adequate rehabilitation facilities. Mortality may be reduced through the use of rehabilitation facilities. Existing emergency

care protocols should continue at established, permitted rehabilitation facilities.

- S2.2.3. Reduce mortality from aerial collisions. Structural modifications and project planning modifications in documented problem areas can reduce potential sources of mortality for bald eagles. The frequency of collisions between eagles and towers or powerlines may be reduced by locating structures away from eagle habitat and increasing structure visibility (*i.e.*, installing marker balls or other marker models).
 - S2.2.4. Reduce eagle mortality due to collisions with automobiles. Increasing roadway clear zones and minimizing access to carrion may reduce collision mortality. Cooperation with DOT is essential to completing this task.
 - S2.2.5. Work with utility companies and municipal governments to reduce mortality from electrocution. Appropriate design and location of power lines can reduce mortality due to electrocution. Poles and lines should be designed to prevent electrocutions in areas of high eagle use.
 - S2.2.6. Prevent mortality due to poisoning. Prohibit the use of poisons for predator control in areas used by feeding eagles. This would alleviate the problem of secondary or unintentional ingestion of poisons which are being used for the control of other species.
 - S2.2.7. Prevent poisoning mortality due to secondary ingestion of euthanized domestic animals. Educate veterinarians and municipalities of the dangers of depositing euthanized domestic animals in landfills. Develop landfill management recommendations to reduce likelihood of secondary ingestion of barbiturates.
- S3. Continue to monitor bald eagle nesting activities in South Florida. Population monitoring is necessary in order to determine the status and distribution of the species. The GFC currently monitors eagle nests twice per nesting season. This activity should be continued and expanded, as necessary, to provide important information on nesting success and the success of the habitat management guidelines, in addition to providing essential information on the population status throughout the state. If the bald eagle is to be delisted in the future, this information is essential to ensuring delisting criteria, once developed, are met.
- S4. Develop public information and education materials to inform the public of the recovery needs of the bald eagle in South Florida. Public information programs should provide

updated, accurate information on the status and needs of eagles and the relationship between eagle recovery and the well-being of man. While support must be evoked from the general public, specific problems such as indiscriminate shooting of eagles must be resolved by focusing efforts at specific user groups.

- S4.1. Continue to use permanently incapacitated eagles for educational presentations. Exhibiting disabled eagles during lectures is an effective method of teaching. Such activities should, however, be carefully limited to qualified, permitted, individuals and employ only eagles which may not be returned to the wild.
 - S4.2. Prepare general informational brochures for distribution in South Florida. This should include life history information relative to the southeast since many general accounts depict only characteristics of northern populations. This brochure should present accurate status information as well as recovery needs. It should also give sources for additional informational materials.
 - S4.3. Develop and distribute information to pilots concerning the potential for disturbance of nesting eagles by aircraft. A poster should be developed and distributed to all public, private, and military airports. Information on eagle and eagle nest protection should also be included in the Airman's Information Manual in the section on bird strike hazard.
- S5. Develop delisting criteria for the bald eagle in South Florida. Delisting criteria for the bald eagle will be developed on a regional basis by the Southeastern Bald Eagle Recovery Team.

Habitat-level Recovery Actions

- H1. Prevent further loss and degradation of bald eagle habitat in South Florida. Despite the amount of habitat loss and degradation throughout South Florida, the number of bald eagles with breeding territories in South Florida has increased. Nevertheless, the continued loss and degradation of bald eagle habitat in South Florida is expected to cause population declines in the long-term if it continues unabated or unmitigated. In the long-term the persistence of bald eagles in South Florida will require protection of their nests, foraging areas, migratory corridors, and juvenile dispersal areas.
- H1.1. Continue to gather information on the effects of habitat loss and degradation of habitat on bald eagles in South Florida. One of the challenges to protecting habitat for bald eagles in South Florida is the different responses of individual pairs to habitat loss and degradation within their territories. Some pairs will abandon their territories when minimal amounts of disturbance occur, while other bald eagle pairs will ignore seemingly significant disturbance. Future efforts to conserve bald eagles in South Florida will require better information on how different types of

habitat loss affect bald eagle pairs and identification of biological effects (such as reduced productivity) that occur regardless of the behavioral responses of nesting adults.

H1.1.1. Identify alterations to terrestrial and aquatic habitats that adversely affect bald eagles in South Florida. Alterations of aquatic habitat have affected eagles in a variety of ways. Altered hydrology due to channelization for flood protection and water storage and agricultural, commercial, and residential uses of surface and groundwater affect the amount of surface water available to support forage fish and other terrestrial prey. Agricultural, commercial, and residential development also affect water quality and the ability of aquatic resources to provide suitable foraging sites for bald eagles.

H1.1.2. Quantify essential characteristics of occupied bald eagle habitat. Quantification of the characteristics of habitats, undertaken in a systematic and uniform format, is needed. Such characteristics should be determined by comparing differences between historic and currently occupied territories. In addition, areas of high productivity should be compared and contrasted to areas of low productivity. This should provide for the accurate prediction of impacts during early planning stages and allow for the protection of potential as well as occupied habitat.

H1.1.3. Quantify responses of bald eagles in South Florida to habitat alteration. Individual eagles, pairs, or groups of eagles vary widely in their response to alteration of habitat. Information is needed to address the effects of disturbance, including the duration, frequency, and intensity as they relate to each stage of reproduction.

H1.2. Protect bald eagle habitats in South Florida through site management. Management of occupied territories in South Florida is the first priority of recovery. Nowhere else in its range is the eagle under greater threat from habitat changes than in the South Florida Ecosystem.

H1.2.1. Continue to implement and adhere to “Habitat Management Guidelines for the Bald Eagle in the Southeast Region”(op cit) [sic]. The current level of knowledge for bald eagle habitat management is reflected in these guidelines and they should be used in resource planning. They should also be reviewed and revised as new information becomes available.

H1.2.2. Develop specific management plans for each breeding territory. Individual management plans should be developed for each breeding area whenever

possible. This should include occupied, recently occupied, and historic nesting areas. The plans should be designed to accommodate local factors of habitat use, use-area configuration, nesting success, and level of tolerance to disturbance.

- H1.2.3. Protect eagle habitat through cooperative agreements, easements, acquisition or other appropriate means. Funding for habitat management should be sought from a multitude of sources including Federal, State, local, and private sources.
 - H1.2.4. Identify and incorporate important bald eagle habitat in land use plans and planning. Identify important habitat in order to ensure that accurate information is available for the development of land use plans.
 - H1.2.5. Use section 7 of the ESA to protect bald eagles and their habitats. Interagency consultations on permits issued by the U.S. COE pursuant to section 10 of the Rivers and Harbors Act and section 404 of the Clean Water Act are important for the conservation of bald eagles in South Florida. With the human population in South Florida expected to almost double over the next 15 years, these interagency consultations will become increasingly important to prevent bald eagles in South Florida from declining.
- H1.3. Prevent or mitigate the degradation of eagle habitat from environmental contaminants. Mercury occurs throughout South Florida and may reduce recovery opportunities for eagles in South Florida. The numbers, nesting effort, and fecundity of bald eagles that nest in areas where high levels of mercury are known or suspected should be monitored to detect possible mercury contamination. Similarly, addled bald eagle eggs, carcasses and prey from areas where high levels of mercury are known or suspected should be tested for mercury contamination.

- H2. Develop methods to restore previously occupied habitat or to establish new territories. In South Florida, an increasing number of bald eagles, territories occur in areas that are being cleared for residential housing or for industrial sites. In some instances, individuals have applied for permits to take bald eagles incidental to land clearing for residential housing. At the same time, several managers of wetland mitigation banks have included bald eagles as beneficiaries of their mitigation banks without demonstrating opportunities to restore or enhance the value of bald eagle territories. In the past, the FWS and GFC have had no information on opportunities to restore previously occupied bald eagle territories or to establish new territories. This information, which would require some experimentation, would help establish measures to minimize or mitigate the effects of habitat loss or degradation on bald eagles associated with land clearing for residential housing

construction in South Florida.

H3. Increase public awareness of habitat-related issues that affect the recovery of the bald eagle in South Florida.

H3.1. Produce an information brochure for landowners. Land management information and guidelines should be prepared for landowners including information on where to obtain additional professional assistance. State foresters should be included in this effort since they provide silvicultural expertise to private landowners.

H3.2. Establish displays at public boat landings to provide information on laws, penalties, rewards, and identification of eagles. Many boaters utilize public landings for access to aquatic habitat used by eagles. This includes use by hunters and fishermen as well as by recreational and commercial boaters. These user groups should be provided with information on identification and legal protection of eagles. Local phone numbers where violations may be reported should also be included.

Recovery for the Florida Scrub-jay, *Aphelocoma coerulescens*

Recovery Objective: TO BE DETERMINED by the recovery team during the ongoing revision of the range-wide recovery plan for the Florida scrub-jay.

South Florida Contribution: STABILIZE and increase the South Florida population.

Recovery Criteria: Since its listing as a threatened species in 1987, the Florida scrub-jay population has declined by approximately 50 percent because of the destruction, fragmentation, and degradation of scrub communities throughout peninsular Florida, due to residential housing or commercial development. These areas are not restorable.

The South Florida recovery objective will be achieved when: a reserve design is developed that identifies contiguous patches of suitable-size scrub habitat, within and between all subregions, that is essential for preventing further declines in the population; any further loss, fragmentation, and degradation of habitat within the reserves has been prevented; occupied habitat within the reserves is protected through land acquisition or cooperative agreements with private landowners; scrub-jays and their scrub habitat are appropriately managed to assure population viability and habitat contiguity; unoccupied and overgrown scrub is restored and managed as suitable habitat within dispersal distance (up to 8 km) of occupied habitat to increase numbers of scrub-jays; and subpopulations within the reserves (throughout all subregions) exhibit an intrinsic rate of increase (r) equal to or greater than 0.0, sustained as a 3-year running average over at least 10 years.

Species-level Recovery Actions

- S1. Determine the distribution of scrub-jays and status of scrub habitat in South Florida.
- S1.1. Update the 1992-1993 statewide survey (Fitzpatrick et al. 1994) in 2002 by ground-truthing a sample of scrub sites that were considered “occupied” during those surveys to determine the current status of the habitat and to verify if scrub-jays are still present. Priority should be given to areas where habitat fragmentation has been the greatest over the past 5 years, *i.e.*, Polk, Highlands, Sarasota, Charlotte, and Indian River counties. Identify key metapopulations that may require more frequent surveys.
 - S1.2. Maintain scrub-jay distribution data in a GIS database. Update the existing GIS database by including information obtained in S1.1 on the distribution of known scrub-jay territories throughout South Florida and the current status of scrub habitat. Ensure terminology is consistent with the 1992-1993 survey: currently occupied, occupied in 1992-1993, formerly occupied (both pre-1980 and current changes from 1992-1993 survey), and unknown.
- S2. Protect and enhance Florida scrub-jay populations.
- S2.1. Develop a reserve design for scrub-jays in South Florida using landscape maps, GIS and spatially explicit population models. These reserves will consist of areas identified as critical to the survival and recovery of the scrub-jay in South Florida. Large, contiguous patches of scrub habitat with minimum interspersions of forested and urbanized areas are most ideal. Non-contiguous patches, outside of the maximum dispersal distance for scrub-jays, must be large enough to maintain viable populations, or must have corridors to link to additional patches of suitable habitat.
 - S2.1.1. Identify all public lands, other conservation lands, and private lands where scrub-jays currently exist. Determine the current status and distribution of scrub-jays on protected and private lands from S1.2.
 - S2.1.2. Identify all unoccupied, potentially restorable scrub on public and other conservation lands. Work with Federal, State, and county agencies and non-governmental organizations to identify areas where scrub management is needed, and where such management would benefit scrub-jays.
 - S2.1.3. Identify additional key privately owned lands that could enhance existing scrub-jay preserves on conservation lands to which suburban scrub-jays could emigrate, or that would provide corridors to facilitate dispersal between occupied conservation lands. Consider willingness of sellers and

economic feasibility.

- S2.1.4. Use spatially explicit models with the existing information on suitable and restorable scrub remaining in South Florida, and scrub-jay biology, to identify the most suitable and feasible alternative for development of a reserve design to conserve scrub-jays in South Florida.
- S2.1.5. Develop criteria under which private lands would be considered for conservation.
- S2.2. Protect, manage, and enhance Florida scrub-jay populations on public lands. In South Florida, scrub-jays occur on Avon Park AFR (Highlands and Polk counties), Hobe Sound NWR (Martin County) Lake Wales Ridge NWR (Highlands and Polk counties), and on the BLM and U.S. Coast Guard Jupiter Inlet tract (Palm Beach County). Scrub-jays also occur on many State and county-administered lands with a multitude of land-use designations. The survival of the Florida scrub-jay depends to a large extent on maintaining and improving scrub habitat on these public lands.
 - S2.2.1. Develop management plans for scrub-jays where they occur on public lands. With assistance from the FWS, each public property manager should develop a long-term management plan designed to protect and enhance scrub-jay populations on their property. The plans should include fire and/or mechanical management to maintain scrub in a suitable condition for scrub-jays.
 - S2.2.2. Implement management plans for scrub-jays on public lands. Public land managers should coordinate to ensure that implementation and timing of management actions on adjacent properties minimize conflict, and that equipment and personnel are used effectively and efficiently.
 - S2.2.3. Facilitate communication among entities responsible for carrying out management activities on public lands. Establish a multi-agency team to assist in coordination of management planning.
- S2.3. Protect, manage, and enhance Florida scrub-jay populations on privately owned lands. Scattered and disjunct scrub-jay populations occur widely on privately owned lands throughout central and South Florida. The largest of these is on the Archbold Biological Station in Highlands County, where the bird has been extensively studied and is well protected.
 - S2.3.1. Protect the “core” population on the Lake Wales Ridge. Continue to protect scrub-jays at Archbold Biological Station and initiate protective

measures on other private lands. Maintain this core population at or above 400 pairs of birds, and maintain habitat for this population such that dispersal distance between habitat gaps is 3.5 km or less (Stith et al. 1996).

- S2.3.2. Work with landowners to protect and maintain suitable habitat for scrub-jays. Small, isolated populations of scrub-jays occur on numerous small patches of privately owned scrub in South Florida. Make efforts to contact landowners to encourage them to enhance and maintain scrub habitat to benefit scrub-jays. Where appropriate, use existing local, State or Federal programs to provide funding assistance.
 - S2.3.3. Recognize or reward protection and management efforts. Management efforts on private lands should be recognized and rewarded in any way possible in light of the limited legal responsibilities involved.
 - S2.3.4. Explore and implement other conservation programs. The opportunities for a tax incentive program at county, State, and Federal levels should be explored and implemented if feasible.
 - S2.3.5. Provide information on management and legal requirements to private landowners and managers. Develop articles and guidelines that contain information and visual aids to identifying habitat of the species, detailed information for managing the species by an array of options depending on the total land management objectives of the owner or manager, and specific information on the legal responsibilities of private landowners through section 9 of the ESA.
- S2.4. Enforce available protective measures. Identify and implement local, State and Federal regulations and guidelines to protect scrub-jays and their habitat.
- S2.4.1. Initiate section 7 consultation when applicable. All Federal agencies must consult with the FWS on any of their activities (authorized, funded, or carried out) that may affect scrub-jays. Such activities include (among others) pesticide use, road construction, military training exercises, clearing of land for new buildings and runways and implementing management plans. Implement on-site minimization through section 7 when needed.
 - S2.4.2. Implement on-site minimization, habitat compensation, and mitigation on non-Federal lands through section 10 when needed. Where adverse effects cannot be avoided, measures must be taken to minimize on-site

disturbance, and compensate or mitigate for the impacts that remain. The FWS generally recommends that areas used as habitat compensation be located in the vicinity of the affected habitat, where appropriate, to enhance existing scrub-jay families, and avoid further fragmentation and isolation of existing habitat.

- S2.4.3. Use reserve design in combination with draft management guidelines when scrub-jays and their habitat may be affected by proposed projects. The FWS, in conjunction with the GFC, developed management guidelines in 1991 (Fitzpatrick et al. 1991) that discuss ways to minimize adverse effects of proposed projects to scrub-jays. Although these guidelines are not official FWS policy, they are useful when reviewing projects and for making recommendations about scrub-jay conservation.
- S3. Identify research needs on the biology and population demography. Although scrub-jays have been well studied at Archbold Biological Station in xeric oak scrub habitat, additional research is needed on the biology of scrub-jays in other xeric communities and in suburban areas.
- S3.1. Gather information on the biology of scrub-jays in southwest Florida. Conduct research on habitat use, reproductive success, nesting, role of helpers, juvenile dispersal, adult and juvenile survival and mortality, predation, and food habits of birds in the scrubby flatwoods habitats of southwest Florida to compare with information known from populations at Archbold Biological Station.
 - S3.2. Conduct risk assessment analysis to determine the probability of persistence of the scrub-jay in South Florida, given the current amount of suitable scrub habitat as well as potentially restorable scrub habitat.
 - S3.2.1. Identify which subpopulations of scrub-jays are considered “viable” according to recovery criteria, and which subpopulations or groups of birds are most vulnerable to extinction.
 - S3.2.2. Incorporate results of S3.2.1. into the reserve design for scrub-jays to assist with project review and ESA consultation process.
 - S3.3. Study the effects of habitat fragmentation due to urbanization. On a landscape level, determine how residential development affects the metapopulation dynamics of scrub-jays. On a population level, identify the conditions that scrub-jays can tolerate and adapt to in a suburban setting, in addition to the conditions that significantly alter their vital rates, such as reproductive success, growth, and survival.

- S3.4. Determine the biological and ecological conditions necessary to ensure natural colonization following habitat restoration. Describe the conditions that are conducive to natural immigration of scrub-jays after restoration of unoccupied scrub. Collect life history information on scrub-jays that naturally immigrate to restored habitat, including immigration, habitat use, territoriality, reproduction, adult and juvenile survival, dispersal, and recruitment.
- S3.5. Continue studies on translocation of scrub-jays. To date, only one study of translocation of scrub-jays has been undertaken. Further research on this technique is needed to assess its utility in recovery. Translocation should only be considered when natural dispersal/immigration to a suitable-sized restored scrub parcel is unlikely, or to “rescue” demographically isolated birds from habitat that will be adversely modified. Translocation could also be used to re-establish birds to historically occupied habitat that is now being appropriately managed.
- S3.5.1. Establish protocols for successful translocation of scrub-jays into unoccupied areas. Establish criteria for successful re-establishment following translocation, such as the number, age structure, social structure, and gender ratios of birds to be used, geographic boundaries for obtaining source birds, and appropriate techniques for capture and release.
- S3.5.2. Release birds into new sites. It is recommended to use birds from source populations within the same subregion for translocation efforts.
- S4. Monitor scrub-jay subpopulations
- S4.1. Monitor representative groups within each subregion in South Florida to collect data on habitat use, reproduction, survival, mortality, dispersal, and recruitment to determine the status and trends of the subpopulations and assess recovery efforts.
- S4.2. Monitor birds in urban areas for changes in their vital rates, such as reproductive success, growth, and survival as urbanization affects territory size.
- S4.3. Monitor natural immigrants and translocated birds. Collect data as in S4.1 to determine the success of birds that inhabit newly restored scrub habitat as well as birds that have been translocated to new areas.
- S5. Inform and involve the public. Inform the public through articles for the news media and popular publications. Particular emphasis should be placed on explaining the status, importance, and biological needs of scrub-jays and the legal responsibilities for the species’ protection.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing scrub habitat. The long-term recovery of the Florida scrub-jay is dependent upon the immediate protection of as much of the remaining occupied and suitable and unoccupied suitable scrub communities as is economically feasible within South Florida.
- H1.1. Prioritize areas identified in reserve design for acquisition and management. Large, contiguous habitat patches are the most ideal for conserving scrub-jays. High priority should be given to areas contiguous with, or within short dispersal distance of, existing conservation lands where scrub-jays occur. High priority should also be given to areas adjacent to suburban sites where scrub-jays occur, allowing natural dispersal of birds from suburban areas to protected habitat.
- H1.2. Protect scrub-jay habitat on private lands through easements, acquisitions, and donations. Lands identified for acquisition should be located adjacent to, or be contiguous with, publicly owned conservation lands or other lands proposed for acquisition that contain scrub-jays. Lands containing scrub-jays should receive special consideration where these lands would consolidate Federal ownership or control and contribute to overall resource management objectives of the agencies. Private landowners should be encouraged to avail themselves of these options.
- H1.2.1. Continue Federal acquisition efforts. Continue acquisition efforts within the Lake Wales Ridge NWR complex. Much of the habitat targeted for acquisition will be acquired by 1998. One or possibly two additional, but currently unidentified parcels may subsequently be targeted for acquisition.
- H1.2.2. Support State acquisition efforts. The Florida (CARL) program has a number of ongoing projects and proposals for the acquisition of scrub habitat in Florida, totaling approximately 13,900 and 2,400 ha., respectively. About 90 percent of the ongoing projects are in South Florida, however the proposed projects are predominantly in North Florida. Florida's Save Our Rivers (SOR) acquisition program administered by the water management districts targets wetlands for protection but some sites also contain xeric uplands, and potentially scrub-jay habitat, that may also benefit.
- H1.2.3. Encourage acquisition by non-governmental organizations. Occupied private sector and suitable, unoccupied scrub not targeted in Federal and State acquisition programs may become available for private purchase and management. Scrub habitats already protected such as those at Archbold Biological Station and The Nature Conservancy's Tiger Creek Preserve,

Saddle Blanket Lakes, and Lake Apthorpe areas are important for the longterm persistence of scrub-jays.

- H1.2.4. Pursue acquisition of lands identified as necessary for developing scrub-jay reserves that are not covered under H1.2.1-H1.2.3 above.
- H1.3. Maintain suitable habitat for scrub-jays. Prescribed burning, where feasible, is the optimal management tool. The fire frequency will vary depending on the type and condition of habitat being managed and the natural fire return interval. Burns should be done in a rotation, with each covering small portions of a preserved tract of scrub. No more than 25 percent of an area occupied by scrub-jays should be burned at any one time (Fitzpatrick et al. 1991). In areas where burns are not feasible, mechanical treatments, such as rollerchopping, provide short-term alternatives.
- H1.4. Prevent loss or fragmentation of scrub habitat within scrub-jay reserves identified in S2.1. Ensure that no habitat gaps > 8 km are created within and between scrub reserves that might preclude dispersal by scrub-jays. Also note any potential physical barriers to dispersal (Stith et al. 1996).
- H2. Restore overgrown or unsuitable scrub habitat. After identification of unoccupied but potentially restorable scrub (see S2.1.2.), work with local, State and Federal agencies and nongovernmental organizations to determine the most feasible and appropriate management protocols (i.e. controlled burns or mechanical techniques at specific rotations) to restore overgrown scrub to suitable habitat for scrub-jays. Implement mechanisms in the protocols or management plans for ensuring continued management of these sites.
- H3. Conduct research to determine the applicability and effectiveness of various mechanical treatments for scrub management. Mechanical treatments, such as rollerchopping or thinning, are needed as an alternative to burning scrub habitat, particularly on lands in or adjacent to urbanized areas.
- H4. Monitor xeric communities that provide scrub-jay habitat.
 - H4.1. Monitor scrub habitat that is occupied by scrub-jays to ensure public lands are managed to maintain scrub in suitable condition for scrub-jays, and to assess when unmanaged areas become unsuitable for scrub-jays. Also monitor to ensure the site is not becoming a “sink” for the population.
 - H4.2. Monitor unoccupied scrub habitat following restoration to collect data on how habitat characteristics affect immigration and establishment of scrub-jays.

- H4.3. Maintain scrub-jay habitat data in a GIS database. Update the existing GIS database by including information obtained from surveys in S1.1 on the current status of scrub habitat in South Florida. Denote the condition of the scrub, and the type and timing of all pertinent management actions.
- H5. Increase public awareness of the scrub ecosystem. Efforts should highlight habitat acquisition initiatives, importance of biodiversity, and biology of scrub-dependent species. Federal, State, and county governments, as well as private organizations, should support the development and dissemination of educational materials pertaining to the conservation of the scrub ecosystem and endemic scrub species. Materials such as brochures, posters, postcards, slide programs and videotapes can improve public understanding of and increase appreciation for protection of scrub habitat. Environmental education programs across central Florida should be encouraged to distribute materials or develop lesson plans on scrub ecosystems, particular scrub species, and the importance of maintaining biological diversity.

Recovery for the Everglade Snail Kite, *Rostrhamus sociabilis plumbeus*

Recovery Objective: RECLASSIFY to threatened once recovery criteria are met.

Recovery Criteria: The objective of this recovery plan is to restore the Everglade snail kite to a stable, secure and self-sustaining status allowing the reclassification of the species from endangered to threatened under the ESA. Due to the limited distribution of the species, its specialized ecological niche, and the irreversible loss of a significant portion of the Kissimmee/Okeechobee/Everglades watershed, the FWS believes it unlikely that the snail kite will ever be elevated above the threatened status. This objective will be achieved when: the 10-year average for the total population size is estimated as greater than or equal to 650, with a coefficient of variation less than 20 percent for the pooled data over the 10-year period; no annual population estimate is less than 500 in the 10-year period; the rate of increase of the population to be estimated annually or biannually, and over the 10-year period, will be greater than or equal to 1.0, sustained as a 3-year running average over 10 years; the feeding range of snail kites will not decrease from its current extent, including as a minimum, the St. Johns Marsh, the Kissimmee Chain of Lakes, Lake Okeechobee, Loxahatchee Slough, Loxahatchee NWR, all of the water conservation areas, Everglades National Park, Big Cypress National Preserve, Fakahatchee Strand, Okaloacoochee Slough, and marshes surrounding the Corkscrew Swamp; and snail kite nesting regularly occurs over the 10-year period in the St. Johns Marsh, Kissimmee Chain of Lakes, Lake Okeechobee, and at least one of the present compartments of the water conservation areas.

The FWS recognizes that the snail kite is a resilient species in a highly changeable environment and that to some degree a “boom and bust” population fluctuation is characteristic of the species. The above criteria for reclassification to threatened are flexible enough to allow substantial declines in population within a given year, while setting goals over a 10-year period.

The global climate fluctuations that are correlated with cycles of flood and drought in South Florida occur on a periodicity of 9 to 14 years (Zhang and Trimble). 1996. The use of 650 individuals as a criterion for recovery needs to be supported by improved techniques of Population Viability Analysis (H3.1, below). Beissinger (1995) suggested that snail kite populations become viable above a minimum population size of 300 individuals, but this PVA needs to be re-evaluated based on the more precise population estimates anticipated from mark/resight techniques.

Species-level Recovery Actions

- S1. Maintain information on the distribution and status of the Everglade snail kite. The present distribution of the snail kite and its recent history of distribution are well documented. Distribution must be monitored in the future. Radio-telemetry has provided information on movement of individuals within the species' range, but would not be continued on a routine basis.
- S1.1. Estimate population size, through mark/resighting of banded individuals. This method is considered technically superior to counts of snail kites at index locations because it allows estimation of the proportion of kites not observed and is less subject to certain errors, such as those caused by differences in experience among individuals conducting the counts and by year-to-year differences in the level of effort. Annual counts of snail kites at index locations do not provide a reliable estimate of population size, nor do they allow estimation of the coefficient of variation (Bennetts et al. 1999a), which is an integral part of the recovery criteria expressed above. An ongoing pilot study by Victoria Dreitz indicates that the mark/resighting techniques used by Bennetts et al. (1999b) to estimate survival is promising as a methodology to estimate population size (R. Bennetts, Station Biologique de la Tour du Valat, personal communication 1998). This method requires considerable commitment of resources to annually mark sufficient numbers of snail kites; this level of funding and personnel may be difficult to sustain in the long term.
- S1.2. Continue surveys of nesting effort and success at the principal breeding areas. Monitoring of breeding should continue at principal breeding sites, such as the St. Johns marsh, Kissimmee Chain of Lakes, Lake Okeechobee, and Water Conservation Areas 2 and 3.
- S1.3. Expand and refine existing information on movements and distribution of the snail kite, particularly changes attributable to drought. Radio telemetry has provided information on movements of snail kites within South Florida; it is expensive and labor-intensive. It may be logistically impractical to design and implement a radio telemetry study quickly enough to respond to a specific drought event. Additional radio telemetry studies should be initiated only to test specific hypotheses that

cannot be tested through other methods.

- S1.4. Organize and maintain a network of biologists to report Everglade snail kite sightings to a clearinghouse. In the past, information on snail kite sightings was requested from the general public, which led to unreliable reports. However, professional biologists can often provide reliable and useful sighting information, particularly when snail kites are dispersed during droughts.
- S2. Protect and enhance the existing population. Because of the nomadic nature of snail kites, they integrate habitat conditions over a large geographic area and are dependent on natural and human-caused environmental conditions throughout the South Florida Ecosystem. The majority of management activities to protect and enhance the snail kite population must occur at an ecosystem level (see below). Actions at the level of the individual or groups of individuals included in the 1986 recovery plan are now considered extremely labor-intensive and would have limited benefit to the species. Such activities include installation of artificial perches and installation of artificial nest structures. Limited experimentation with captive propagation has shown it to be difficult, and the snail kite population is now considered more resilient and not currently in need of such emergency measures. Only two species-specific recovery tasks in this category are considered necessary at this time:
- S2.1. Update the critical habitat designation for the Everglade snail kite. Critical habitat has not been modified since its original designation in 1977 and is in need of revision. Earlier publications correctly pointed out the importance of Lake Okeechobee and the Everglades as snail kite habitat. However, more recent information suggests that although restoration of Lake Okeechobee and the Everglades must be compatible with snail kite recovery, greater emphasis must be placed on larger wetland systems in the species, range and on smaller peripheral wetlands. Nesting of snail kites in Lake Kissimmee, Lake Tohopekaliga, and East Lake Tohopekaliga since the early 1980s is a significant change that should be considered in revising critical habitat. Although a portion of the St. Johns Marsh south of State Road 60 is included in the current critical habitat, the principal areas being used by snail kites north of that highway need to be included. Other areas outside of the Okeechobee/Everglades basin that should be considered for designation are the Big Cypress National Preserve and marshes surrounding the Corkscrew Swamp.
- S2.2. Use provisions of section 7 of the ESA to protect the Everglade snail kite. Water management of the COE's C&SF project is critical to the survival and recovery of the snail kite. The SJRWMD and SFWMD are involved with the COE in water management decisions subject to section 7 consultation. The FWS needs to provide conservation recommendations to enhance habitat conditions for the snail

kite throughout the C&SF project. Specific guidance should include water regulation of the St. Johns Marsh impoundments, Kissimmee Chain of Lakes, Lake Okeechobee, Loxahatchee NWR, Water Conservation Areas 2 and 3, Everglades National Park and Big Cypress National Preserve.

- S3. Continue or initiate research on the life history of the Everglade snail kite.
- S3.1. Expand information on survival of juvenile and adult snail kites. Although snail kites have been banded for decades, intensive banding for estimation of survival has occurred only since 1992. Intensive banding must be continued through long-term meteorological cycles to estimate the effects of drought on snail kite survival. This is a key unknown element in the life history of the species that has significance in assessing opportunities for recovery and probability of extinction relative to natural cycles and water management policy.
 - S3.2. Develop and validate a snail kite model that can evaluate both stochastic natural events and human-caused modifications of habitat throughout the species' range. An individual-based spatially explicit snail kite model is being developed as part of the Across Trophic Level System Simulation (ATLSS). The geographic scope of ATLSS does not include the Kissimmee Chain of Lakes or the St. Johns Marsh. While complete modeling across all trophic levels will not include these northern areas, they should be appended to the boundaries of the model at levels dealing with snail kite dispersal, reproduction, and survival, to model the snail kite population as a whole.
 - S3.3. Investigate the genetic variability of the Everglade snail kite. Analysis by electrophoresis has not indicated the potential for a genetic bottleneck in the snail kite population. Although additional genetic research does not appear to be a high recovery priority, analysis of heterozygosity using DNA analysis would be desirable.
- S4. Monitor trends in Everglade snail kite population and levels of contaminants. S4.1. A mark-resighting effort will provide estimates of both total population size and survival. Because marking of birds is most often conducted at nesting aggregations, routine monitoring has included counting the total nests and determining nesting success. However, there is general agreement among researchers that changes in the kite population is more sensitive to survival than reproduction. Although researchers should continue to monitor reproduction at the major nesting areas, the emphasis of long-term monitoring should be estimation of total population size and survival.
- S4.2. Conduct periodic monitoring of contaminant levels in apple snails and Everglade snail kites. The limited sampling of apple snails and Everglade snail kites to date

has emphasized the potential risks of methylmercury contamination. Although this limited sampling has not suggested an immediate threat to snail kites from mercury contamination, additional studies should be conducted on a regular basis in the long term (approximately 5 to 10 year intervals). Apple snails can be collected specifically for analysis, whereas analysis of snail kites is generally limited to occasional discovery of dead specimens or analysis of shed feathers. More emphasis must be placed on detection of herbicides in both apple snails and snail kites. Snail kites can ingest apple snails containing herbicides (such as bypyridyls), applied in agricultural fields and transported by runoff into the aquatic food web, or herbicides (such as fluoridone), applied to control aquatic vegetation.

- S5. Increase public awareness about Everglade snail kites. A snail kite brochure has been distributed via donations from the St. Johns River Water Management District, Palm Beach County Solid Waste Authority, and Florida Power and Light Co. This material should be reviewed, updated, and published as a second edition. The GFC is developing signs to inform ORV users at launching sites along I-75 about responsible ORV use, including protection of the snail kite. Funding is needed to produce and install similar signs informing the public about protection of snail kites at boat launching sites in the Kissimmee Chain of Lakes, St. Johns marsh, and Lake Okeechobee. Information on the biology of the snail kite and the threats it faces should be included in middle school and high school curricula.

Habitat-level Recovery Actions

H1. Prevent degradation of existing Everglade snail kite habitat.

- H1.1. Plan and carry out periodic extreme drawdowns of individual lakes on a rotational basis in the Kissimmee Chain of Lakes. These projects involve extensive cooperation and cost sharing among a number of agencies, often including simultaneous lake management activities, such as muck removal, discing, burning, and aquatic weed control. Water levels must be lowered early enough to avoid initiation of nesting by snail kites and thus prevent incidental take of nests. Cooperation is needed between the water management districts to ensure that no more than one human-caused drawdown occurs simultaneously among the principal habitats for the snail kite.
- H1.2. Control or remove exotic vegetation in wetlands. The long-term direct and secondary effects on snail kites or apple snails of spraying aquatic weeds are poorly known. Research on these long-term impacts should be initiated. Current control programs are mainly directed at *Melaleuca quinquenervia*, *Schinus terebinthifolius*, and *Hydrilla verticillata*.
- H1.3. Use controlled burns to open up areas of overly dense herbaceous and/or shrubby

vegetation in lake littoral zones and marshes. Burning can be accomplished under natural low water conditions or in conjunction with the extreme drawdowns mentioned above. Although controlled burns with the presence of surface water or saturated soils may be beneficial, it would probably not be practical or advisable to attempt to change plant communities through uncontrollable muck fires in the Everglades.

- H1.4. Ensure that information on wetlands of importance to Everglade snail kite nesting and feeding is considered in review of regulatory permits. The COE and DEP are preparing GIS data layers that will be routinely available to regulators. Information on snail kite nesting areas and other important habitats needs to be included.
- H1.5. Prevent cultural eutrophication of lakes and marshes. Addition of nitrogen and phosphorus from agricultural and residential areas is accelerating eutrophication of Florida's lakes and marshes. Long-term degradation of habitat caused by eutrophication leads to buildup of organic muck, overly dense herbaceous and shrubby vegetation, and oxygen depletion. Moderate eutrophication may not harm the snail kite, but in the long term, both the abundance of apple snails and the ability of snail kites to locate snails in dense vegetation is reduced. Reduction of nutrient inputs at the source needs to be addressed by best management practices, including rates of application and stormwater retention on site. Construction and maintenance of wastewater treatment plants must be improved to control discharge of nutrients in lakes and streams.
- H1.6. Evaluate effects of Lake Okeechobee's regulation schedule on Everglade snail kite habitat. Observations since 1992 suggest a general degradation of nesting habitat in the littoral zone of Lake Okeechobee from the loss of willows in nesting areas (R. Bennetts. Station Biologique de la Tour du Valat, personal communication 1998). Modification of the regulation schedule to increase water storage could cause additional loss of vegetation in the littoral zone, which would be adverse to the ecology of the lake as a whole, including the snail kite. Conversely, extending periods of low water in the lake through a combination of agricultural, urban, and environmental restoration demands would also be detrimental to the snail kite. Evaluation of proposed changes to water regulation in Lake Okeechobee must consider the effect on the snail kite in the context of protection of all the fish and wildlife resources in the lake and elsewhere in the C&SF system. Long-term monitoring of changes in wetland vegetation in relation to water management practices needs to be conducted throughout the C&SF system as indicators of habitat suitability for snail kites, rather than relying on short-term changes in snail kite population, distribution, or reproduction.

H2. Restore areas to suitable habitat.

- H2.1. Reverse the expansion of cattails as a dominant plant in portions of the Everglades through reduction in nutrient loading from agricultural and urban sources. Portions of the Water Conservation Areas and the Holey Land WMA are now relatively unsuitable habitat for the snail kite due to growth of dense monocultures of cattails. The Everglades Construction Project and additional treatment areas (such as portions of the Water Preserve Areas in the C&SF Restudy) need to be implemented. The influence of nutrient levels bound in the soil on the persistence of cattails after water quality improvement needs to be predicted and then determined empirically.
- H2.2. Construct and operate the Modified Water Deliveries to Everglades National Park and C-111 projects. These projects will restore flow patterns to northeast Shark River Slough and other portions of the southern Everglades, enhancing Everglade snail kite habitat.
- H2.3. Through the C&SF Restudy, investigate, plan, and carry out restoration projects in the Kissimmee/Okeechobee/Everglades watershed. As a whole, restoration projects proposed through the C&SF project should restore water quantity, water quality, timing, and sheetflow, as opposed to flow through canals. Wherever practical, impoundment of water behind levees should be reduced, provided that this action does not overdrain areas upstream of the presently impounded areas. The establishment of Water Preserve Areas and additional compartments for storage and treatment of water should be reviewed for management opportunities that may support recovery of the Everglade snail kite.
- H3. Conduct research on the biology and life history of the Everglade snail kite.
- H3.1. Complete and use ATLSS modeling of the snail kite to predict the response of snail kites to changes in hydropattern anticipated for specific water management proposals. In addition to the need to correctly describe the life history of the snail kite itself, the ATLSS modeling must include linkage to apple snail distribution and abundance, vegetation characteristics in the landscape influencing the snail kite's successful foraging, and linkage of all these factors to hydrology. ATLSS simulations (and/or other Population Viability Analysis models) can also provide estimates of the vulnerability of the snail kite population as a whole to extinction. Such information should be used to refine, if necessary, our use of 650 birds as a recovery criterion.
- H3.2. Continue and expand research on the effects of natural and human-caused hydrologic events on the ecology of the apple snail. This research will provide needed information for the ATLSS modeling described above, and even before completion of ATLSS, this research can be used in decisions on water

management.

- H3.3. Evaluate the effectiveness of long-term climate predictions to reduce the likelihood of coincidence of human-caused drawdowns and drought. Prediction of long-term climate patterns is still inexact, but climatological monitoring can increasingly predict the probability of El Niño events perhaps 1 or two years in advance. Florida's subtropical climate is significantly affected by these global shifts, and this may be useful in adjusting water regulation schedules according to anticipated "wet" or "dry" years. Human-caused drawdowns should be avoided prior to entering a drought, because snail kites will have fewer options for refuge from drought and because refilling of drained lakes or marshes will be prolonged during drought.
- H3.4. Perform a detailed statistical analysis of rainfall records throughout central and South Florida to identify the intensity and spatial and temporal extent of droughts. This information will provide an estimate of the threat to the snail kite from region-wide drought. It will be used to estimate the probability of extinction over long time scales in response to severe drought under a range of future land use scenarios.
- H3.5. Evaluate the need for secondary treatment in addition to the nutrient removal afforded by macrophytic stormwater treatment areas. Determine effective methods of treatment to reduce nutrients below levels affecting the ecology of the Everglades.
- H4. Monitor habitat/ecological processes. Expansion of existing monitoring programs throughout the C&SF system is expected as restoration projects are generated through the C&SF Restudy, with an increased emphasis on adaptive management. The snail kite should be included in monitoring of ecological indicators along with analysis of vegetation patterns and hydrology throughout the system.
- H5. Increase public awareness of ecological relationships, environmental stressors, and restoration activities in the South Florida Ecosystem. Because the range of the snail kite coincides closely with the C&SF system and because it is endangered, it can serve as a symbolic species for restoration efforts in South Florida. Information on the kite's status, threats, and its ecological relationship with other species should be integrated in public education on restoration activities. Public outreach can include newsletters, newspapers, magazines, the worldwide web, and classroom materials.

Recovery for the Cape Sable Seaside Sparrow, *Ammodramus maritimus mirabilis*

Recovery Objective: RECLASSIFY to threatened once recovery criteria are met.

Recovery Criteria: Before the sparrow's listing as an endangered species, the distribution and abundance of the short-hydroperiod prairies that provide habitat for the Cape Sable seaside sparrow had declined by more than 50 percent due to destruction, fragmentation, and degradation of habitat for residential housing construction or agriculture. These areas are probably not restorable. Many of the remaining short-hydroperiod prairies that supported the Cape Sable seaside sparrow have been converted into long-hydroperiod wetlands, or have been degraded due to increased fire frequencies and/or woody species invasion as a result of reduced hydroperiods by water management practices in South Florida. The feasibility of fully restoring these areas is still uncertain. Consequently, this recovery plan outlines criteria for reclassifying the Cape Sable seaside sparrow from endangered to threatened.

This objective will be achieved: if the loss of functional Cape Sable seaside sparrow habitat, as a result of current and past water management practices, and the invasion of woody and exotic plant species, is eliminated; if Cape Sable seaside sparrow habitat west of Shark River Slough and in Taylor Slough, which has been degraded by current and past water management practices, is restored; when demographic information on the Cape Sable seaside sparrow supports, for a minimum of 5 years, a probability of persistence [T(N)] that is equal to or greater than 80 percent (± 0.05), for a minimum of 100 years; when the rate of increase (r) for the total population is equal to or greater than 0.0 as a 3-year running average for at least 10 years; when a minimum of three stable, self-sustaining core breeding areas are secured; when a stable age structure is achieved in the core populations; and, when a minimum population of 6,600 birds is sustained for an average of 5 years, with all fluctuations occurring above this level.

Species-level Recovery Actions

S.1. Determine the distribution and status of Cape Sable seaside sparrows.

- S1.1. Continue and expand distribution surveys. Conduct annual distribution surveys in all areas known to have historically supported Cape Sable seaside sparrows. Expand distribution surveys as appropriate, based on results of previous nesting and telemetry surveys and peer review. Survey information will be used to approximate total population numbers.
- S1.2. Incorporate information from wintering ecology studies on Cape Sable seaside sparrow habitat use into a GIS database. Information on the distribution of Cape Sable seaside sparrows during the nonbreeding season should be incorporated into a GIS database.
- S1.3. Review and revise the current critical habitat designation based on distribution surveys. Presently designated critical habitat does not adequately encompass the areas occupied by core populations and must be re-evaluated. Critical habitat should, at minimum, include habitat west of Shark River Slough that supports one of the two core subpopulations, and should include an analysis of wintering habitat

requirements. Additionally, some of the currently designated critical habitat has been lost to agricultural development and may not be appropriate for inclusion in a revised designation.

- S1.4. Survey habitat components of both occupied and unoccupied habitat to determine why Cape Sable seaside sparrows are absent. An improved understanding of Cape Sable seaside sparrow habitat selection within short-hydroperiod marl prairies will improve our ability to optimally manage sparrow habitats.
- S2. Protect existing populations of Cape Sable seaside sparrows. Existing short-hydroperiod marl prairie must be protected and enhanced for Cape Sable seaside sparrows if the population is to survive. Current water management practices must be changed to restore more natural timing, volume, and placement of water flows.
- S2.1. Develop the appropriate water management regimes to protect Cape Sable seaside sparrows in Everglades NP, Big Cypress National Preserve, and the Southern Glades Wildlife and Environmental Area. The Cape Sable seaside sparrow is restricted to the marl prairies of South Florida that are in public ownership. Many of these prairies have been altered by water management practices. Protecting the existing core breeding populations of the Cape Sable seaside sparrow is critical to the species' survival and recovery and will depend on changing current water management regimes to improve this species' breeding habitat.
 - S2.2. Conduct section 7 consultations on Federal activities that may affect Cape Sable seaside sparrows. Numerous Federal activities to restore the Everglades ecosystem are in planning stages or are currently in operation. Cape Sable seaside sparrows are presently utilizing habitats that will be affected by these activities. Any Federal activities resulting in changes in hydropatterns within areas presently utilized by sparrows must receive thorough analyses with regard to effects on sparrows, and management decisions must be made that allow sparrow numbers to remain stable or increase.
 - S2.3. Develop and implement Reasonable and Prudent Alternatives (RPAs) to avoid the likelihood of jeopardy. Current water management practices are jeopardizing the continued existence of the Cape Sable seaside sparrow. RPAs that will avoid further jeopardy conditions must be developed and implemented.
- S3. Increase the distribution and abundance of the Cape Sable seaside sparrow. Where possible, potential habitat should be managed to encourage (re)occupation by Cape Sable seaside sparrows. In general, maintenance and/or restoration of Cape Sable seaside sparrows in all areas will involve water management, fire management, control of exotics, and control of human-related habitat impacts (airboats, etc.).

- S3.1. Recover the core subpopulation west of Shark River Slough. Between 1981 and 1993, an important core area west of Shark River Slough supported nearly half of the total sparrow population. By 1996, the number of sparrows utilizing the habitat west of Shark River Slough had decreased by approximately 90 percent (Pimm et al. 1996). The main factor affecting sparrow habitat in this area is disruption of natural hydrological patterns. The key to restoring this subpopulation will be the restoration of more natural flows to northeast Shark River Slough and a reduction of damaging regulatory releases through the S-12 structures.
- S3.2. Recover East Everglades-Taylor Slough subpopulations to levels consistent with restored hydropatterns. The major factors affecting birds within these regions are fire and related hydrological conditions. To maintain populations in Taylor Slough and adjacent areas of eastern Everglades NP and the Southern Glades Wildlife and Environmental Area, the effects of water management and fire management programs should be considered. The effects of the operation of pump stations and adjacent canals should be evaluated. The effects of the fire program should also be evaluated, specifically, the effects of large area burns, including boundary burning.
- S3.3. Restore disturbed habitats identified as potential Cape Sable seaside sparrow habitat, creating opportunities for this species to recolonize former habitat, including Lostman's Slough, the historic Ochopee population, and any additional sites that may be suitable within Everglades National Park, Big Cypress National Preserve, and the Southern Glades Wildlife and Environmental Area. Restore habitats for recolonization by Cape Sable seaside sparrows. Management techniques to restore disturbed Cape Sable seaside sparrow habitat may include controlled burning, hydrological manipulation, and exotic removal.
- S3.4. Re-establish subpopulations of Cape Sable seaside sparrows through translocation. Every effort should be made to restore and maintain the short hydroperiod marl prairies. However, if efforts to manage water deliveries and habitat result in improved habitat conditions, but do not result in a stable or increasing Cape Sable seaside sparrow population, then translocation should be initiated as a last resort.
- S3.4.1. Develop a protocol for translocating Cape Sable seaside sparrows. The necessary protocol to translocate Cape Sable seaside sparrows needs to be developed. DOI guidelines should be followed.
- S3.4.1.1. Determine the subpopulation levels that will trigger translocation. Determine the number of sparrows within each subpopulation that will trigger implementation of translocation. Determine the length of time that each subpopulation should remain at these numbers before initiating translocation.

- S3.4.1.2. Determine the subpopulation levels at which the removal of individuals from the donor site has minimal risk. Determine the minimum number of individuals necessary within a subpopulation before individuals can be removed without causing risk to the donor subpopulation.
- S3.4.1.3. Determine whether translocated individuals must have a specific age structure. A particular age structure may be necessary to improve chances for successful translocation.
- S3.4.2. Identify recipient sites for Cape Sable seaside sparrows. There is a need to determine where translocated birds should be placed. Should they be placed in proximity to occupied areas in order to establish a genetic link or do we place them as far from occupied habitat as possible.
- S3.5. Initiate controlled propagation *only* as a last resort for the recovery of Cape Sable seaside sparrows. Captive propagation is to be used only when all other measures employed to maintain or improve the status of Cape Sable seaside sparrows in the wild have failed, and would be used to produce individuals for release back into the wild.
 - S3.5.1. Develop a protocol for a controlled propagation program for the Cape Sable seaside sparrow. Develop protocol for a Cape Sable seaside sparrow controlled propagation program as per Department of Interior and Department of Commerce draft controlled propagation policy. The plan will identify the lead agency responsible for the effort, including the role of FWS facilities, personnel and resources, or those of non-FWS cooperators, as appropriate, and the estimated cost and duration of controlled propagation efforts.
 - S3.5.2. Review the controlled propagation protocol developed for the Dusky seaside sparrow, identify weaknesses and inconsistencies, and make the appropriate changes for Cape Sable seaside sparrows. Protocol established for the Dusky seaside sparrow failed to accomplish the goal of keeping the population from becoming extinct. We can learn from our mistakes and develop a better protocol for Cape Sable seaside sparrows.
 - S3.5.3. Develop a genetic management plan for Cape Sable seaside sparrows and submit for approval. Controlled propagation can only be initiated when supported by an approved genetic management plan.
- S4. Conduct research on aspects of the life history and population ecology of Cape Sable

seaside sparrows. To properly manage habitat and to account for the effects of management actions and natural events, it is necessary to conduct certain studies on Cape Sable seaside sparrows. Overall, the goals of such studies are to understand the species' demographics, limiting factors, and the extent that habitat characteristics limit expansion of the population. This information will also be necessary to determine whether translocation and /or captive propagation is necessary or feasible.

- S4.1. Continue research on the ecology of Cape Sable seaside sparrows outside of the breeding season. Additional information about the behavior or habitat needs of the sparrow outside of the breeding season is needed. Information on sparrow habitat use throughout the year will lead to better habitat management for the bird.
 - S4.1.1. Identify all areas that provide essential habitat for all life stages of the Cape Sable seaside sparrow. Critical areas should be identified and managed appropriately.
 - S4.1.2. Determine seasonal movement patterns and colonizing ability. Determine the movement patterns of adults outside of the nesting season and the dispersal and mortality of adults and fledglings; this information will aid in understanding how the Cape Sable seaside sparrow colonizes suitable, unoccupied habitat.
- S4.2. Better define the habitat requirements of the Cape Sable seaside sparrow. The specific habitat needs of the sparrow need better definition. It is necessary to determine habitat correlates of abundance, adult survival, nest placement, predation, and reproductive success. Determine individual patterns of habitat use, time budgets, movements, foraging tactics, nesting, foraging activity areas, and year-to-year changes in territory use.
- S4.3. Determine age-specific survivorship for Cape Sable seaside sparrows. This information will be necessary to determine species' intrinsic rate of increase and persistence time and will be used to determine whether the species can be reclassified to threatened.
- S4.4. Determine age-specific fecundity for Cape Sable seaside sparrows. This information will be necessary to determine the species' intrinsic rate of increase and will be necessary to determine whether the species can be reclassified to threatened.
- S4.5. Research predation rates and how water levels and other factors influence predation. A better understanding of predation on the Cape Sable seaside sparrow and the factors that influence predation rates will assist in developing management

strategies.

- S4.6. Continue development of population models for the Cape Sable seaside sparrow. Development of individual-based population viability analysis and risk assessment models should continue. These models can be used to determine possible population responses to changes in its vital rates, particularly in response to water management, fire, and hurricanes.
- S5. Monitor Cape Sable seaside sparrow subpopulations to assure that further declines in range and numbers do not occur and that recovery actions are being implemented and are effective. Monitoring will be essential in evaluating the success of management actions.
- S6. Increase public awareness about Cape Sable seaside sparrows. Produce brochures, signs, and other materials to educate the public about the ecological role of the Cape Sable seaside sparrow in the Everglades and the importance of appropriately managing the limited remaining short hydroperiod marl prairies. The public should understand that the continued existence of Cape Sable seaside sparrows is an indication of a healthy Everglades and that to maintain the sparrow, higher priority should be given to managing the habitat for native faunal species as opposed to flood control.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing Cape Sable seaside sparrow habitat in South Florida. Work with the COE, Everglades NP, Big Cypress National Preserve, GFC, and SFWMD to determine whether proposed restoration hydropatterns will degrade habitats in areas utilized by Cape Sable seaside sparrows or habitat designated as critical habitat. Habitat management should optimize habitats for all of South Florida's flora and fauna, without risking extinction of the Cape Sable seaside sparrow.
 - H1.1. Review the effects of hydrologic restoration in Everglades NP, Big Cypress National Preserve, and the Southern Glades Wildlife and Environmental Area on areas utilized by Cape Sable seaside sparrows and make the appropriate management decisions. For example, if a specific restoration alternative is found to reduce the ability of the Cape Sable seaside sparrow to breed in that region, we need to determine whether alternatives for hydrologic restoration will be necessary to prevent the extinction of the Cape Sable seaside sparrow.
 - H1.2. Develop detailed maps of Cape Sable seaside sparrow habitat. Collect detailed habitat information and enter this information into a GIS database.
 - H1.3. Monitor changes in habitat as a result of changes in hydrologic regimes and fire events. Using the detailed habitat maps developed per task H1.2, monitor changes in the distribution and suitability of the Cape Sable seaside sparrow's habitats over

time to ensure that existing habitat is not degraded.

- H1.4. Determine the necessary management practices to maintain or restore Cape Sable seaside sparrow habitat (as identified by S1.2 above).
- H2. Restore habitat in the Everglades and Big Cypress basins. Some habitats utilized by Cape Sable seaside sparrows in past years are no longer suitable. Restore these areas for recolonization by Cape Sable seaside sparrows.
 - H2.1. Define the constituent elements of critical habitat for Cape Sable seaside sparrows. Constituent elements are a pivotal part of any critical habitat designation. When redefining critical habitat for Cape Sable seaside sparrows, constituent elements must be included to allow the critical habitat designation to function as a tool aiding in recovery of the sparrow. Any new critical habitat designation must include hydrologic criteria and should capture the structure and composition of the sparrow's breeding and nonbreeding habitat.
 - H2.2. Establish and implement the appropriate hydrologic regimes necessary to support Cape Sable seaside sparrows. This should be completed for the area west of Shark River Slough and for any areas identified as potential Cape Sable seaside sparrow habitat, and should include water delivery schedules, operational criteria for water control structures, and adjacent canal water level stages.
 - H2.3. Establish and implement the appropriate fire management necessary to support Cape Sable seaside sparrows. This task will be especially important for the areas of subpopulations B through F.
 - H2.4. Remove woody species and/or exotics from disturbed habitats previously used by Cape Sable seaside sparrows. This will allow sparrows to reoccupy these areas when necessary.
- H3. Conduct research on the habitat needs of the Cape Sable seaside sparrow. Additional information is needed on habitat selection in relation to vegetative succession and factors that influence vegetative succession.
 - H3.1. Conduct a quantitative study to better understand changes in dominant plant species that have occurred within the Cape Sable seaside sparrow's breeding habitat in response to local hydrological conditions in Taylor Slough, northeast Shark River Slough and west of Shark River Slough. There is evidence that shifts have occurred in plant species composition within these regions as a result of altered hydroperiods. By gaining further information on these shifts and correlating changes in vegetation composition with hydroperiod conditions, we

- will be able to more effectively manage Cape Sable seaside sparrow habitat.
- H3.2. Implement a study to determine the natural and anthropogenic factors that regulate woody plant growth and colonization in short-hydroperiod prairies. This information will aid in our ability to control woody invasion in short-hydroperiod marl prairies.
 - H3.3. Develop methods to manipulate vegetative communities. Many communities have shifted as a result of hydrologic practices and are in need of restoration for use by Cape Sable seaside sparrows. Management practices (hydrological, fire, and exotic control) should be developed to restore these communities.
 - H3.4. Determine the effects of altered hydrologic patterns on the fire frequency of marl prairies. This information will enable appropriate management of habitats that have been altered by hydrologic regimes over the past 20 years and development of appropriate burn programs.
 - H3.5. Continue research on the effects of fire frequency on Cape Sable seaside sparrow habitat use. Information on the species' response to fire frequency will better enable us to manage habitats appropriately for Cape Sable seaside sparrows.
- H4. Monitor Cape Sable seaside sparrow habitat by implementing a long-term vegetation monitoring program. This program should be continued for a minimum of 10 years to incorporate inter and intra-annual variability in hydrologic and fire conditions resulting from different rainfall and water management scenarios.
- H5. Increase public awareness about short-hydroperiod marl prairies and their key role in the Everglades ecosystem. Produce brochures, signs, and other materials to educate the public about the ecological role of the Cape Sable seaside sparrow in the Everglades and the importance of preserving what limited short-hydroperiod marl prairie remains. The public should understand that the continued existence of Cape Sable seaside sparrows is an indication of a healthy Everglades and that functional short-hydroperiod marl prairies are necessary to have a restored Everglades ecosystem.

Recovery for the Florida Grasshopper Sparrow, *Ammodramus savannarum floridanus*

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: This objective will be achieved when any further loss, fragmentation, and degradation of habitat within the Kissimmee River basin has been prevented; when at least 10 protected and managed sites contain stable, self-sustaining populations of 50 to 100 breeding pairs of Florida grasshopper sparrows within the historic range of the species; and when Florida

grasshopper sparrows on each of these sites exhibit a rate of increase (r) equal-to or greater than 0.0, sustained as a 2-year running average over at least 6 years.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. It may be possible to reclassify the Florida grasshopper sparrow if there is sufficient, restorable habitat that can be recolonized by additional populations; however, the feasibility of such restoration and recolonization is still uncertain. This recovery objective will be reassessed annually based on new research, management, and monitoring information. These criteria will be refined if new information identifies new ways of re-establishing populations of this species or expanding its current range.

Species-level Recovery Actions

- S1. Determine the distribution and abundance of the Florida grasshopper sparrow. Additional surveys should be undertaken to more accurately determine current distribution and abundance of the Florida grasshopper sparrow. The locations of remaining dry prairie habitat at Avon Park AFR, Three Lakes WMA, and the Ordway-Whittell Kissimmee Prairie Sanctuary are provided in Shriver (1996). In addition to these maps, LANDSAT data could be used to locate potential habitat on private lands which may contain grasshopper sparrows.
- S2. Protect and enhance existing populations of Florida grasshopper sparrows.
 - S2.1. Encourage natural colonization of restored habitats by Florida grasshopper sparrows. Many areas within the historic range of the Florida grasshopper sparrow are being restored as part of the COE and SFWMD Kissimmee River restoration. Other areas are being restored because of a change in land use in the Kissimmee River valley (such as the expansion of the Three Lakes WMA). There are also efforts underway to connect the Ordway-Whittell Kissimmee Prairie Sanctuary with Kissimmee Prairie SP. Dispersal of the Florida grasshopper sparrow into restored areas from occupied sites should be encouraged by establishing corridors. Corridors may be established by selectively removing pines or other tree species and applying prescribed fire. The removal of pine plantations at Avon Park AFR should be completed to increase prairie size and connectivity between the disjunct populations there.
 - S2.2. Develop and implement a plan to re-introduce Florida grasshopper sparrows into suitable habitats in the Kissimmee River Valley. Many areas once supported grasshopper sparrows in the past, but are not currently occupied. Some of these areas still have suitable habitat for the sparrows, while others will need restoration. The survival and recovery of the Florida grasshopper sparrow will depend on reestablishing Florida grasshopper sparrow populations in these areas. The second recovery priority is establishing a specific plan to re-introduce and re-establish Florida grasshopper sparrows into areas that currently support suitable habitat.

This plan must identify the specific areas that are suitable for such re-introductions, protocols for determining when habitat is suitable for a reintroduction, the size of a reintroduced population, monitoring protocols for re-introduced populations, and land management prescriptions for re-introduction areas.

- S2.3. Develop a captive propagation plan for the Florida grasshopper sparrow following DOI guidelines, and implement as warranted. An estimated 600 adult Florida grasshopper sparrows (1996 census) exist in the wild. In the event of further declines in the size or distribution of the Florida grasshopper sparrow, a captive population may provide the difference between survival and extinction for this species. The captive propagation plan should identify specific demographic thresholds that would trigger the establishment of captive populations, facilities that could support a captive propagation program, protocols for selecting and capturing individuals for a captive population, reintroduction protocols, and criteria that clearly state when the captive propagation program could be ended.
- S3. Conduct research to determine the basic biological needs of The Florida grasshopper sparrow. Although considerable research has been done on the biology and ecology of the Florida grasshopper sparrow, more information is necessary before the Florida grasshopper sparrow can be properly managed and effects of habitat management actions assessed.
 - S3.1. Develop information on the Florida grasshopper sparrow's basic biology, including genetic and ecological studies. Biological studies should be continued to expand scientific knowledge of the demographics of Florida grasshopper sparrow populations (survivorship, fecundity, mortality, dispersal) and the relationship of these demographic variables to habitat availability and quality under various management regimes. Continue studies to assess effects of grazing on reproductive success.
 - S3.2. Continue winter ecology studies. The winter ecology and life history needs of the Florida grasshopper sparrow may be a limiting factor to the recovery of the species. Winter ecology investigations should continue in order to determine if management actions need to be revised in order to maximize survival of wintering birds.
 - S3.3. Develop a reserve design for Florida grasshopper sparrows using landscape maps, GIS, and spatially-explicit population models. Population viability analyses can be determined from existing demographic data, and can be combined with landscape-coverage GIS data to develop spatially-explicit models. Using these tools, the reserve design will identify large, contiguous areas of prairie habitat

necessary for the survival and recovery of Florida grasshopper sparrows in South Florida.

- S4. Continue efforts to monitor the status and trends of Florida grasshopper sparrow populations.
 - S4.1. Develop consistent survey/census protocols and assure continuation and consistency of ongoing monitoring protocols. Evaluate existing monitoring techniques to determine which are best able to identify small changes in Florida grasshopper sparrow populations. Surveys for Florida grasshopper sparrows should be consistent on all sites. At a minimum, population surveys should provide a minimum population estimate plus a relative measure of abundance.
 - S4.2. Monitor Florida grasshopper sparrow populations on public lands to evaluate management actions. Establish monitoring programs for the Florida grasshopper sparrow on the Avon Park AFR, Kissimmee Prairie SP, and Three Lakes WMA to determine if fire management, water management, and other management actions are consistent with the recovery needs of the sparrow.
 - S4.3. Monitor the success of reintroduced Florida grasshopper sparrow populations. To determine whether recovery efforts are proving successful, it will be necessary to conduct periodic censuses and surveys of all introduced populations.
- S5. Increase public awareness of the biology, ecology, status and trends of the Florida grasshopper sparrow. The public must be made more aware of the status and trends of the Florida grasshopper sparrow, its recovery needs, and opportunities for the public to participate in the sparrow's recovery. This public awareness program must include an effort to contact owners of lands that support populations of Florida grasshopper sparrows; it must also include development and distribution of educational materials developed specifically to inform the public about the Florida grasshopper sparrow.
- S6. Assess reclassification criteria based on the results of research projects; revise as necessary.

Habitat-level Recovery Actions

- H1. Protect and enhance currently occupied habitat. Alteration and habitat loss are primary threats to prairie species. As much of the remaining prairie habitat as possible must be secured. State and COE efforts to restore the Kissimmee River floodplain might provide useful habitat for prairie dependent species. Habitat must be maintained in an early stage of succession through selective thinning and prescribed burning.
 - H1.1. Protect and enhance Florida grasshopper sparrow habitat on public and private

land. Florida grasshopper sparrows currently occur on the Avon Park AFR, Kissimmee Prairie SP, and Three Lakes WMA; additional populations occur on adjacent private lands. These populations are critical to the survival and recovery of the sparrow. These lands are being managed to support populations of the Florida grasshopper sparrow; these management efforts must continue.

H1.1.1. Maintain and enhance habitat on acquired lands or lands under conservation easements or agreements. Conduct prescribed burns, selective thinning, or mechanical manipulation at periodic intervals to maintain dry prairie and pasture habitat and prevent forest encroachment. Intensive rangeland improvements should be discouraged in prairie areas to maintain as many native plant species as possible.

H1.1.2. Encourage purchase. State, county, and local governments and private organizations can purchase lands. The FWS can consider purchase of land to protect endangered or threatened species through its Land Acquisition Planning System.

H1.1.3. Discourage changes in the present level of cattle grazing where conducive to grasshopper sparrows. On most private lands, cattle grazing is at the level of one animal per ha. This level of grazing does not seem to be detrimental to prairie species, but it should not be increased until further studies have been conducted. Current land management practices appear to, at a minimum, sustain grasshopper sparrows. Provide additional incentives for private landowners to enhance habitat for Florida grasshopper sparrows.

H1.2. Protect and enhance habitat on public lands. Prairie habitat present on public lands should be protected and enhanced for prairie dependent species. Sites that are occupied by these prairie species include Avon Park AFR in Polk and Highlands counties, the Florida Game and Fresh Water Fish Commission's Three Lakes WMA in Osceola County, the Kissimmee Prairie SP property in Okeechobee County, and the National Audubon Society's Kissimmee Prairie Sanctuary in Okeechobee County. Federal land management agencies should try to protect, maintain, and enhance prairie habitat on all lands they manage. Since caracara nesting is minimal on Avon Park AFR and this site is essential for the survival of the Florida grasshopper sparrow, grazing should not be increased in this area, and prairie management should focus on the grasshopper sparrow. Other public lands should use the recommendations obtained from habitat component research on the caracara to determine which management actions are compatible with the survival of both species.

- H1.2.1. Continue prescribed burns at periodic intervals. Occupied areas should be burned in a mosaic fashion on a periodic rotational basis (generally every 1.5 to 3 years) to maintain early stages of succession. The burn interval may vary depending on site, vegetation, fuel loads, hydrology, etc. and may extend from 1 to 4 years at certain locations.
- H1.2.2. Maintain pastures in native vegetation to the extent possible. Prairie species may be adversely affected if pasture lands are improved to the point where native vegetation is removed. Pastures will not be suitable for grasshopper sparrows if they are heavily grazed or managed heavily for grazing.
- H1.2.3. Do not allow reforestation of prairies. Prairie species prefer areas devoid of trees. Grasshopper sparrows, especially, cannot breed in forested areas. However, scattered live-oak/ cabbage palm hammocks are valuable components of prairie systems. Although these hammocks are not used by grasshopper sparrows, they are compatible with sparrow management and should not be removed.
- H1.2.4. Establish appropriate burn seasonality. Fire management should be performed in all seasons, although the majority of prescribed burns to benefit grasshopper sparrows should be done during the season of occurrence of most natural lightning fires: from late spring to early summer.
- H1.2.5. Avoid construction of fences or other structures in grasshopper sparrow habitat. Fencing or other vertical structures may be used as perches by grasshopper sparrow predators and should be avoided in areas important to the sparrow.
- H1.2.6. Avoid land management and maintenance activities during the nesting season. Management/maintenance activities such as mowing, rollerchopping, fertilizing, and use of heavy equipment that may affect grasshopper sparrows or native flora should be avoided during the nesting season (15 March to 15 September).
- H1.3. Conduct section 7 consultations on all Federal activities that might affect grasshopper sparrows and their habitat. The Air Force and the Department of the Interior will consult with the FWS on any activities (authorized, funded, or carried out) that might adversely affect prairie species on land they control in Florida. Such activities include: pesticide use, road building, construction of new facilities, training exercises, clearing for new runways, etc.

- H2. Create, restore, or expand habitat wherever possible. Habitat loss has occurred throughout the range of prairie species, and has been the primary factor threatening the survival of these animals.
- H2.1. Continue to identify areas of suitable unoccupied habitat or potential habitat. Shriver (1996) provides maps of suitable dry prairie habitat on three of the sites where Florida grasshopper sparrows occur. Continue these efforts using LANDSAT imagery and GIS to locate areas of suitable or suboptimal habitat on private lands. Ground-truth these areas to determine suitability for sparrows, and determine the feasibility of improving the selected sites for sparrow occupation.
- H2.2. Improve selected areas as needed. Restore available sites to suitable conditions through fire management and removal of woody plants.
- H2.3. Expand habitat in currently occupied areas, and restore habitat in currently unoccupied areas. Continue the removal of pine plantations at Avon Park AFR to increase prairie size and connectivity between the disjunct populations there. Continue efforts to connect Kissimmee Prairie SP with the Ordway-Whittell Kissimmee Prairie Sanctuary. Wherever possible, enhance prairie habitat in the vicinity of occupied habitat, through prescribed burning, chopping, and woody vegetation removal to enhance areas to attract grasshopper sparrows.
- H3. Continue research on grasshopper sparrow/habitat interactions. Research should continue to determine how habitat correlates to grasshopper sparrow abundance, and how changes in habitat use relate to fire and plant succession. Information is especially needed on non-breeding ecology and habitat use, as well as on territory shifts as they relate to habitat quality. Information is also needed to determine whether grazing has an effect on sparrow fitness. These studies can be done on any of the protected populations where cattle grazing is occurring on sparrow habitat during any time of the year. Information obtained through these studies will indicate the best management practices for areas important to both breeding and post-breeding survival. This will relate directly to land management activities at occupied sites.

Recovery for the Wood Stork, *Mycteria americana*

Recovery Objective: RECLASSIFY to threatened, then delist.

South Florida Contribution: The former Science Subgroup (now Science Coordination Team) of the South Florida Ecosystem Restoration Task Force and Working Group prepared a set of recommendations for success measures for the South Florida Ecosystem restoration program. Included in these recommendations are targets for the recovery of nesting wading birds in the

Everglades basin (WCAs and ENP). The Science Subgroup's measure of success for the wood stork is a breeding population between 1,500 to 2,500 pairs. The goal for wood stork recovery in

South Florida is to support 2,500 nesting pairs in the Everglades and Big Cypress Basin systems and to support, as a South Florida Ecosystem component, 35 percent (3,500 nesting pairs) of the southeast United States recovery and delisting nesting population of 10,000 pairs.

Recovery Criteria: South Florida will contribute to the recovery of the total population, if the wood stork foraging and nesting habitat in the Everglades watershed is restored and/or enhanced as a result of the modified water storage and delivery programs being developed by the SFWMD and the COE. The recovery criteria as identified in the wood stork recovery plan, for the Everglades and Big Cypress Basin is a population of 2,500 nesting pairs. The recovery criteria for the South Florida Ecosystem populations, which also includes nesting colonies in coastal counties in central Florida and nesting colonies in the Kissimmee Basin, is 35 percent (3,500 nesting pairs) of the total recovery population of 10,000 pairs.

Species-level Recovery Actions

S1. Determine the distribution and status of wood storks in South Florida. All evidence suggests that the wood stork population in the southeast U.S. is a single population, with individuals moving throughout the landscape in response to habitat conditions; the recovery of wood storks depends on the success of the birds throughout their range. Historically, South Florida supported greater than 70 percent of the nesting wood storks in the Southeast. Recent nesting populations in South Florida average around 10 to 13 percent with the major nesting occurring at the Corkscrew colony. More recent data provided by Ogden (1997) also present evidence that South Florida provides winter foraging grounds for many of the recently developed northern breeding colonies in north Florida, Georgia, and South Carolina. The restoration and enhancement of the South Florida foraging habitat is important to the overall recovery of the wood stork population and the reversal of the decreasing nesting trends in South Florida. Distribution must be monitored into the future to determine wood stork response to Everglades restoration activities.

S1.1. Conduct wood stork annual nesting surveys within the Everglades and Big Cypress Basins and the east and west coast populations. The health and productivity of colonies must be known to evaluate the status and recovery of the wood stork. Long-term wading bird nesting data in South Florida suggest that the number of pairs of birds initiating nesting in a given year is a better indicator of ecosystem health than is nesting success. The number of pairs of wood storks attempting to breed in South Florida should be monitored annually to determine wood stork response to ecosystem conditions in South Florida. Conducting annual nesting surveys within these basins will provide information on annual nesting patterns for wood storks in South Florida and will allow us to best respond with the appropriate management strategies for the species. Much could be learned about

wood stork ecology in the Everglades by detailed review of the multi-year systematic reconnaissance flight data. Detailed evaluation of these data is necessary.

- S1.2. Locate foraging and roosting habitat. Wood storks take several years to mature to breeding age. The survival of birds during these years is critical. Research that gains a better understanding of where non-breeding birds go in Florida needs to be conducted. Research on what habitats are critical to their survival and what factors may be limiting their survival is also necessary. Identifying important foraging and roosting habitat is critical to the recovery of the wood stork. Recent studies along the Georgia and South Carolina coast have provided valuable information on roosting and foraging behavior (Bryan and Coulter 1995); additional work of this sort is needed in South Florida.
 - S1.3. Develop standardized census procedures for wood storks nesting in South Florida. Systematic nesting survey protocol should be developed for both the Everglades and Big Cypress basins. This protocol will allow for comparison between years and between basins.
- S2. Protect and enhance wood storks in the South Florida Ecosystem through provisions of section 7 of the ESA. The majority of management activities to protect and enhance wood storks in the South Florida ecoregion must occur at an ecosystem level (see habitat-level recovery actions), not a species-specific level; wood storks respond to changing environmental conditions by integrating habitat conditions over a large geographic area and therefore will be more affected by large-scale management practices. However, the review of Federal water management practices through section 7 consultations is one vehicle whose implementation will be imperative to the survival and recovery of the wood stork. Much of the landscape utilized by wood storks in South Florida is subject to Federal and State water management practices; water management of the COE's C&SF project is critical to the survival and recovery of the wood stork. The FWS needs to provide conservation recommendations to enhance habitat conditions for the wood stork throughout the C&SF project. Specific guidance should include operational schedules (water regulation) for Lake Okeechobee, the WCAs, Everglades NP, and Big Cypress National Preserve. The Kissimmee River basin also supports important colonies of wood storks. The water management goals of the Kissimmee River basin may affect foraging and nesting success in these colonies. Proposed land management actions on these restoration lands need to be examined in relation to wood stork habitat requirements.
- S3. Conduct research on the biology and life history of wood storks. Recovery efforts for wood storks will be more effective with a complete understanding of population biology, movement patterns, foraging ecology and behavior, the importance of roost sites, and the

possible impacts of contaminants on South Florida wood storks. To date, information on nesting patterns and the number of wood storks initiating nesting in South Florida has been collected for some regions in some years. Additional information is needed on wood stork demographics and movement patterns between the colonies and foraging and roosting sites.

- S3.1. Determine the productivity of wood storks nesting in South Florida. To estimate the productivity of wood storks, the number of fledged young per nest and the number of fledged young per successful nest must be determined for the major nesting colonies in South Florida during the same breeding cycle.
- S3.2. Determine survivorship of wood storks in South Florida. This parameter is one of the least understood, and research on this topic may provide more new insights into population dynamics than any other effort. We need to determine survivorship of fledged young to adulthood to better gauge what amount of productivity is required to maintain or increase wood storks nesting in South Florida. This might be accomplished through a massive multi-year leg banding (or wing tagging) effort in multiple colonies, radio-instrumenting a certain number of birds (with mortality sensors) or possibly by surveys during the non-breeding season to determine the adult:sub-adult ratio.
- S3.3. Determine the age structure of the wood stork population in the southeast U.S. This information will be necessary to determine whether the population is sustainable and can be delisted.
- S3.4. Determine the movement patterns of South Florida wood stork fledglings and post-breeding South Florida adult wood storks. Movement patterns will provide information on behavior, habitat utilization, and potential critical foraging areas. The survival of fledgling wood storks is dependent on their ability to find suitable foraging areas when they first begin to forage independently. If fledglings must travel great distances to forage, their survival may be hampered. Additionally, understanding the movement patterns of adult wood storks after they complete breeding will answer questions such as: 1) Do adult wood storks “help” fledglings to find suitable foraging sites, and 2) Are there foraging sites within a “critical” distance from breeding colonies in South Florida, or do adult storks, upon completion of breeding, move out of South Florida?
- S3.5. Determine foraging ecology and behavior of wood storks. The number of wood storks nesting in South Florida has greatly declined. Information on foraging by wood storks in South Florida needs to be completed to determine the interdependence of successful nesting by wood storks in South Florida and the

availability of suitable foraging sites. Information from the systematic reconnaissance flights should provide information on foraging distribution for multiple years and should help to answer some questions on the foraging ecology of the wood stork, but additional work must be completed to understand the characteristics of the forage base that are necessary to provide functional wood stork foraging habitat in South Florida.

- S3.5.1. Re-evaluate wood stork foraging studies in Everglades NP. Studies on the forage base available and utilized by storks in Everglades NP were done in the 1970s. A comparative study should be completed to determine if changes have occurred in the prey base available to wood storks. This issue should again be addressed since this ecosystem is vital to recovery goals, is important as a wintering area for all storks, and has recently been documented to have problems with mercury contamination (Sundlof et al. 1994).
- S3.5.2. Conduct studies on the prey base available in areas identified as critical foraging sites during the breeding season. We need to collect information on the prey base available to wood storks at foraging areas receiving high use during the breeding season. This information should be compared to identical information collected at sites not utilized by wood storks during the same time period.
- S3.5.3. Determine foraging requirements of wood storks during the nonbreeding season. Research concerning the foraging ecology of this species should also examine foraging requirements during the wintering or non-breeding period. In some years, the inland marshes of the Everglades have supported the majority of the U.S. population of wood storks. During the non-breeding seasons in 1985 to 1989, up to 55 percent of the entire U.S. population may have relied on the WCAs (which comprise only a portion of the Everglades system) to meet their foraging requirements (Bancroft et al. 1992). Understanding the processes that determine whether storks in the non-breeding season are concentrated on a small area of habitat or dispersed throughout their entire winter range will provide management flexibility and decrease the likelihood of negative impacts to a large proportion of the population during a single season.
- S3.5.4. Continue studies on wood stork nocturnal foraging activities. Preliminary studies by Bryan (1995) indicate that storks in South Carolina and Georgia are active nighttime feeders. The prevalence of nocturnal foraging activities by this species needs to be studied both seasonally and geographically in South Florida. Nocturnal feeding may be more

important for wood storks feeding in tidal marshes than in freshwater marshes, but, if nocturnal feeding by wood storks is significant, regulatory decisions may need to reflect this information to protect wood stork foraging grounds from disturbance “around the clock.”

- S3.6. Determine the importance of wood stork roost sites. Recent surveys of the Georgia and South Carolina coast documented the presence of a large number of stork roost sites, but only a limited number of roosts were inhabited repeatedly by numerous storks. Research concerning the function and use of such sites and habitats in South Florida is needed. If important roost sites are identified in South Florida, protective measures should be developed. These studies could also assess foraging habitats utilized from these sites, thus providing important information about the non-breeding season.
 - S3.7. Determine the impacts of contaminants on wood storks in South Florida. Potential impacts from contaminants need to be reconsidered in light of recent findings concerning the amount of mercury present in the Everglades Ecosystem and the discovery of severe impacts of DDT/DDE-based estrogen-mimicking compounds on wildlife in a large Florida wetland (Guillette et al. 1994).
 - S3.7.1. Conduct mercury studies on wood storks in South Florida. Studies should be conducted in the South Florida Ecosystem to document effects of mercury on wood storks.
 - S3.7.2. Conduct contaminant studies on wood storks throughout the region. Develop baseline contaminant information from a variety of colony sites throughout the region to determine if further studies are needed.
 - S3.8. Complete models for the wood stork population. Population viability assessment and risk analysis models should be performed for the wood stork population once the necessary information is acquired. Once completed, the relative importance of the South Florida Ecosystem, and the ability of the wood stork to successfully breed in South Florida, should be determined.
 - S3.9. Develop models of wood stork colony dynamics in South Florida wetlands. These models are needed as planning tools for improved ecosystem restoration programs. Potentially one important ecological model for the Everglades is a wood stork population dynamics model that is a part of the “Across-Trophic-Level System Simulation” (ATLSS) set of models being developed by the South Florida/Caribbean Field Station of the USGS, BRD.
- S4. Monitor wood storks in South Florida. Annual nesting and foraging surveys should be

completed for wood storks in South Florida. These surveys will provide the information necessary to monitor the success of ecosystem and species-specific recovery actions. Surveys should be performed on an annual basis within both the Everglades and Big Cypress basins until the species is delisted.

- S4.1. Conduct long-term monitoring of the number of wood storks initiating nesting in South Florida, as described by tasks 1.1. and 1.2.
 - S4.2. Organize systematic censuses of wood stork foraging habitat in the Big Cypress region, comparable to existing censuses (systematic reconnaissance flights) in the Everglades basin. The fact that declines in nesting effort and delays in timing of colony formation have shown similar trends in the Big Cypress basin have been well documented in the Everglades basin suggests that the Big Cypress colonies are dealing with similar kinds of habitat deterioration on the foraging grounds. The location and relative importance of stork foraging grounds in the Big Cypress basin are much less known, and should be determined as a basis for developing protection strategies in this region; this survey would provide the information necessary to monitor the success of both ecosystem and species-specific recovery actions.
 - S4.3. Continue foraging surveys in the Water Conservation Areas and Everglades NP. This information is necessary to follow the trends of wood storks in South Florida and should be continued until the species is delisted.
 - S4.4. Initiate and continue demographic surveys, such as colony surveys to determine productivity; additionally, studies to determine survivorship should be continued until enough data have been collected to determine wood stork rates of growth, reproduction, and survival. This information will be critical to determine whether or not the species can be delisted.
- S5. Increase public awareness. Wood storks are an indicator species of the Everglades Ecosystem; the health of the Everglades can be measured by the ability of the wood stork to successfully breed in the Everglades. The Maine coastal seabird colony restoration program uses the puffin as its symbol. The wood stork is a symbol of the health of the Everglades and Big Cypress basins and could be used as a barometer of the success of Everglades restoration projects.
- S5.1. Increase awareness and appreciation of wood storks through educational materials. Wood storks utilize a variety of wetland habitats and have been identified as an indicator species for the Everglades. Additionally, they are visually unique and generate interest from the general public. Make the wood stork a symbol of the Everglades through the use of environmental education materials and programs.

- S5.1.1. Develop and distribute educational materials. Currently, there are several brochures, videos, and educational packets available that focus on wood storks. This information needs to be kept up to date. New educational material should be developed to increase the awareness of a larger audience.
 - S5.1.2. Develop information for private landowners. Wood storks breeding in the Corkscrew Swamp and in the northern and central Big Cypress basin in South Florida forage in surrounding wetlands, many of which are on private lands. Material explaining wood stork ecology and suggesting management practices benefitting storks should be distributed to private landowners.
 - S5.1.3. Develop educational materials for schools. Since wood storks occur in Florida, Georgia and South Carolina, it would be cost-effective to develop educational materials that could be used in schools in all three states.
 - S5.1.4. Develop material for policy makers and elected officials. The wood stork should be included as part of a larger effort to inform and educate South Florida policy makers and elected officials of the importance of maintaining and protecting wetland habitats throughout the Big Cypress and Everglades basins.
- S5.2. Provide opportunities for the public to view wood storks in captivity. Maintaining wood storks in captivity should be for the sole purpose of public education, awareness, and research to enhance survival of the species. Currently, there are nearly two dozen American wood storks in captivity in North American zoos and related facilities.
- S5.2.1. Maintain captive populations for the purpose of education, awareness, and research. FWS draft policy on controlled propagation sanctions captive propagation of listed species when recommended in an approved recovery plan and supported by an approved genetics management plan. Captive propagation of wood storks is not considered necessary for the purpose of supplementing wild populations through reintroduction programs. Captive breeding and rearing efforts will not be made for this purpose. However, good captive management of wood storks may result in reproduction. The resulting progeny may be used to supplement other captive populations under approval of the FWS. If available space within captive facilities becomes saturated, further production of offspring should be prevented within the scope of laws governing captive endangered wildlife.

S5.2.2. Develop policy on rescue, rehabilitation and release of injured wood storks. The FWS, in conjunction with the American Zoological Association, should develop a policy for dealing with wood storks that are rescued from the wild. Adult wood storks are not as frequently received by licensed wildlife rehabilitators as other wetland bird species. Opportunities for rescue may most likely occur when field personnel are in the colonies and witness distress. This may be as a result of nest abandonment when food sources become scarce or when chicks fall out of the nest for reasons such as adult bird interactions or wind storms. Where possible, field personnel should return downed chicks to the nest. When replacement is not viable, the usual protocols for triage and rehabilitation should be followed in placement with a licensed wildlife rehabilitator.

Habitat-level Recovery Actions

H1. Prevent degradation of existing wood stork habitat in South Florida through identification and protection. At a minimum, for continued survival of the U.S. population, currently occupied nesting, foraging, and roosting habitat in South Florida must be protected from further loss or degradation. Watersheds supporting natural nesting habitat should remain unaltered, or be restored to function as a natural system if previously altered.

H1.1. Create distribution maps of important wood stork colony, foraging, and roosting sites in South Florida for protection and restoration. Important colony sites have been identified for the WCAs and Everglades NP. However, colony sites in the Big Cypress basin are not as well known. Very little is known about roosting sites in South Florida. Identifying all important colony sites, roosting sites, and foraging habitat is critical to the recovery of the wood stork. A GIS database should be developed from data collected by colony, roosting, and foraging surveys, as delineated by species-specific tasks S1.1 and S1.3; a GIS database will aid recovery biologists in targeting areas in need of protection, restoration, or management, and will allow managers and private landowners to more efficiently protect and manage these lands for wood storks.

H1.2. Prioritize habitats that need protection. Develop a prioritization scheme to focus protection and restoration efforts on colonies and feeding sites with the greatest degree of threat. Efforts should be made to identify important foraging and roost sites associated with high priority colonies.

H1.3. Work with private landowners to protect habitat. Conservation agencies need to recognize the significant contributions that private landowners can make for the protection of wood storks. For example, many of the foraging grounds utilized by storks breeding at the Corkscrew colony in South Florida are in private ownership and are threatened by conversion to citrus farming; the future success of this

colony is dependent on maintaining viable foraging habitat within the region.

- H1.3.1. Inform landowners. Inform all landowners having critical foraging and roost sites (as defined in task H1.2.) on their properties. Encourage compliance with existing regulatory mechanisms (see task H1.6.).
 - H1.3.2. Provide assistance and support to landowners in managing their property for the benefit of wood storks. Assistance can be in the form of written material explaining best management practices, site visits, local recognition, tax and/or monetary incentives. State and Federal agencies should work with private landowners in an effort to incorporate wood stork feeding habitat into current management practices.
 - H1.3.3. Develop management plans for private lands. Conservation agencies should assist landowners in developing specific management plans for their properties. These management plans should adequately protect sites yet be flexible enough to respond to the changing needs of the landowner. The success or failure of management prescriptions for nesting, roosting, and foraging areas should be clearly documented and reported.
- H1.4. Protect sites from disturbance. The FWS developed habitat management guidelines for wood storks (Ogden 1990) in an effort to reduce disturbance to colony sites. These management guidelines discuss various types of activities known to disturb nesting wood storks. Additionally, certain types of habitat management activities can adversely impact colony sites. Cypress logging is a potential threat to some colonies. Human disturbance causes wood storks to leave nests, exposing eggs to predation and exposure. Posting or other appropriate protection may provide some benefit to storks nesting or foraging within the Big Cypress and Everglades basins.
- H1.5. Use existing regulatory mechanisms to protect foraging habitat in South Florida. The central and northern Big Cypress basin historically supported large numbers of nesting wood storks. Presently, much of this historic range is being converted to citrus and pasture for cattle grazing. Coordinated efforts should also be used to seize opportunities to provide enhanced feeding areas through the mitigation process.
- H1.5.1. Review Federal actions for impacts to wood storks. Wetlands are altered for mining, agriculture, and residential purposes. Permitting authority over such activities is held by local governments, agencies in the State of Florida (DEP, SFWMD) and the Federal government (COE, EPA). Important feeding areas should be included as a category of waters for which the FWS receives COE pre-discharge notification pursuant to

section 404 of the Clean Water Act. section 7 of the Endangered Species Act requires that all Federal agencies ensure that their actions are not likely to jeopardize the continued existence of any listed species or destroy or modify their critical habitat. Federal agencies conducting actions that may affect the continued existence of wood storks must consult with the Service.

H1.5.2. Encourage conservation of wood stork habitat in conservation plans. Section 10(a) (1)(B) of the Endangered Species Act provides for incidental take permits that have the potential to contribute to the conservation of listed species. If appropriate, applicants should be encouraged to consider conservation of wood stork habitat when preparing Habitat Conservation Plans.

H2. Restore and enhance habitat. A prerequisite for the recovery of wood storks in the southeastern United States is the restoration and enhancement of suitable habitat throughout the mosaic of habitat types used by this species. Historically, South Florida supported greater than 70 percent of the nesting by wood storks in the Southeast. The deterioration of the Everglades and Big Cypress basins has resulted in decreased nesting by wood storks in South Florida and increased nesting in northern Florida, Georgia, and South Carolina.

H2.1. Restore the South Florida Ecosystem. Recover traditional Everglades and Big Cypress colony locations. The water delivery formula and schedules developed by the Experimental Water Deliveries Program, the structural modifications to canals and levees proposed for ecosystem restoration of Everglades NP through the Modified Water Deliveries and C-111 Projects, and the regional Everglades restoration planning process (C&SF Restudy) conducted by the COE, should address the recovery of the ecological processes that made it possible for the pre-drainage Everglades basin to support large numbers of storks and other wading birds. These ecological processes were made possible by the large spatial scale of the pre-drainage Everglades, the strong between-year variation in surface water patterns, and the strong flows of surface water into the estuaries.

H2.1.1. Reevaluate the effectiveness of all authorized projects on restoring habitat in the Everglades basin. The Southern Everglades Restoration Alliance (SERA), a group of cooperating agencies, was created to oversee the implementation of authorized ecosystem restoration projects associated with the C&SF Project. SERA is presently re-evaluating projects in the southern Everglades for their effectiveness in ecosystem restoration. The FWS should be involved in project evaluations, and should determine whether recovery efforts will improve habitat conditions for the wood

stork. If any authorized projects are found to lack the necessary components (including the appropriate operational schedules and regulatory components) to increase the ability of the wood stork to successfully nest or forage in South Florida, the FWS should help in the development of alternative designs that maximize ecosystem benefit.

- H2.1.2. Develop operational criteria that re-establish hydropatterns of the pre-drainage system. Operational schedules will be the most important component of Everglades restoration efforts. Operational schedules must truly balance the needs for flood protection with those of the Everglades ecosystem.
- H2.1.3. Restore the timing of nesting by wood storks in the southern Everglades through ecosystem restoration measures. Develop a restoration plan that includes the necessary addition or removal of structures, levees, and canals, to restore hydropatterns throughout the Everglades system; depths, period of inundation and sheetflow patterns should more closely match those of the pre-drainage system.
- H2.1.4. Provide feedback for adaptive restoration planning. Monitor stork colony patterns during implementation and testing of future efforts to improve hydrologic conditions. Use information on the location, timing, size and success of stork colonies in the Everglades and Big Cypress basins to evaluate ecological responses to the restoration programs and as a basis for designing future iterations in the restoration process.
- H2.1.5. Analyze and report on existing record of stork colony patterns in the Everglades basin, including the effects of initial restoration programs on the ecological recovery of Everglades NP. A report should be completed that incorporates all stork colony data from the Everglades basin and which assesses the impacts of past and current restoration programs, such as the Experimental Program of Water Deliveries to Everglades NP, on wood stork and wading bird colony patterns in Everglades NP; this report should be used to evaluate restoration efforts to date, and to improve future restoration programs.
- H2.2. Protect and enhance wood stork foraging habitat in private ownership in South Florida through partnership agreements. Historically, South Florida supported greater than 70 percent of the wood stork nesting effort in the southeast U.S.; the number of wood storks nesting in South Florida has been reduced to a fraction of the historic number. Every effort should be made to protect and enhance that portion of the population that continues to breed and winter in South Florida. For

example, the Corkscrew Swamp colony has consistently supported a significant number of nesting wood storks in South Florida. Many of the surrounding wetlands used for foraging by wood storks in this colony are in private ownership and are in danger of being converted to other land uses, such as citrus farming. Protecting these wetlands will be critical to protect the Corkscrew colony and help to preserve wood stork colonies in South Florida.

- H2.3. Acquire land identified as important habitat for wood storks in South Florida. Federal and State conservation agencies and private conservation organizations should continue efforts to acquire important habitat utilized by wood storks in South Florida. Initial land acquisition efforts should be carefully targeted to sites having the greatest potential for maintaining storks over time. Large, stable colonies that are in immediate threat from disturbance either through direct threat to the colony site or through a loss of surrounding foraging habitat, should be of highest priority. Priority should also be given to larger colonies with a history of annual use, sites most in need of management, and colony sites where alternate habitat is not available.

- H3. Conduct research on the critical habitat components necessary to trigger successful nesting by wood storks in South Florida. We do not know what specific habitat characteristics are necessary to trigger nesting by wood storks in South Florida. Wood storks could be responding to a suite of habitat characteristics such as water depth, photoperiod, rainfall patterns, prey densities, etc. Projects should be completed that will help to identify some of these habitat characteristics.
 - H3.1. Determine the densities, species composition and size classes of fishes necessary to result in successful nesting by wood storks in South Florida. Use information gathered in task S3.5 (species-level) to establish study locations. Water management practices may have resulted in fish populations that no longer represent “natural” populations. This information may aid us in developing the appropriate operational criteria for the Everglades restoration. It will also establish a baseline from which to compare the effects of ecosystem restoration activities.
 - H3.2. Determine the effects of natural and human-caused hydrologic events on the ecology of the prey base utilized by wood storks in South Florida. This information can be used to determine the optimal operational schedules for South Florida’s public lands.
 - H3.3. Determine if reduced freshwater flows into the northern Florida Bay mainland estuaries, as a result of the South Dade Conveyance System and the Experimental Program of Water Deliveries to Everglades NP, have caused wood storks to delay nesting in South Florida. These mainland estuaries historically provided important

early dry season foraging habitat; reduced freshwater flows may have significantly altered available prey base.

- H4. Monitor the status of areas identified as important wood stork habitat in South Florida. Monitor habitats identified by task H1.1. annually to determine whether changes are occurring in response to management actions. For example, habitats likely to be affected by hydrologic restoration projects should be monitored to determine impacts, both beneficial and adverse, on wood storks. The appropriate management decisions need to be considered, discussed, and implemented if adverse impacts are detected.
- H5. Increase public awareness about wood storks as an indicator of the health of the Everglades Ecosystem. Educational materials should be developed that identify the importance of the wood stork as an indicator of the health of the Everglades Ecosystem. This information will be key to gain the necessary public support for the restoration of the Everglades. The wood stork is a highly visible component of the Everglades and is perfect to serve as an indicator species to the public.

Recovery for the Red-cockaded Woodpecker, *Picoides borealis*

Recovery Objective: PERPETUATE VIABLE POPULATIONS where species currently exists. South Florida Contribution: ESTABLISH SUPPORT POPULATIONS to facilitate range-wide recovery.

Recovery Criteria: South Florida can contribute the establishment of one or more viable populations of red-cockaded woodpeckers toward the overall recovery goal for the species throughout its range. In particular, we should focus on increasing numbers of birds in the hydric pine flatwoods community of southwest Florida; South Florida is the only place where red-cockaded woodpeckers inhabit this community type throughout their range.

This objective will be achieved when: a reserve design for South Florida is developed that identifies patches of suitable-size nesting and foraging habitat (stands of old-age, mature pines of adequate size) essential for preventing further declines in the population; when any further loss and fragmentation of habitat within these reserves has been prevented; when suitable, occupied habitat within the reserves is protected through appropriate management on public and private lands, land acquisition, and cooperative agreements with private landowners; when additional nesting and foraging habitats are created or restored adjacent to existing clusters; when augmentation or artificial cavities are successfully implemented where needed to establish new groups; and when groups of red-cockaded woodpeckers within the reserves sustain

Species-level Recovery Actions

- S1. Determine the distribution and status of red-cockaded woodpeckers in South Florida. The status of the red-cockaded woodpecker in South Florida will remain uncertain and controversial until reliable census data are acquired. A range-wide survey was completed

for most Federal lands in 1982. Additional surveys are needed on public and private lands to update our information on the status of active and inactive clusters, as well as the availability of suitable unoccupied habitat throughout South Florida.

- S1.1 Conduct surveys on Federal and other public lands. Current surveys should be expanded to include Federal properties not included in the original survey as well as other public lands such as state forests, parks, wildlife management areas, and conservation lands.
 - S1.2. Conduct surveys on private lands. Develop non-invasive techniques (i.e. use of aerial photography) to identify potentially suitable habitat on private lands that could be occupied by red-cockaded woodpeckers. Work with landowners to obtain access to survey those lands and other private properties where red-cockaded woodpeckers are known to occur.
 - S1.3. Repeat surveys at 5 to 10 year intervals. Surveys should be repeated at 5 to 10 year intervals to determine local trends and to maintain consistency with region-wide surveys.
 - S1.4. Use survey techniques that are consistent with region-wide surveys. Use of standardized procedures in censusing local populations will facilitate communication among investigators, managers, and policy makers, and permit the integration of South Florida data into regional and range-wide estimates. Use these data to determine population status and trends.
 - S1.5. Maintain red-cockaded woodpecker distribution data in a GIS database. Update the existing GIS database by including information on the distribution of known clusters of red-cockaded woodpeckers and the current status of pine flatwoods communities throughout South Florida.
- S2. Protect red-cockaded woodpeckers in South Florida.
- S2.1. Develop a reserve design for red-cockaded woodpeckers in South Florida using landscape maps, GIS and spatially explicit models. Design reserves to consist of areas identified as critical to the survival of the red-cockaded woodpecker in South Florida. Large, contiguous patches of pineland habitat are ideal. Non-contiguous patches must be large enough to support at least short-term viable populations of at least 10 clusters, or must have corridors to link to additional suitable habitat.
 - S2.1.1. Identify all public lands, other conservation lands, and private lands where red-cockaded woodpeckers currently exist. Determine the current status and distribution of red-cockaded woodpeckers on protected and private

lands from S1.5.

- S2.1.2. Identify all unoccupied, potentially restorable pineland areas on public and other conservation lands. Work with Federal, State, and county agencies and NGOs to identify areas where management is needed, and where such management would benefit red-cockaded woodpeckers.
 - S2.1.3. Identify additional key privately owned lands that could enhance existing red-cockaded woodpecker preserves on conservation lands, that would serve as source sites for red-cockaded woodpeckers, or that would provide corridors to facilitate dispersal between occupied conservation lands.
 - S2.1.4. Use spatially explicit models with the existing information on suitable and restorable pineland habitat remaining in South Florida, and data on red-cockaded woodpecker biology, to identify the most suitable and feasible alternative for development of a reserve design to conserve red-cockaded woodpeckers in South Florida.
- S2.2. Protect, manage, and enhance red-cockaded woodpecker populations on public lands. In South Florida, red-cockaded woodpeckers are Federally protected on Avon Park AFR and Big Cypress National Preserve, and also occur on state-administered lands. The survival of the red-cockaded woodpecker depends to a large extent on maintaining and enhancing clusters on these public lands.
- S2.2.1. Develop management plans for red-cockaded woodpeckers where they occur on public lands. With assistance from the FWS, each public property manager should develop a long-term management plan designed to protect and enhance red-cockaded woodpecker clusters on their property. The plans should include fire and/or mechanical management to maintain the habitat in a suitable condition, as well as the use of starts or artificial cavities where feasible. Monitoring should be incorporated in the plan as feedback for adaptive management.
 - S2.2.2. Implement management plans for red-cockaded woodpeckers on public lands. Public land managers should coordinate efforts to ensure that the implementation and timing of management actions on adjacent properties are not in conflict, and that equipment and personnel are used effectively and efficiently.
- S2.3. Encourage protection and management of red-cockaded woodpeckers on private lands. In 1992, the FWS began developing a conservation strategy to address red-cockaded woodpecker losses on private lands, economic impacts to private

landowners of providing habitat, and cooperative conservation efforts between the public and private sectors (Costa 1995). A number of incentives have been proposed to compensate private landowners willing to manage for red-cockaded woodpeckers.

- S2.3.1. Develop Memorandums of Agreement between the FWS, private landowners, and other cooperators. Agreements should specify management actions needed to protect the species and identify the party responsible (landowner or Federal agency) for implementing the various actions. Agreements should set forth the total commitments of the two parties including land base, funds, equipment, manpower, and time period, and provide a means and time frame for terminating the agreement.
- S2.3.2. Implement Safe Harbor Policy for red-cockaded woodpeckers where it would benefit recovery. The Safe Harbor concept could work in South Florida for the large tracts of privately held pine flatwoods, such as in the southwestern part of the state. This program could be a key to maintaining population exchange of red-cockaded woodpeckers in South Florida and lend more demographic stability to population centers.
- S2.3.3. Recognize or reward protection and management efforts. Management efforts on private lands should be recognized and rewarded in any way possible in light of the limited legal responsibilities involved.
- S2.3.4. Develop and implement other conservation programs. The opportunities for a model tax incentive program at State and Federal levels should be explored and implemented if feasible.
- S2.3.5. Provide information on management and legal requirements to private landowners and managers.
 - S2.3.5.1. Continue development of information articles and management guidelines oriented to private lands. These articles and guidelines should include information and visual aids to identify habitat of the species, detailed information for managing the species by an array of options depending on the total land management objectives of the owner or manager, and specific information on the legal responsibilities of private landowners through section 9 of the ESA. Legal responsibilities under section 7 of the ESA should also be detailed to explain the different obligations when there is Federal involvement of any kind.

- S2.3.5.2. Distribute information to private landowners and managers through professional and industrial associations. The information developed in S2.3.5.1. should be distributed through a variety of professional and trade associations and agencies, such as the State and Private Forestry branch of the USDA Forest Service, county agricultural extension agents, and state forestry associations.
- S2.4. Enforce available protective measures. Employ local, State and Federal regulations and guidelines to protect red-cockaded woodpeckers and their habitat.
- S2.4.1. Initiate section 7 consultation when applicable. All Federal agencies must consult with the FWS on any of their activities (authorized, funded, or carried out) that might adversely affect resident red-cockaded woodpecker populations. Such activities include (among others) pesticide use, road construction, military training exercises, and clearing of land for new buildings and runways. Implement on-site minimization through section 7 when needed.
- S2.4.2. Implement on-site minimization, habitat compensation, and mitigation on private lands through section 10 when needed. Where adverse effects cannot be avoided, measures must be taken to minimize on-site disturbance, and compensate or mitigate for the impacts that remain. The FWS generally recommends that areas used as habitat compensation be located in the vicinity of the affected habitat, where appropriate, to enhance existing clusters, and avoid further fragmentation and isolation of existing habitat.
- S2.5. Revise the Federal guidelines for evaluating red-cockaded woodpecker habitat in South Florida. The FWS needs to work toward revising the Federal guidelines (Henry 1989) to be beneficial for red-cockaded woodpeckers in South Florida. These guidelines are inadequate for South Florida, particularly for the hydric slash pine flatwoods in southwest Florida. At least half of the areas there would fail to meet the 23.1 cm dbh criteria for determining suitable habitat, and more than half of the clusters would fail to meet the standard for determining suitable cavity trees (Beever and Dryden 1992).
- S3. Conduct research on the life history and population dynamics of red-cockaded woodpeckers in South Florida. Although red-cockaded woodpeckers have been well studied, very little is known about the life history and subsequent management needs of birds in South Florida.

- S3.1. Gather basic life history and demographic data, such as reproductive success, juvenile and adult survival and mortality, juvenile recruitment into the breeding population, the role of helpers, home range size requirements, and dispersal of birds within the various subpopulations in South Florida.
- S3.2. Conduct risk assessment analysis to determine the probability of persistence of red-cockaded woodpeckers in South Florida, given the current amount of available, suitable pineland habitat. Include pineland areas that could be restored or enhanced to become suitable habitat.
 - S3.2.1. Identify which subpopulations of red-cockaded woodpeckers are considered “viable” according to our recovery criteria, and which subpopulations or groups of birds are most vulnerable to extinction.
 - S3.2.2. Incorporate results of this effort into the reserve design for red-cockaded woodpeckers to assist with project review and consultation purposes.
- S3.3. Study the effects of habitat fragmentation due to urbanization. On a landscape level, determine how residential development affects the metapopulation dynamics of red-cockaded woodpeckers. On a population level, identify the conditions that red-cockaded woodpeckers can tolerate and adapt to in a suburban setting, in addition to the conditions that significantly alter their vital rates, such as reproductive success, growth, and survival.
- S3.4. Determine the biological and ecological conditions necessary to ensure natural colonization following habitat restoration. Describe the conditions that are conducive to natural immigration of red-cockaded woodpeckers after restoration of unoccupied pineland communities. Collect life history information on red-cockaded woodpeckers that naturally immigrate to restored habitat, including immigration, habitat use, territoriality, reproduction, adult and juvenile survival, dispersal, and recruitment.
- S3.5. Research feasibility of translocation of red-cockaded woodpeckers in South Florida. Translocation of red-cockaded woodpeckers has been shown to be successful in areas outside of South Florida, and has not yet been attempted here. Explore opportunities for translocating red-cockaded woodpeckers to establish new populations, to enhance gene flow, or to salvage groups permitted for incidental take.
 - S3.5.1. Identify areas in South Florida where red-cockaded woodpeckers occur in small, isolated populations that are subject to eventual extinction, or where habitat is so threatened that birds would not be able to survive due to

stochastic events, demographic problems and/or a lack of genetic vigor.

S3.5.2. Conduct an experimental translocation of birds from one of the areas identified in 3.5.1. to an area with suitable habitat that can support additional birds. Follow the protocols established for red-cockaded woodpeckers that have been successful elsewhere (Costa and Kennedy 1994).

S4. Monitor red-cockaded woodpecker subpopulations.

S4.1. Monitor representative groups within each subpopulation in South Florida to collect data on habitat use, reproduction, survival, mortality, dispersal, and recruitment. Use these data to determine the status and trends of birds throughout South Florida.

S4.2. Monitor birds in urban areas for changes in their vital rates, such as reproductive success, growth, and survival, as urbanization affects territory size.

S4.3. Monitor natural immigrants and translocated birds. Collect data as in S4.1 to determine the success of birds that inhabit newly restored habitat as well as birds that have been translocated to new areas.

S5. Inform and involve the public. This is an ongoing task. Particular emphasis should be placed on explaining the status, importance and biological needs of red-cockaded woodpeckers and the legal responsibilities for the species' protection.

S5.1. Prepare informative articles for the news media and popular publications. Information articles for the news media and popular publications should be prepared. The news media should be contacted and encouraged to utilize the information articles as prepared or incorporate all or part of the information in articles prepared by news media staff.

S5.2. Distribute information to the public via mailings to conservation groups and individuals and through public meetings. The popular publications should be distributed to the public via mailings to conservation groups and individuals, and through public meetings. Availability of the publications should be publicized and the public encouraged to request copies.

Habitat-level Recovery Actions

H1. Prevent degradation of existing red-cockaded woodpecker habitat in South Florida. The long-term survival of the red-cockaded woodpecker is dependent upon the immediate protection of as much of the remaining occupied and suitable, unoccupied pineland

communities as possible, given biological, social, economic, and legal constraints.

- H1.1. Prioritize areas identified in reserve design for management and acquisition. Large, contiguous habitat patches are the most ideal for conserving red-cockaded woodpeckers. High priority should be given to areas contiguous with, or within short dispersal distance of, existing conservation lands where red-cockaded woodpeckers occur. High priority should also be given to areas adjacent to suburban sites where red-cockaded woodpeckers occur, allowing natural dispersal of birds from suburban areas to protected habitat.
- H1.2. Protect red-cockaded woodpecker habitat on private lands through easements, acquisitions, and donations. Lands identified for acquisition should be located adjacent to, or be contiguous with, publicly owned conservation lands or other lands proposed for acquisition that contain red-cockaded woodpecker clusters. Lands containing red-cockaded woodpeckers should receive special consideration where these lands would consolidate Federal ownership or control and contribute to overall resource management objectives of the agencies.
 - H1.2.1. Support State acquisition efforts. The Florida Conservation and Recreation Lands (CARL) program has a number of ongoing projects and proposals for the acquisition of threatened vegetative communities in Florida. Florida's Save Our Rivers (SOR) acquisition program administered by the water management districts targets wetlands for protection but some sites also contain xeric uplands, and potentially red-cockaded woodpecker habitat that could benefit from the SOR program.
 - H1.2.2. Encourage acquisition by Non-Governmental Organizations. Occupied and suitable, unoccupied areas not targeted in Federal and State acquisition programs may become available for private purchase and management.
 - H1.2.3. Pursue acquisition of lands identified as necessary for developing red-cockaded woodpecker reserves that are not covered under H1.2.1 or H1.2.2.
- H1.2. [sic] Maintain adequate nesting habitat in addition to currently active clusters, to replace clusters abandoned or lost through mortality, and to provide for population expansion. Cavity trees can be provided by lengthened rotations, by leaving old-growth remnant trees well distributed throughout younger stands, by perpetuating small remnant stands or patches of old-growth throughout the forest area, or by a combination of these methods. Manage clusters as stands rather than as individual trees and avoid isolating clusters from adjacent forest cover and

foraging habitat. Burn or otherwise treat clusters to control hardwood stocking. Potential nesting habitat should be burned and thinned similarly to clusters.

- H1.3. [sic] Maintain adequate foraging habitat to support existing groups and to facilitate establishment of new territories. Although the loss of nesting habitat is the most serious threat to red-cockaded woodpeckers, groups cannot survive without adequate foraging habitat as well. In South Florida, because of the difference in habitat structure and composition, more habitat is needed for foraging than in areas in the northern portion of the species' range (Hovis and Labisky 1996; Beaver and Dryden 1992).
- H1.4. Prevent loss or fragmentation of pine flatwoods within reserves identified in S2.1. Ensure that no habitat gaps are created within reserves that might preclude dispersal by red-cockaded woodpeckers.
- H2. Restore and enhance red-cockaded woodpecker habitat.
 - H2.1. Use artificial starts in suitable areas. Suitable substrate for cavity excavation is a limiting factor in localized situations, so artificial starts should be excavated in selected trees both in clusters and in suitable but unoccupied nesting/roosting habitat.
 - H2.2. Create artificial cavities in suitable areas. When the availability of trees suitable for cavity excavation in a cluster is severely restricted, or when the management objective is to induce colonization of an unoccupied but suitable area, artificial cavities can be created in suitable trees (Copayon 1990; Allen 1991; Taylor and Hooper 1991).
- H3. Conduct research on habitat needs and management for red-cockaded woodpeckers in South Florida.
 - H3.1. Determine the amount of foraging habitat needed to sustain a group of woodpeckers in South Florida in both mesic and hydric pine flatwood habitats. The current Federal foraging guidelines for red-cockaded woodpeckers are unsuitable for use in South Florida because of the significant differences in habitat quality. These data are needed to produce guidelines specific to South Florida.
 - H3.2. Investigate the best method(s) to provide and manage nesting habitat. Determine whether successful ongoing management activities for red-cockaded woodpeckers elsewhere are suitable for use in South Florida, or how they may be modified for use here.

- H3.3. Determine the potential carrying capacity for clusters of red-cockaded woodpeckers on existing public and private lands where suitable or restorable habitat exists.
 - H3.4. Assess the biological processes associated with cluster abandonment (e.g., interspecific competition, predation, etc.), and methods for preventing abandonment.
 - H3.5. Determine whether retention of snags and dead and abandoned cavity trees within clusters increases or decreases competitive pressure on red-cockaded woodpeckers.
- H4. Monitor xeric communities that provide red-cockaded woodpecker habitat.
- H4.1. Monitor pineland habitat that is occupied by red-cockaded woodpeckers to ensure public lands are managed to maintain habitat in suitable condition for red-cockaded woodpeckers, and to assess when unmanaged areas become unsuitable. Also monitor to ensure the site is not becoming a population “sink.”
 - H4.2. Monitor unoccupied pine flatwood communities following restoration to collect data on habitat characteristics upon immigration and establishment of red-cockaded woodpeckers. This will provide information on the habitat conditions that are suitable for red-cockaded woodpeckers following restoration.
 - H4.3. Maintain red-cockaded woodpecker habitat data in a GIS database. Update the existing GIS database by including information obtained from surveys in S1.1 on the current status of pineland habitat in South Florida. Record the condition of the habitat, and the type and timing of all pertinent management actions.
- H5. Increase public awareness of pine flatwoods communities. Efforts should highlight habitat acquisition initiatives, importance of biodiversity, and biology of pineland-dependent species. Federal, State, and county governments, as well as private organizations, should support the development and dissemination of educational materials pertaining to the conservation of the remaining pine flatwoods in South Florida. Materials such as brochures, posters, postcards, slide programs and videotapes can improve public understanding of and increase appreciation for protection of this community. Environmental education programs throughout South Florida should be encouraged to distribute materials or develop lesson plans on the pine flatwoods community, highlight species such as the red-cockaded woodpecker, and discuss the importance of maintaining biological diversity.

The Reptiles

Recovery for the American Crocodile, *Crocodylus acutus*

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: The initial recovery plan for this species identified habitat alteration and human disturbances as the primary threats to this species and those that warranted its listing. Although efforts have been undertaken to ameliorate these threats, it is generally believed that these factors continue to act against the American crocodile to some extent. However, despite the ongoing influences of these threats, the crocodile has increased in numbers and is approaching population levels targeted by the initial recovery plan. It is apparent, therefore, that the effects of these threats are not as deleterious as previous assessments may have suggested, and that the reclassification of this species is possible.

Previous recovery efforts identified the need for a minimum of 60 breeding females within the population before reclassification could be considered. Since these criteria were developed, new information, based on consistent surveys, has indicated that the total number of nesting females has increased substantially over the last 20 years, from about 20 animals to about 50, and that nesting has remained stable at the major nesting areas. Based on the fact that the population appears stable, and that all of the threats as described in the original listing have been eliminated or reduced, reclassification of the crocodile will be possible, provided existing levels of protection continue to be afforded to crocodiles and their habitat, and that management efforts continue to maintain or enhance the amount and quality of available habitats necessary for all life stages

Species-level Recovery Actions

- S1. Conduct surveys to determine the current distribution and abundance of American crocodiles. Survey all remaining suitable habitats in South Florida for American crocodiles. Most knowledge about the current distribution of crocodiles comes from surveys conducted within Everglades NP, the upper Florida Keys, and areas surrounding Turkey Point in Miami-Dade County. These areas correspond to locations with the highest known crocodile densities, but do not represent the entire range of the American crocodile. Surveys for crocodiles have not been conducted in large portions of South Florida; for example, American crocodiles have been observed in increasing numbers on the southwest coast of Florida, north to the J.N. Ding Darling NWR. These areas should be surveyed in order to determine the size and distribution of the American crocodile population and should include occurrence of individuals and nesting effort.
 - S1.1. Evaluate coastal wetlands to determine their suitability for crocodiles. Inventory potential habitat for American crocodiles with an emphasis on the southwest coast of Florida from Whitewater Bay north to Marco Island. Most known nesting and nursery sites are now publicly owned, but large areas of mangrove-lined coastline have not been surveyed for crocodiles. Before beginning time-consuming

population surveys, coastal habitat in southwestern Florida should be assessed to identify areas that could support American crocodiles. Continue to survey coastal wetlands of Biscayne Bay because of the increased potential for human/crocodile interactions.

- S1.2. Survey crocodile colonies in suitable habitats in South Florida. In combination with S1.1, survey suitable habitats for all age classes of crocodile, especially in Biscayne Bay where nesting has been documented, and those areas of southwest Florida where information on the distribution and status of crocodiles is lacking. If substantial aggregations are located, they should be included in annual population monitoring programs.

- S2. Protect and enhance existing colonies of American crocodiles. Although numbers of crocodiles are increasing in South Florida, habitat loss and degradation may limit the extent to which this expansion continues. In order to sustain the growth of the crocodile population, habitat that is suitable to meet the needs of all age classes must be protected. In some cases this habitat must be restored. Even though information is not available on the habitat requirements for each age class of American crocodile, the recovery team has basic information about the biotic and abiotic factors required for survival of this species. Although juvenile and adult crocodiles are less susceptible to fluctuations in their environment than hatchlings, the availability of refugia adjacent to deep water may be the single most important habitat characteristic that ensures the survival of these age classes.
 - S2.1. Reduce or eliminate sources of American crocodile mortality. All activities that affect crocodile habitat should be evaluated and appropriate steps taken to minimize or eliminate adverse affects to crocodiles and their habitat.
 - S2.1.1. Control human-induced crocodile mortality and disturbance. Reduce or eliminate anthropogenic sources of mortality. Human causes of mortality may be additive to an otherwise unknown level of natural mortality. However, many depressed populations can be pushed beyond their capability to recover when sources of additive mortality also affect population levels.
 - S2.1.2. Alert motorists on roads where repeated collisions between automobiles and American crocodiles have occurred. State Road 905, U.S. 1, and Card Sound Road have been posted with crocodile crossing warning signs for some time, but collisions with automobiles still occur periodically. An assessment of the effectiveness of signing should be conducted to determine if additional information would be useful in reducing American crocodile mortalities.

- S2.1.3. Reduce the incidence of American crocodile road mortalities by installing box culverts. Construct culverts on portions of U.S. 1 to reduce automobile-crocodile collisions. Automobile-crocodile collisions have occurred periodically on portions of U.S. 1 and may be minimized through installation of pass-through culverts. Although there remains uncertainty about the effectiveness of installing culverts for the safe passage of crocodiles under highways, it is likely they will be used to some extent. When U.S. Highway 1 is widened, culverts should be installed at locations where crocodile mortalities have occurred.
- S2.1.4. Control terrestrial predators of crocodile eggs and hatchlings in areas where they may be artificially high. Human visitation of some areas (such as Cape Sable in Everglades NP) create unnatural conditions for predators such as raccoons. These animals could be adversely affecting survival and recruitment of the crocodile on public lands.
- S2.2. Continue long-term assessment of pesticide and heavy metal contamination levels in crocodile eggs. Assessments of environmental contaminants in eggs should be conducted every 5 years.
- S2.3. Assure coordinated management actions by interagency agreements or other means. Responsibility for the management of the American crocodile is currently divided between the State of Florida (GFC), the NPS, and the FWS. Currently the GFC, in consultation with the FWS, is managing human-crocodile conflicts outside of Everglades NP. The NPS retains management authority for crocodiles within Everglades NP. The FWS protects the American crocodile throughout its range through its regulatory programs. Steps should be taken to insure that the actions of these agencies are coordinated and non-conflicting.
- S3. Conduct research on the biology and life history of crocodiles. Although basic information on the biology of the American crocodile has been collected, more detailed information is needed to determine the status of the crocodile population in South Florida.
- S3.1. Determine the carrying capacity of remaining crocodile habitat in South Florida. The expansion of the American crocodile population in South Florida will be limited by the amount of habitat suitable for one or more life-history stages (*e.g.*, nesting, feeding, dispersal, refuge, etc.). To estimate the potential for the American crocodile population to continue to grow, it will be necessary to identify limiting habitats. Historical information on the South Florida crocodile population and information on other American crocodile populations may be essential in determining the carrying capacity for South Florida.

- S3.2. Conduct research to determine basic biological needs of the American crocodile. Conduct or continue mark-recapture efforts, population and nest surveys, and habitat monitoring in the vicinity of previous research and monitoring work done on Key Largo, Turkey Point, and Everglades NP. Where other congregations of crocodiles are found in the future, conduct similar efforts. We know little about the species in southwest Florida or within the recently discovered breeding aggregation on Marco Island. Additional information is needed to determine the demographics of the American crocodile. Information on survival, recruitment, fecundity, and mortality are important in assessing the relative health of this population.
 - S3.3. Evaluate the effects of human disturbances on crocodile behavior. Conduct research to determine behavioral reactions to human disturbances.
 - S3.4. Develop identification techniques for American crocodiles. Distinguishing genetic differences between American crocodiles found in South Florida from American crocodiles throughout the remainder of their range will be essential in assessing the extent to which foreign crocodiles have contributed to the present genetic profile of crocodiles in South Florida.
- S4. Monitor the South Florida crocodile population. Long-term monitoring is essential to the assessment of the status of the crocodile population.
- S4.1. Coordinate monitoring programs and protocols. Data collected, marking system, and database management methods should be standardized among researchers.
 - S4.2. Conduct surveys for American crocodiles. Ongoing population surveys at Key Largo, Everglades NP, Turkey Point, and Biscayne Bay are important in the long-term assessment of the crocodile population in South Florida. Survey data should provide information on the number, distribution, and size class trends in these areas. As the population expands, survey efforts should be initiated in other areas where congregations of crocodiles occur.
 - S4.3. Conduct a mark-recapture program for the American crocodile. Mark-recapture data provide important information on growth, survival, and dispersal. These data will be essential in assessing the status of the crocodile in South Florida.
- S5. Inform the public about the recovery needs of crocodiles. The public is generally unaware of the biology and status of the American crocodile, and misunderstandings still result in adverse sentiment towards this species. Public education is required to provide accurate biological information and to stimulate interest in the conservation of the American crocodile. Public information should include the general public, public officials, land

managers, and policy makers.

- S5.1. Continue relocation of problem crocodiles. GFC policy currently provides for the relocation of crocodiles that threaten human safety. Although this program results in the non-lethal removal of problem animals, it reduces the likelihood that habituated or bold crocodiles will be killed by members of the public. This program reduces mortality and provides opportunities for public education.
- S5.2. Assess the effectiveness of road signage for reducing the numbers of American crocodiles killed by automobiles. U.S. 1 in the Florida Keys has been posted with crocodile crossing warning signs for some time, but collisions with automobiles still occur periodically. An assessment of the effectiveness of signing should be conducted to determine if different approaches to these signs should be used to reduce crocodile mortalities along these two roads. The signs that have been used for the West Indian manatee should be examined as alternative models.
- S5.3. Develop and distribute informational brochures regarding the biology and conservation of American crocodiles. Distribution locations should include facilities that rent boats and personal watercraft, fishing charters, county and State parks, bait and tackle shops, restaurants along Florida Bay, and neighborhoods with resident crocodiles.

Habitat-level Recovery Actions

H1. Protect nesting, basking, and nursery habitat of American crocodiles in South Florida.

- H1.1 Acquire or otherwise protect habitat for crocodiles. Large amounts of suitable habitat for American crocodiles have been protected inside Everglades NP, Biscayne NP, and Crocodile Lake NWR. However, extensive areas of suitable, occupied habitat and potentially restorable habitat for American crocodiles are not protected, particularly in southwestern Florida (Collier and Lee counties). Once lands that support suitable, occupied, or potentially restorable habitat for American crocodiles have been identified (see Task S1.), those lands should be protected either through additional land acquisition or cooperative management agreements with the land owner or land manager.
- H1.2. Protect essential crocodile habitat on private lands. If suitable habitat for American crocodiles is found on private lands, determine owner and appropriate conservation measures such as acquisition, easements, transfer of development rights, establishment of protective management plans, etc. Less than simple fee title acquisition may be required for crocodile habitat on private lands. Conservation agreements or easements or transfer of development rights may protect crocodile habitat on some private lands.

H2. Manage and restore suitable habitat of American crocodiles.

H2.1. Continue to maintain nesting sites adequate to maintain viability of the American crocodile. Crocodile Lake NWR on Key Largo, Everglades National Park, and Florida Power and Light's Turkey Point nuclear electrical generating facility currently provide the majority of nesting habitat for the American crocodile in South Florida. These areas must be adequately managed to sustain or increase the current level of nesting. Continue efforts to control exotic plants that have invaded portions of crocodile nesting habitat in these areas.

H2.2. Restore areas to suitable habitat. Much of the suitable habitat outside of Everglades and Biscayne national parks has been degraded or destroyed due to residential, commercial, or agricultural uses. Some of these areas may be suitable for restoration efforts. This will require: removal of exotic plants that degrade the quality of dispersal habitat for juvenile crocodiles, nesting sites, and basking areas; restoration of native vegetation in areas where the control of exotic vegetation or other human disturbances created large gaps in vegetated shoreline; and restoration of hydroperiods and hydroperiods in the Everglades and Big Cypress drainages so that hydrologic patterns mimic timing, flows, and depths that would have occurred under a rainfall-driven system. Natural hydroperiods will likely provide sufficient fresh water to periodically flush creek beds to maintain deepwater refugia for breeding adults. Restored hydroperiods also will decrease average salinities during late summer, when hatchlings require low-salinity water.

H2.1. [sic] Complete the Project to Modify Water Deliveries to Everglades NP and the Canal 111 Project. Both of these U.S. Army COE projects are designed to restore more natural patterns of water deliveries to eastern Florida Bay through Taylor Slough and Shark River Slough. Both projects should substantially improve habitat quality for American crocodiles in eastern Florida Bay. Although these projects have been authorized and construction on these projects initiated, they have not been completed. Both projects must be completed to increase the likelihood of the crocodiles' survival and recovery in the wild.

H2.2. [sic] Continue to monitor the effects of the Program of Experimental Water Deliveries to Everglades NP on the American crocodile to determine optimal operational schedules. As outlined in item H2.1. the COE is currently authorized to construct the Project to Modify Water Deliveries to Everglades National Park and the Canal 111 Project. Both of these projects are designed to restore more natural patterns of water deliveries to eastern Florida Bay through Taylor Slough and Shark River Slough and should substantially improve habitat quality for American crocodiles in eastern Florida Bay. However, the benefits of these projects to the American crocodile will depend on how the structures associated with the projects

will be operated. The Program of Experimental Water Deliveries to Everglades NP iteratively assesses how the operations of water control structures affect the health of Everglades NP and associated biota. American crocodiles are currently being monitored as part of the Experimental Program; this monitoring should continue with a specific emphasis on determining the response of American crocodiles and their habitat to different operational schedules.

- H2.3. Continue habitat and population modeling to determine operational schedules for structures associated with the Program to Modify Water Deliveries to Everglades NP, Canal 111, and the Central and Southern Florida Flood Control Project that provide optimal habitat for the American crocodile. The operations of structures associated with these three projects will determine the actual benefits of these projects to the American crocodile. For example, these projects could be operated in ways that either restore or create nursery habitat for juvenile American crocodiles (see item H2.4.). Some of the information necessary to determine how to operate structures associated with these projects to optimize habitat for American crocodiles will be generated by the monitoring program associated with the Experimental Program of Water Deliveries to Everglades National Park, but additional evaluations will be necessary. Additional models that will help determine optimal operational schedules are being developed as part of the USGS's (BRD) Across Tropic Level System Simulation. This modeling effort should continue and new efforts should be initiated to determine optimal operational schedules for COE structures in South Florida.
- H2.4. Create additional nesting habitat for crocodiles in South Florida. Recovery of the American crocodile is dependent on the availability of adequate nesting sites, and an increase in the amount of suitable nesting habitat could increase recruitment into the population.
- H2.5. Restore or create nursery habitat for American crocodiles in South Florida. This will generally require restoration of suitable, lower-salinity regimes to nursery areas for juvenile American crocodiles. Restoration of mangrove wetlands within Crocodile Lake NWR has resulted in increased salinity in one important nursery area, rendering the area less suitable for hatchlings. On Florida's southeastern coast, three COE projects (Project to Modify Water Deliveries to Everglades NP, Canal 111 Project, and the Central and Southern Florida Flood Control Project) will have significant effects on salinity regimes in nursery habitat for American crocodiles. On Florida's southwestern coast, efforts to restore Rookery Bay, the Big Cypress drainage, and the Ten Thousand Islands Region could have similar benefits to the American crocodile. As these projects undergo further development, benefits to nursery habitat for American crocodiles should be included as performance criteria to determine project benefits.

- H2.6. Continue to enforce land-use restrictions in essential crocodile habitat. The NPS and FWS preclude human use in important crocodile habitat in the areas these two agencies manage in Florida Bay and on Key Largo. These restrictions, as well as others that may be required if new crocodile congregations are located, will help protect crocodiles during their recovery. Periodic assessments should be conducted to determine the need for land-use restrictions.
- H3. Conduct research on the habitat relationships of the American crocodile. Much of the habitat-based research needed for the recovery of the American crocodile is currently addressed in one or more research projects dealing with the maintenance and recovery of the Florida Bay ecosystem. However, specific research information on the relationship of American crocodiles to salinity regimes, exotic species, and adjacent land uses will be critical to the design of future management actions for the American crocodile.
- H4. Continue to monitor crocodile habitat.
- H4.1. Continue to monitor crocodile nesting habitat to determine environmental factors that affect nesting success.
- H4.2. Continue long-term assessments of pesticide and heavy metal contamination levels in South Florida ecosystems. Numerous contaminant assessment projects are ongoing in South Florida. Support of these projects and use of the periodic data they provide will be important in assessing the quality of crocodile habitat.
- H5. Increase public awareness of the habitat needs of crocodiles. Tidally influenced areas provide important habitat for crocodiles, but these areas are also attractive to humans for recreational and residential uses. Efforts to protect crocodile habitat will probably not be well received because of the public's general misperceptions about crocodiles. Effective protection and restoration of habitat can only be achieved if these efforts demonstrate that such protection will also benefit other commercially and recreationally important species. Habitat protection should be approached from an ecosystem perspective, emphasizing conservation benefits to Florida Bay. The efforts that have been used to increase public awareness of the habitat needs of the West Indian manatee should serve as the model for these efforts.

Recovery for the Eastern Indigo Snake, *Drymarchon corais couperi*

Recovery Objective: ENSURE numerous populations exist and are protected.

South Florida Contribution: STABILIZE and increase population.

Recovery Criteria: There is a general lack of information on the status and trends of eastern indigo snakes in South Florida. Although the primary threat identified when the eastern indigo

snake was listed has been ameliorated, we believe that an additional threat of habitat loss and fragmentation continues to affect the survival and recovery of this species. The objective to stabilize and increase numbers of eastern indigo snakes in South Florida will require protection of individuals as well as the habitat where they are known to occur. Additional research and monitoring of the snake's life history will also be necessary. More data on the demographics of this species are needed before we can determine an appropriate amount of habitat to ensure persistence of the species. One measure of demographic data that could determine an increasing population would be a rate of increase (r) greater than 0.0 as a 3-year running average over at least 10 years. Once it is determined that sufficient, suitable habitat exists in South Florida for the eastern indigo snake population to stabilize or increase, delisting criteria can be considered. The development of delisting criteria will require the analysis of demographic data to demonstrate that there are adequate, contiguous tracts of upland habitat in South Florida to ensure at least a 95 percent probability of persistence for the eastern indigo snake for 100 years.

Species-level Recovery Actions

- S1. Determine the distribution of the eastern indigo snake in South Florida. The distribution of the eastern indigo snake in South Florida is poorly documented. However, because this species is wide-ranging throughout a variety of habitats, we feel it is infeasible to survey all terrestrial habitats it could occupy.
 - S1.1. Compile distribution data for eastern indigo snakes from all available sources. Existing data sources on the distribution of indigo snakes throughout South Florida should be compiled and entered into a Geographic Information System database.
- S2. Protect and enhance existing populations of indigo snakes in South Florida.
 - S2.1. Support land acquisition programs through Federal, State, and private efforts. The 1982 recovery plan estimated that at least 4,000 ha is needed to sustain a viable population of eastern indigo snakes. The acquisition of diverse habitat will increase the potential for recovery of this and other listed species in South Florida.
 - S2.2. Protect eastern indigo snakes on public lands. The eastern indigo snake utilizes a variety of upland habitat types in Florida, particularly pine flatwoods, high pine, scrubby flatwoods, and scrub communities. Habitat management practices should be implemented to maintain biodiversity and minimize impacts from motor vehicles and commercial forestry practices. Ecotonal areas between upland/xeric habitats should be maintained using controlled burns at intervals appropriate for specific community types.
 - S2.3. Protect eastern indigo snakes on private lands. Landowners should be informed about indigo snakes and their habitat requirements. Include this information in general habitat management guidelines that address the needs of other listed

species, and suggest management options to landowners. Encourage favorable management practices such as controlled burning whenever possible. The possibility of long-term renewable leases and conservation agreements involving Federal, Tribal, State, and local government agencies should be investigated where outright acquisition is not acceptable to the landowner.

S2.4. Identify, evaluate, and eliminate other threats to the survival of the indigo snake. Regulations are in place to control the pet trade and gassing of gopher tortoise burrows. In addition to the outright loss of habitat associated with conversion to residential or agricultural uses, potential threats such as predation from domestic animals and pesticide contamination may become more problematic and threaten the continued persistence of eastern indigo snakes in some areas. Because pesticide use on adjacent agricultural and residential lands poses a potential risk to eastern indigos, management plans should consider these risks and alleviate threats whenever possible. Trapping efforts may be needed on public lands where free-ranging domestic animals threaten this species.

S2.5. Enforce available protective measures.

S2.5.1. Conduct section 7 consultations on Federal activities that may affect eastern indigo snakes. Federal agencies should consult with the FWS on any activity (authorized, funded, or carried out) that may affect the eastern indigo snake. Such activities include, but are not limited to, pesticide use, road building, construction of new facilities, military training exercises, wetland fill, clearing for new runways, etc. Because this species is found in a variety of habitats, it should be considered in almost all consultations.

S2.5.2. Implement the FWS South Florida Field Office's eastern indigo snake guidelines. The guidelines should be used for section 7 and section 10 consultations, and be incorporated into permits where feasible.

S3. Continue studies on the biology and ecology of the indigo snake. Adequate long-term protection of the eastern indigo snake depends on a thorough understanding of its life history. Because this species occurs in low densities naturally, it is difficult to survey and study. As a result, many aspects of its life history are poorly understood.

S3.1 Investigate techniques to effectively survey eastern indigo snakes. The use of subterranean cameras or scopes to investigate gopher tortoise burrows, particularly during winter months, has proven useful in some circumstances. However, other methods, such as the use of pheromones to attract males, should be investigated. This information is necessary to assess population levels and status of this species, and to accurately monitor existing populations and the response to management

- prescriptions.
- S3.2. Continue research to better evaluate home range size, age of dispersal, and dispersal distance of the eastern indigo snake. More data are needed on these biological requirements to develop and evaluate management actions. Information on movements is critical for the development and management of conservation reserves for this species.
 - S3.3. Conduct additional life history studies to build the general knowledge base for the eastern indigo snake. Information on reproductive success, fecundity, longevity, and other basic population demographics is needed to assess the status and trends of the population.
 - S3.4. Conduct population modeling (i.e. risk assessment) once basic demographic data are known.
 - S3.5. Determine the status and distribution of eastern indigo snakes in disturbed habitat. Identify whether eastern indigo snakes are able to persist in habitats modified by residential, commercial, and agricultural uses.
- S4. Monitor populations. Once standardized survey techniques are developed, begin long-term monitoring on conservation lands where eastern indigo snakes are known to occur. This information is needed to determine status and trends for the population.
- S5. Improve public attitude and behavior towards the eastern indigo snake. Public opinion concerning snakes in general and eastern indigo snakes in particular should be improved so that the common tendency to kill snakes on sight will be decreased. The general public can be reached through videos, television programs, lectures, and articles in newspapers and magazines. For South Florida, educational materials should be made available in Spanish and Creole. Emphasis should be placed on the harmless and beneficial nature of the species and the threats to its survival and recovery.
- S5.1 Discourage the use of rat poison in or near eastern indigo snake habitat. The use of poison to control rats in areas inhabited by this species should be discouraged as indirect poisoning of may occur.

Recovery for the Green Sea Turtle, *Chelonia mydas*

Recovery Objective: DELIST the species once recovery criteria has been met.

South Florida Contribution: SUPPORT delisting actions.

Recovery Criteria: The South Florida recovery contribution parallels the existing recovery plans

for the sea turtles. South Florida's objective for the loggerhead turtle, green turtle, leatherback turtle and hawksbill turtle will be achieved when: the level of nesting for each species is continuously monitored and increases to the species-specific recovery goal; beaches supporting greater than 50 percent of the nesting activity are in public ownership; all important nesting beaches are protected and appropriately managed to prevent further degradation; non-native nuisance species have been controlled or eliminated on public lands; at least 60 percent hatch success is documented on major nesting beaches; effective lighting ordinances or lighting plans are implemented; and beaches are restored or rehabilitated to be suitable for nesting where appropriate.

Species-level Recovery Actions

- S1. Continue standardized surveys of nesting beaches. Nesting surveys are undertaken on the majority of nesting beaches. In the past, beach coverage varied from year to year, as did the frequency of surveys, experience and training of surveyors, and data reporting. Consequently, no determination of nesting population trends had been possible with any degree of certainty. However, in 1989, to better assess trends in nesting, DEP, in cooperation with FWS, initiated an Index Nesting Beach Survey (INBS) program to collect nesting data that can be used to statistically and scientifically analyze population trends. The INBS program should continue to gather a long-term data base on nesting activities in Florida that can be used as an index of nesting population trends.
- S2. Protect and manage populations on nesting beaches. Predators, poaching, tidal inundation, artificial lighting and human activities on nesting beaches diminish reproductive success. Monitoring of nesting activity is necessary to implement and evaluate appropriate nest protection measures and determine trends in the nesting population.
 - S2.1. Evaluate nest success and implement appropriate nest protection measures. Nesting and hatching success and hatchling emerging success on beaches occurring on State or Federal lands and all other important local or regional nesting beaches should be evaluated. Appropriate nest protection measures should be implemented by FWS and DEP, and appropriate local governments or organizations, to ensure greater than 60 percent hatch rate. Until recovery is ensured, however, projects on all Federal and State lands and key nesting beaches, such as those in Brevard, Indian River, St. Lucie, Martin, and Palm Beach counties, should strive for a higher rate of hatching success. In all cases, the least manipulative method should be employed to avoid interfering with known or unknown natural biological processes. Artificial incubation should be avoided. Where beach hatcheries are necessary, they should be located and constructed to allow self release, and hatch rates approaching 90 percent should be attained. Nest protection measures should always enable hatchling release the same night of hatching.

- S2.2. Determine influence of factors such as tidal inundation and foot traffic on hatching success. Tidal inundation can diminish hatching success, depending on frequency, duration, and developmental stage of embryos. Some nests are relocated due to the perceived threat from tides. The extent to which eggs can tolerate tidal inundation needs to be quantified to enable development of guidelines for nest relocation relative to tidal threats. The effect of foot traffic on hatching success is unknown, although many beaches with significant nesting also have high public use. FWS should support research and, in conjunction with DEP, develop recommendations for nest protection from tidal threat and foot traffic.
- S2.3. Reduce effects of artificial lighting on hatchlings and nesting females. Studies have shown that light pollution can deter female sea turtles from coming onto the beach to nest; in fact, brightly lit beaches have been determined to be used less frequently for nesting. Also, females attempting to return to sea after nesting can be disoriented by beach lighting and have difficulties making it back to the ocean. In some cases, nesting females have ended up on coastal highways and been struck by vehicles. Artificial beach lighting is even more detrimental to hatchling sea turtles, which emerge from nests at night. Under natural conditions, hatchlings move toward the brightest, most open horizon, which is over the ocean. However, when bright light sources are present on the beach, they become the brightest spot on the horizon and attract hatchlings in the wrong direction, making them more vulnerable to predators, desiccation, exhaustion, and vehicles.
- S2.3.1. Implement and enforce lighting ordinances and resolve lighting problems in areas where lighting ordinances have not been adopted. FWS and DEP should identify and resolve artificial lighting impacts to sea turtles in South Florida. Since 1987, hatchling disorientation incidents observed by DEP marine turtle permit holders and park personnel have been reported through standardized reporting forms. Report forms serve as documentation for lighting problems on nesting beaches and allow the identification of specific problem light sources. FWS and DEP should use these report forms to locate and resolve lighting problems, with the help of local governments, through public education efforts, and by directly contacting the owners of the problem lights and making recommendations for their modification. FWS and DEP should also probatively conduct pre-season lighting inspections to identify and make recommendations for correcting problem light sources before they result in disorientation events.

Where lighting ordinances have been adopted and enforced, hatchling disorientation and disorientation have been drastically reduced. All coastal counties and communities with nesting beaches should adopt ordinances

(March through October on the Atlantic Coast and May through October on the Gulf Coast). Many incorporated communities within Broward and Palm Beach counties, Florida, are particularly problematic because of the high-density nesting beaches and the lack of effective lighting regulations. DEP should ensure appropriate lighting on new construction projects and ensure follow-up surveys to assess continued compliance with lighting plans.

- S2.3.2. Evaluate extent of hatchling disorientation and disorientation on all important nesting beaches. FWS, DEP, and counties should continue to evaluate hatchling disorientation and disorientation problems on all important nesting beaches. Many lighting ordinance requirements do not become effective until 11 p.m., whereas over 30 percent of hatchling emergence occurs prior to this time (Witherington et al. 1990). FWS, DEP, and county governments should also support research to gather additional quantitative data on hatchling emergence times and nesting times on representative beaches throughout South Florida to support the most effective time requirements for lighting ordinances.
- S2.3.3. Prosecute individuals or entities responsible for hatchling disorientation and disorientation under the Endangered Species Act or appropriate State laws. Hatchling disorientation and disorientation from artificial lights can cause high mortality and be the major source of hatchling mortality on some nesting beaches if not controlled. Law enforcement efforts should be focused where lighting ordinances are not being implemented or enforced on major nesting beaches and where repeated violations are not corrected.
- S2.4. Ensure beach nourishment and coastal construction activities are planned to avoid disruption of nesting and hatching activities. These activities can cause significant disruption of nesting activities during the nesting season when viewed cumulatively over the nesting range. Nest relocation can involve manipulation of large numbers of nests, which can result in lowered hatch success and altered hatchling sex ratios, and therefore is not an acceptable alternative to altering the timing of projects during the peak nesting period. COE, FWS, and DEP should ensure beach nourishment and other beach construction activities are not permitted during the nesting season on important nesting beaches.
- S2.5. Ensure law enforcement activities eliminate poaching and harassment. Poaching, while not a significant cause of nest loss regionally, is occasionally a local problem. Poaching has been repeatedly reported around the Ten Thousand Islands NWR and adjacent islands in southwest Florida. In addition, intentional and unintentional disturbance and harassment of nesting turtles is an increasing

problem on many beaches. FWS should work closely with DEP to identify problem areas and focus intensive law enforcement efforts to eliminate poaching and deter harassment of nesting turtles.

S3. Continue to gather information on species and population biology.

- S3.1. Determine etiology of fibropapillomatosis. Research on the fibropapilloma disease should be continued and expanded. Fibropapillomatosis (FP) is a disease of sea turtles characterized by the development of multiple tumors on the skin and also internal organs, most frequently the lungs and kidneys. The tumors interfere with swimming, eating, breathing, seeing, and reproduction, and turtles with heavy tumor burdens become severely debilitated and die. FP has seriously impacted green sea turtle populations in Florida (about 50 percent of juvenile green turtles in Indian River Lagoon and Florida Bay have fibropapillomas) and is now emerging as a significant threat to the loggerhead as well. FP is a transmissible disease caused by a virus, and, while both a unique herpesvirus and retroviruses have been identified in FP tumors, neither has yet been proven to be the cause of the disease. Researchers are concerned that there may be environmental (contaminant) cofactors for this disease in nearshore areas. Continuation and expansion of research on the disease is essential to developing an approach to remedying the problem.
- S3.2. Maintain the Sea Turtle Stranding and Salvage Network. Most accessible United States beaches in the Atlantic and Gulf of Mexico are surveyed for stranded sea turtles by volunteer or contract personnel. Through the Sea Turtle Stranding and Salvage Network, stranding data are archived and summarized by the NMFS Miami Laboratory. These data provide an index of sea turtle mortality and are thought to be a cost-effective means of evaluating the effectiveness of the (Turtle Exclusion Device) TED regulations. These data also provide basic biological information on sea turtles and are useful in determining other sources of mortality. The systematic stranding surveys of index areas need to be continued in South Florida. Periodic review of the efficacy of surveys should also be conducted.
- S3.3. Centralize administration and coordination of tagging programs. Sea turtle researchers commonly tag turtles encountered during their research projects, and usually maintain independent tagging data bases. The lack of centralization for administering these tagging data bases often results in confusion when tagged turtles are recaptured, and delays in reporting of recaptures to the person originally tagging the turtle. NMFS and FWS should investigate the possibilities of establishing a centralized tagging data base, including Passive Integrated Transponder (PIT) tags.

- S3.3.1. Centralize tag series records. A centralized tag series data base is needed to ensure that recaptured tagged turtles can be promptly reported to persons who initially tagged the animal. The tag series data base would include listings of all tag series that have been placed on sea turtles in the wild, including the name and address of the researcher. This would eliminate problems in determining which researcher is using which tag series or types of tags, and would preclude unnecessary delays in reporting of tag returns. NMFS and/or FWS should establish and maintain this data base.
- S3.3.2. Centralize turtle tagging records. In addition to the need for a centralization of tag series records, there are advantages in developing a centralized turtle tagging data base. Such a data base would allow all turtle researchers to trace unfamiliar tag series or types to their source, and also to have immediate access to important biological information collected at the time of original capture. The major disadvantage is that this data base would require frequent editing and updating, and would be costly and somewhat time consuming to maintain. It would also make it possible for unethical researchers to exploit the work of others, while providing no guarantees that such contributions would be acknowledged. NMFS and FWS should determine whether such a data base can be established and is feasible to maintain.
- S3.4. Develop requirements for care and maintenance of turtles in captivity, including diet, water quality, tank size, and treatment of injury and disease. Sea turtles are maintained in captivity for rehabilitation, research, or educational display. Proper care will ensure the maximum number of rehabilitated turtles can be returned to the wild and a minimum number removed from the wild for research or education purposes. None of these requirements has been scientifically evaluated to determine the best possible captive conditions for sea turtles. FWS and NMFS should support the necessary research to develop these criteria, particularly relating to diet and the treatment of injury and disease. These criteria should be published and required for any permit to hold sea turtles in captivity. FWS, NMFS and/or DEP should inspect permitted facilities at least annually for compliance with permit requirements.
- S4. Monitor trends in nesting activity. DEP and FWS should continue to refine standardized nest survey criteria, identify additional index survey beaches to be monitored, and continue to conduct training workshops for surveyors. Consequently, DEP and FWS should ensure that routine monitoring of nesting beaches is done on at least a weekly basis during the time that green turtles are nesting, including the timeframes of any nesting that occurs outside of the regular survey period.

- S5. Continue information and education activities. Sea turtle conservation requires long-term public support over a large geographic area. The public must be factually informed of the issues, particularly when conservation measures conflict with human activities, such as commercial fisheries, beach development, and public use of nesting beaches. Public education is the foundation upon which a long-term conservation program will succeed or fail.
- S5.1. Update existing slide programs and information leaflets on sea turtle conservation for the general public. FWS has developed a bi-lingual slide tape program on sea turtle conservation and should keep the program current and available for all public institutions and conservation organizations. FWS and DEP should continually update and supply the public with informational brochures on sea turtle ecology and conservation needs.
- S5.2. Disseminate information from brochures and reports on recommended lighting modifications or measures to reduce hatchling disorientation and disorientation. Recently published literature contains information on the types of light, screening or shading that is best for turtles (*e.g.*, Witherington and Martin 1996).
- S5.3. Develop public service announcements (PSA) regarding the sea turtle artificial lighting conflict, and disturbance of nesting activities by public nighttime beach activities. A professionally produced public service announcement for radio and TV would provide tremendous support and reinforcement of the many coastal lighting ordinances. It would generate greater support through understanding. FWS and DEP should develop a high quality PSA that could be used throughout the Southeast during the nesting season.
- S5.4. Ensure facilities permitted to hold and display captive sea turtles have appropriate informational displays. Over 50 facilities are permitted to hold sea turtles for rehabilitation, research, and public education. Many are on public display and afford opportunities for public education. Display of accurate information on the basic biology and conservation problems of sea turtles should be a requirement of all permittees. All facilities should be visited by FWS, NMFS and/or DEP to ensure captive sea turtles are being displayed in a way to meet these criteria.
- S5.5. Post informational signs at public access points on nesting beaches. Public access points to nesting beaches provide excellent opportunities to inform the public of necessary precautions for compatible public use on the nesting beach and to develop public support through informational and educational signs. FWS, NPS, DEP and other appropriate organizations should post such educational and informational signs on nesting beaches as appropriate.

Habitat-level Recovery Actions

H1. Protect and manage nesting habitat. Coastal development has already destroyed or degraded many miles of nesting habitat in South Florida. Although sea turtle nesting occurs on over 2,240 km of beaches within the southeast United States, development pressures are so great that cumulative impacts could result in increased degradation or destruction of nesting habitat and eventually lead to a significant population decline if not properly managed.

H1.1. Ensure beach nourishment projects are compatible with maintaining good quality nesting habitat. Beach nourishment can improve nesting habitat in areas of severe erosion and is a preferred alternative to beach armoring. However, placement of sand on an eroded section of beach or an existing beach in and of itself may not provide suitable nesting habitat for sea turtles. Although beach nourishment may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during construction.

H1.1.1. Evaluate sand transfer systems as an alternative to beach nourishment. Sand transfer systems can diminish the necessity for frequent beach renourishment and thereby reduce disruption of nesting activities and eliminate sand compaction. The construction and operation of these systems must be carefully evaluated to ensure important nearshore habitats are not degraded or sea turtles injured or destroyed.

H1.1.2. Refine a sand budget formulation methodology for Sebastian Inlet. Inlets interrupt the natural flow of longshore sediment transport along the shoreline. The interrupted flow of sand is diverted either offshore in ebb tide shoals, into bays or lagoons in flood tide shoals, or in navigation channels (National Research Council 1990). As a result, erosion occurs downdrift of the interrupted shoreline. There are six man-made inlets on the Atlantic coast from Indian River County to Broward County. In Indian River County, for example, erosion has been nearly 2 m per year at Sebastian Inlet SRA (just south of Sebastian Inlet), when the average erosion rate for the county is just under .3 m per year (J. Tabar, Indian River County, personal communication 1996). DEP, Sebastian Inlet Tax District, and Indian River County should conduct engineering studies to refine a sand budget formulation methodology for the Sebastian Inlet. Other needs include: annually bypassing sand to downdrift beaches, conducting further studies of the long-term effects of the flood shoal on the inlet-related sediment budget, identifying the long-term impacts of sand impoundments and sediment volume deficit to downdrift areas, and determining the area of inlet influence.

H1.2. Prevent degradation of nesting habitat from seawalls, revetments, sand bags, sand fences, or other erosion control measures. One of the most difficult habitat protection efforts throughout South Florida is trying to minimize or eliminate the construction of seawalls, riprap, groins, sandbags, and improperly placed drift or sand fences. In 1995, the Florida Legislature passed a law giving coastal counties and municipalities the authority to approve construction of coastal armoring during certain emergency situations. (All non-emergency armoring situations must still receive a DEP permit prior to construction.) Although the new law weakened prior regulations on armoring, it does require that emergency armoring structures approved by a coastal county or municipality be temporary and that the structure be removed, or a permit application submitted to DEP for a permanent rigid coastal structure, within 60 days after the emergency installation of the structure. In addition, to implement this new law, DEP finalized a formal agency rule on coastal armoring on September 12, 1996.

H1.2.1. Ensure laws regulating coastal construction and beach armoring are enforced. The 1996 DEP rule recommends that local governments obtain an incidental take permit from FWS under section 10 of the Endangered Species Act and develop a sea turtle habitat conservation plan prior to authorizing armoring projects. The new rule also requires that several measures be undertaken to address sea turtle concerns for non-emergency armoring and for placement of permanent rigid coastal structures subsequent to an emergency (temporary) armoring event. For example, the new regulations require that (1) special conditions be placed on permitted activities to limit the nature, timing, and sequence of construction, as well as address lighting concerns; (2) structures not be used where the construction would result in a significant adverse impact; and (3) armoring be removed if it is determined to not be effective or to be causing a significant adverse impact to the beach and dune system.

H1.2.2. Ensure failed erosion control structures are removed. Failed erosion control structures such as uncovered plastic bags or tubes and fragmented concrete or wooden structures degrade nesting habitat and deter nesting activities. DEP should ensure failed structures are removed from nesting beaches.

H1.2.3. Develop standard requirements for sand fence construction. Sand fences can effectively build dune systems and improve nesting habitat; however, improperly designed sand fences can trap nesting females or hatchlings and prevent access to suitable nesting habitat. DEP and FWS should develop and evaluate sand fencing designs and establish standard requirements for sand fence construction.

- H1.3. Identify important nesting beaches experiencing greater than 40 percent nest loss from erosion and implement appropriate habitat restoration measures (without relocation). Some important nesting beaches now suffer severe erosion as a result of inlet maintenance or jetty construction. In some situations, limited safe locations for relocating nests place constraints on nest relocation programs. Nest relocation programs should be considered as a short-term measure at best to protect nests in these situations, with primary efforts directed toward habitat restoration. DEP and FWS should review all important nesting beaches and identify those with 40 percent or more nest loss due to erosion or tidal inundation. Habitat restoration plans should be developed and implemented for identified nesting beaches.
- H1.4. Acquire or otherwise ensure the long-term protection of important nesting beaches. Acquisition of important sea turtle nesting beaches would ensure long-term protection of U.S. nesting habitat. Acquisition and protection of undisturbed nesting habitat would enhance sea turtle nesting and hatching success.
- H1.4.1. Continue to acquire in fee title all undeveloped beaches between Melbourne Beach and Wabasso Beach, Florida, for the Archie Carr National Wildlife Refuge. The Archie Carr NWR was designated by Congress in 1989 in recognition of the need for long stretches of quiet, undisturbed sandy beaches, with little or no artificial lighting, to ensure the reproductive success and survival of sea turtles. The refuge is located within a 33-km stretch of beach on the barrier islands of Brevard and Indian River counties on the Atlantic coast of Florida. Approximately 30 to 35 percent of all green sea turtle nesting in the U.S. occurs along this stretch of beach. The proposed acquisition plan for the refuge set a goal for purchase of 15 km within four sections of this 33-km stretch. Three of the sections are located in Brevard County and one in Indian River County. Partners in the land acquisition effort for the refuge and adjacent buffer areas on the barrier island include FWS, DEP, Brevard County, Indian River County, Richard King Mellon Foundation, The Conservation Fund, and The Nature Conservancy. To date, contributions from the State of Florida and local county partnerships account for over 70 percent of land acquisition expenditures, while contributions from the Richard King Mellon Foundation account for over 21 percent of acquisition costs for lands on the barrier island. Federal acquisition efforts account for about 8 percent of purchases to date.

About 61 percent of the available beachfront acquisitions for the Refuge have been completed. Of the original 15 km of beachfront identified for acquisition, approximately 8 km have been acquired and 5 km are awaiting purchase. The remaining lands have been purchased for private

development and are no longer available. Escalating coastal development in Brevard and Indian River counties threatens the remaining parcels identified for acquisition. Ongoing development continues to fragment the remaining habitat and could result in increased lighting and beach armoring, which negatively impact sea turtles. A narrow window of opportunity is left to acquire the last remaining lands required for the refuge.

H1.4.2. Evaluate the status of the high-density nesting beaches on Hutchinson Island, Florida, and develop a plan to ensure its long-term protection. Approximately 10 percent of green sea turtle nesting in the United States occurs along this 32 km beach. Development is degrading nesting habitat, and public use is causing significant disturbance to nesting activities. DEP and FWS should evaluate the threats and take appropriate measures, including acquisition, to ensure long-term protection.

H1.4.3. Evaluate status of other undeveloped beaches that provide important habitat for maintaining historic nesting distribution and develop a plan for long-term protection. DEP and FWS should evaluate other nesting beaches in the Southeast that contribute significantly to the historic nesting distribution to ensure long-term protection.

H2. Restore areas to suitable habitat.

H2.1. Reestablish dunes and native vegetation. Dune restoration and revegetation with native plants should be a required component of all renourishment projects. This will enhance beach stability and nesting habitat and may result in the need for less frequent renourishment activities.

H2.2. Remove exotic vegetation and prevent spread to nesting beaches. Australian pine trees shade nests and can alter natural hatchling sex ratios. Australian pines also aggressively replace native dune and beach vegetation through shading and chemical inhibition and consequently exacerbate erosion and loss of nesting habitat. Erosion can topple trees and leave exposed roots that can entrap nesting females. Removal of exotics, such as is ongoing at St. Lucie Inlet SP, Hobe Sound NWR, and Dry Tortugas NP, Florida, should continue. DEP, FWS, and NPS should identify other important nesting beaches where exotic vegetation is degrading nesting habitat and work with responsible parties to restore natural vegetation.

H3. Conduct research to evaluate the relationship of sand characteristics (including aragonite) and female nesting behavior, nesting success, hatching success, hatchling emerging

success, hatchling fitness, and sex ratios. Beach nourishment may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand. These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings. Gas diffusion of nests could be affected by sand grain shape, size, and compaction and variations may alter hatching success. Sand color and moisture influence nest incubation temperature and can affect hatchling sex determination. The effect of importing non-native materials, such as aragonite, to U.S. beaches for beach nourishment adds additional unknowns that could conceivably affect female nesting behavior, nesting success, hatching success, hatchling emerging success, hatchling fitness, and sex ratios and should be fully evaluated before large-scale use.

Studies of alternative sand sources for beach renourishment and their suitability for sea turtles are needed. After years of beach renourishment, Miami-Dade County is running out of suitable sand material for future renourishment projects. Broward and Palm Beach counties will also be running out of sand sources in the near future. COE is exploring the potential use of sand from upland sand sources and the importation of sand from the Bahamas and the Turks and Caicos Islands. Concerns have been raised about the long-term consequences to nesting and incubating sea turtles using these alternative beach renourishing materials. In order to adequately address these concerns in section 7 consultations, studies must be conducted on the suitability of these materials prior to receiving a proposal for large-scale nourishment of Florida beaches with these alternative sand sources.

Recovery for the Hawksbill Sea Turtle, *Eretmochelys imbricata*

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: SUPPORT delisting actions.

Recovery Criteria: The South Florida recovery contribution parallels the existing recovery plans for the sea turtles. South Florida's objective for the loggerhead, green, leatherback, and hawksbill sea turtle, will be achieved when: the level of nesting for each species is continuously monitored and increases to the species-specific recovery goal; beaches supporting greater than 50 percent of the nesting activity are in public ownership; all important nesting beaches are protected and appropriately managed to prevent further degradation; non-native nuisance species have been controlled or eliminated on public lands; at least 60 percent hatch success is documented on major nesting beaches; effective lighting ordinances or lighting plans are implemented; and beaches are restored or rehabilitated to be suitable for nesting where appropriate.

Species-level Recovery Actions

- S1. Continue standardized surveys of nesting beaches. Nesting surveys are undertaken on the majority of nesting beaches. In the past, beach coverage varied from year to year, as did the frequency of surveys, experience and training of surveyors and data reporting. Consequently, no determination of nesting population trends had been possible with any degree of certainty. However, in 1989, to better assess trends in nesting, DEP, in cooperation with FWS, initiated an Index Nesting Beach Survey (INBS) program to collect nesting data that can be used to statistically and scientifically analyze population trends. The INBS program should continue to gather a long-term data base on nesting activities in Florida that can be used as an index of nesting population trends.
- S2. Protect and manage populations on nesting beaches. Predators, poaching, tidal inundation, artificial lighting, and human activities on nesting beaches diminish reproductive success. Monitoring of nesting activity is necessary to implement and evaluate appropriate nest protection measures and determine trends in the nesting population.
- S2.1. Evaluate nest success and implement appropriate nest protection measures. Nesting and hatching success and hatchling emerging success on beaches occurring on State or Federal lands and all other important local or regional nesting beaches should be evaluated. Appropriate nest protection measures should be implemented by FWS and DEP, and appropriate local governments or organizations, to ensure greater than 60 percent hatch rate. Until recovery is ensured, however, projects on all Federal and State lands and key nesting beaches, such as those in Brevard, Indian River, St. Lucie, Martin, and Palm Beach counties, should strive for a higher rate of hatching success. In all cases, the least manipulative method should be employed to avoid interfering with known or unknown natural biological processes. Artificial incubation should be avoided. Where beach hatcheries are necessary, they should be located and constructed to allow self release, and hatch rates approaching 90 percent should be attained. Nest protection measures should always enable hatchling release the same night of hatching.
- S2.2. Determine influence of factors such as tidal inundation and foot traffic on hatching success. Tidal inundation can diminish hatching success, depending on frequency, duration, and developmental stage of embryos. Some nests are relocated due to the perceived threat from tides. The extent to which eggs can tolerate tidal inundation needs to be quantified to enable development of guidelines for nest relocation relative to tidal threats. The effect of foot traffic on hatching success is unknown, although many beaches with significant nesting also have high public use. FWS should support research and, in conjunction with DEP, develop recommendations for nest protection from tidal threat and foot traffic.
- S2.3. Reduce effects of artificial lighting on hatchlings and nesting females. Studies

have shown that light pollution can deter female sea turtles from coming onto the beach to nest; in fact, brightly lit beaches have been determined to be used less frequently for nesting. Also, females attempting to return to sea after nesting can be disoriented by beach lighting and have difficulties making it back to the ocean. In some cases, nesting females have ended up on coastal highways and been struck by vehicles. Artificial beach lighting is even more detrimental to hatchling sea turtles, which emerge from nests at night. Under natural conditions, hatchlings move toward the brightest, most open horizon, which is over the ocean. However, when bright light sources are present on the beach, they become the brightest spot on the horizon and attract hatchlings in the wrong direction, making them more vulnerable to predators, desiccation, exhaustion, and vehicles.

S2.3.1. Implement and enforce lighting ordinances and resolve lighting problems in areas where lighting ordinances have not been adopted. FWS and DEP should identify and resolve artificial lighting impacts to sea turtles in South Florida. Since 1987, hatchling disorientation incidents observed by DEP marine turtle permit holders and park personnel have been reported through standardized reporting forms. Report forms serve as documentation for lighting problems on nesting beaches and allow the identification of specific problem light sources. FWS and DEP should use these report forms to locate and resolve lighting problems, with the help of local governments, through public education efforts, and by directly contacting the owners of the problem lights and making recommendations for their modification. FWS and DEP should also probatively conduct pre-season lighting inspections to identify and make recommendations for correcting problem light sources before they result in disorientation events.

Where lighting ordinances have been adopted and enforced, hatchling disorientation and disorientation have been drastically reduced. All coastal counties and communities with nesting beaches should adopt ordinances (March through October on the Atlantic Coast and May through October on the Gulf Coast). Many incorporated communities within Broward and Palm Beach counties, Florida, are particularly problematic because of the high-density nesting beaches and the lack of effective lighting regulations. DEP should ensure appropriate lighting on new construction projects.

S2.3.2. Evaluate extent of hatchling disorientation and disorientation on all important nesting beaches. FWS, DEP, and counties should continue to evaluate hatchling disorientation and disorientation problems on all important nesting beaches. Many lighting ordinance requirements do not become effective until 11 p.m., whereas over 30 percent of hatchling

emergence occurs prior to this time (Witherington et al. 1990). FWS, DEP, and county governments should also support research to gather additional quantitative data on hatchling emergence times and nesting times on representative beaches throughout South Florida to support the most effective time requirements for lighting ordinances.

- S2.3.3. Prosecute individuals or entities responsible for hatchling disorientation and disorientation under the Endangered Species Act or appropriate State laws. Hatchling disorientation and disorientation from artificial lights can cause high mortality and be the major source of hatchling mortality on some nesting beaches if not controlled. Law enforcement efforts should be focused where lighting ordinances are not being implemented or enforced on major nesting beaches and where repeated violations are not corrected.
- S2.4. Ensure beach nourishment and coastal construction activities are planned to avoid disruption of nesting and hatching activities. These activities can cause significant disruption of nesting activities during the nesting season when viewed cumulatively over the nesting range. Nest relocation can involve manipulation of large numbers of nests, which can result in lowered hatch success and altered hatchling sex ratios, and therefore is not an acceptable alternative to altering the timing of projects during the peak nesting period. COE, FWS, and DEP should ensure beach nourishment and other beach construction activities are not permitted during the nesting season on important nesting beaches.
- S2.5. Ensure law enforcement activities eliminate poaching and harassment. Poaching, while not a significant cause of nest loss regionally, is occasionally a local problem. Poaching has been repeatedly reported around the Ten Thousand Islands NWR and adjacent islands in southwest Florida. In addition, intentional and unintentional disturbance and harassment of nesting turtles is an increasing problem on many beaches. FWS should work closely with DEP to identify problem areas and focus intensive law enforcement efforts to eliminate poaching and deter harassment of nesting turtles.
- S3. Continue to gather information on species and population biology.
 - S3.1. Determine etiology of fibropapillomatosis. Research on the hawksbill sea turtle fibropapilloma disease should be continued and expanded. Fibropapillomatosis (FP) is a disease of sea turtles characterized by the development of multiple tumors on the skin and also internal organs, most frequently the lungs and kidneys. The tumors interfere with swimming, eating, breathing, seeing, and reproduction, and turtles with heavy tumor burdens become severely debilitated and die. FP has seriously impacted green turtle populations in Florida (about 50 percent of juvenile

green turtles in Indian River Lagoon and Florida Bay have fibropapillomas) and is now emerging as a significant threat to the loggerhead as well. FP is a transmissible disease caused by a virus, and, while both a unique herpesvirus and retroviruses have been identified in FP tumors, neither has yet been proven to be the cause of the disease. Researchers are concerned that there may be environmental (contaminant) cofactors for this disease in nearshore areas. Continuation and expansion of research on the disease is essential to developing an approach to remedying the problem.

- S3.2. Maintain the Sea Turtle Stranding and Salvage Network. Most accessible U. S. beaches in the Atlantic and Gulf of Mexico are surveyed for stranded sea turtles by volunteer or contract personnel. Through the Sea Turtle Stranding and Salvage Network, stranding data are archived and summarized by the individual states and the NMFS Miami Laboratory. These data provide an index of sea turtle mortality, and are thought to be a cost-effective means of evaluating the effectiveness of the TED regulations. These data also provide basic biological information on sea turtles and are useful in determining other sources of mortality. The systematic stranding surveys of index areas need to be continued in South Florida. Periodic review of the efficacy of surveys should also be conducted.
- S3.3. Centralize administration and coordination of tagging programs. Sea turtle researchers commonly tag turtles encountered during their research projects and usually maintain independent tagging data bases. The lack of centralization for administering these tagging data bases often results in confusion when tagged turtles are recaptured, and delays in reporting of recaptures to the person originally tagging the turtle. NMFS and FWS should investigate the possibilities of establishing a centralized tagging data base, including PIT tags.
- S3.3.1. Centralize tag series records. A centralized tag series data base is needed to ensure that recaptured tagged turtles can be promptly reported to persons who initially tagged the animal. The tag series data base would include listings of all tag series that have been placed on sea turtles in the wild, including the name and address of the researcher. This would eliminate problems in determining which researcher is using which tag series or types of tags, and would preclude unnecessary delays in reporting of tag returns. NMFS and/or FWS should establish and maintain this data base.
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to have immediate access to important biological information collected at the time of original capture. The major disadvantage is that this data base would require frequent editing and updating, and would be costly and somewhat time consuming to maintain. It would also make it possible for unethical researchers to exploit the work of others, while providing no guarantees that such contributions would be acknowledged. NMFS and FWS should determine whether such a data base can be established and is feasible to maintain.

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- S4. Monitor trends in nesting activity. DEP and FWS should continue to refine standardized nest survey criteria, identify additional index survey beaches to be monitored, and continue to conduct training workshops for surveyors. Surveys in Florida do not routinely cover the end of the hawksbill nesting season. Consequently, DEP and FWS should ensure that routine monitoring of nesting beaches is done on at least a weekly basis during the time period that hawksbill turtles nest, including any period of nesting that occurred outside of the regular survey period.
- S5. Continue information and education activities. Sea turtle conservation requires long-term public support over a large geographic area. The public must be factually informed of the issues, particularly when conservation measures conflict with human activities, such as commercial fisheries, beach development, and public use of nesting beaches. Public education is the foundation upon which a long-term conservation program will succeed or fail.
- S5.1. Update existing slide programs and information leaflets on sea turtle conservation for the general public. FWS has developed a bilingual slide tape program on sea turtle conservation and should keep the program current and available for all public institutions and conservation organizations. FWS and DEP should continually update and supply the public with informational brochures on sea turtle

ecology and conservation needs.

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Habitat-level Recovery Actions

- H1. Protect and manage nesting habitat. Coastal development has already destroyed or degraded many miles of nesting habitat in South Florida. Although sea turtle nesting occurs on over 2,240 km of beaches within the southeast United States, development pressures are so great that cumulative impacts could result in increased degradation or destruction of nesting habitat and eventually lead to a significant population decline if not properly managed.
 - H1.1. Ensure beach nourishment projects are compatible with maintaining good quality nesting habitat. Beach nourishment can improve nesting habitat in areas of severe erosion and is a preferred alternative to beach armoring. However, placement of sand on an eroded section of beach or an existing beach in and of itself may not

provide suitable nesting habitat for sea turtles. Although beach nourishment may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during construction.

H1.1.2. Evaluate sand transfer systems as an alternative to beach nourishment.

Sand transfer systems can diminish the necessity for frequent beach renourishment and thereby reduce disruption of nesting activities and eliminate sand compaction. The construction and operation of these systems must be carefully evaluated to ensure important nearshore habitats are not degraded or sea turtles injured or destroyed.

H1.1.3. Refine a sand budget formulation methodology for Sebastian Inlet. Inlets interrupt the natural flow of longshore sediment transport along the shoreline. The interrupted flow of sand is diverted either offshore in ebb tide shoals, into bays or lagoons in flood tide shoals, or in navigation channels (National Research Council 1990). As a result, erosion occurs downdrift of the interrupted shoreline. There are six man-made inlets on the Atlantic coast from Indian River County to Broward County. In Indian River County, for example, erosion has been nearly 2 m per year at Sebastian Inlet SRA (just south of Sebastian Inlet), when the average erosion rate for the county is just under .3 m per year (J. Tabar, Indian River County, personal communication 1996). DEP, Sebastian Inlet Tax District, and Indian River County should conduct engineering studies to refine a sand budget formulation methodology for the Sebastian Inlet. Other needs include: annually bypassing sand to downdrift beaches, conducting further studies of the long-term effects of the flood shoal on the inlet-related sediment budget, identifying the long-term impacts of impoundment of sand and sediment volume deficit to downdrift areas, and determining the area of inlet influence.

H1.2. Prevent degradation of nesting habitat from seawalls, revetments, sand bags, sand fences, or other erosion control measures. One of the most difficult habitat protection efforts throughout South Florida is trying to minimize or eliminate the construction of seawalls, riprap, groins, sandbags, and improperly placed drift or sand fences. In 1995, the Florida Legislature passed a law giving coastal counties and municipalities the authority to approve construction of coastal armoring during certain emergency situations. (All non-emergency armoring situations must still receive an DEP permit prior to construction.) Although the new law weakened prior regulations on armoring, it does require that emergency armoring structures approved by a coastal county or municipality be temporary and that the structure be removed, or a permit application submitted to DEP for a permanent rigid coastal structure, within 60 days after the emergency installation of the structure.

In addition, to implement this new law, DEP finalized a formal agency rule on coastal armoring on September 12, 1996.

- H1.2.1. Ensure laws regulating coastal construction and beach armoring are enforced. The 1996 DEP rule recommends that local governments obtain an incidental take permit from FWS under section 10 of the Endangered Species Act and develop a sea turtle habitat conservation plan prior to authorizing armoring projects. The new rule also requires that several measures be undertaken to address sea turtle concerns for non-emergency armoring and for placement of permanent rigid coastal structures subsequent to an emergency (temporary) armoring event. For example, the new regulations require that (1) special conditions be placed on permitted activities to limit the nature, timing, and sequence of construction, as well as address lighting concerns; (2) structures not be used where the construction would result in a significant adverse impact; and (3) armoring be removed if it is determined to not be effective or to be causing a significant adverse impact to the beach and dune system.
- H1.2.2. Ensure failed erosion control structures are removed. Failed erosion control structures such as uncovered plastic bags or tubes and fragmented concrete or wooden structures degrade nesting habitat and deter nesting activities. DEP should ensure failed structures are removed from nesting beaches.
- H1.2.3. Develop standard requirements for sand fence construction. Sand fences can effectively build dune systems and improve nesting habitat; however, improperly designed sand fences can trap nesting females or hatchlings and prevent access to suitable nesting habitat. DEP and FWS should develop and evaluate sand fencing designs and establish standard requirements for sand fence construction.
- H1.3. Identify important nesting beaches experiencing greater than 40 percent nest loss from erosion and implement appropriate habitat restoration measures (without relocation). Some important nesting beaches now suffer severe erosion as a result of inlet maintenance or jetty construction. In some situations, limited safe locations for relocating nests place constraints on nest relocation programs. Nest relocation programs should be considered as a short-term measure, at best, to protect nests in these situations, with primary efforts directed toward habitat restoration. DEP and FWS should review all important nesting beaches and identify those with 40 percent or more nest loss due to erosion or tidal inundation. Habitat restoration plans should be developed and implemented for identified nesting beaches.

H1.4. Acquire or otherwise ensure the long-term protection of important nesting beaches. Acquisition of important sea turtle nesting beaches would ensure long-term protection of nesting habitat for sea turtles nesting in the United States. Acquisition and protection of undisturbed nesting habitat would enhance sea turtle nesting and hatching success.

H1.4.1. Continue to acquire in fee title all undeveloped beaches between Melbourne Beach and Wabasso Beach, Florida, for the Archie Carr National Wildlife Refuge. The Archie Carr NWR was designated by Congress in 1989 in recognition of the need for long stretches of quiet, undisturbed sandy beaches, with little or no artificial lighting, to ensure the reproductive success and survival of sea turtles. The refuge is located within a 33-km stretch of beach on the barrier islands of Brevard and Indian River counties on the Atlantic coast of Florida. The proposed acquisition plan for the refuge set a goal for purchase of 15 km within four sections of this 33-km stretch. Three of the sections are located in Brevard County and one in Indian River County.

Partners in the land acquisition effort for the refuge and adjacent buffer areas on the barrier island include FWS, DEP, Brevard County, Indian River County, Richard King Mellon Foundation, The Conservation Fund, and The Nature Conservancy. To date, contributions from the State of Florida and local county partnerships account for over 70 percent of land acquisition expenditures, while contributions from the Richard King Mellon Foundation account for over 21 percent of acquisition costs for lands on the barrier island. Federal acquisition efforts account for about 8 percent of purchases to date.

About 61 percent of the available beachfront acquisitions for the Refuge have been completed. Of the original 15 km of beachfront identified for acquisition, approximately 8 km have been acquired and 5 km are awaiting purchase. The remaining lands have been purchased for private development and are no longer available. Escalating coastal development in Brevard and Indian River counties threatens the remaining parcels identified for acquisition. Ongoing development continues to fragment the remaining habitat and could result in increased lighting and beach armoring, which negatively impact sea turtles. A narrow window of opportunity is left to acquire the last remaining lands required for the refuge.

H1.4.2. Evaluate status of other undeveloped beaches that provide important habitat for maintaining the historic nesting distribution and develop a plan

for long-term protection. DEP and FWS should evaluate other nesting beaches in the Southeast that contribute significantly to the historic nesting distribution to ensure long-term protection.

H2. Restore areas to suitable habitat.

H2.1. Reestablish dunes and native vegetation. Dune restoration and revegetation with native plants should be a required component of all renourishment projects. This will enhance beach stability and nesting habitat and may result in the need for less frequent renourishment activities.

H2.2. Remove exotic vegetation and prevent spread to nesting beaches. Australian pine trees shade nests and can alter natural hatchling sex ratios. Australian pines also aggressively replace native dune and beach vegetation through shading and chemical inhibition and consequently exacerbate erosion and loss of nesting habitat. Erosion can topple trees and leave exposed roots that can entrap nesting females. Removal of exotics, such as is ongoing at St. Lucie Inlet SP, Hobe Sound NWR, and Dry Tortugas NP, Florida, should continue. DEP, FWS, and NPS should identify other important nesting beaches where exotic vegetation is degrading nesting habitat and work with responsible parties to restore natural vegetation.

H3. Conduct research to evaluate the relationship of sand characteristics (including aragonite) and female nesting behavior, nesting success, hatching success, hatchling emerging success, hatchling fitness, and sex ratios. Beach nourishment may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand. These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings. Gas diffusion of nests could be affected by sand grain shape, size, and compaction and variations could alter hatching success. Sand color and moisture influence nest incubation temperature and can affect hatchling sex determination. The effect of importing non-native materials, such as aragonite, to U. S. beaches for beach nourishment adds additional unknowns that could conceivably affect female nesting behavior, nesting success, hatching success, hatchling emerging success, hatchling fitness, and sex ratios and should be fully evaluated before large-scale use.

Studies of alternative sand sources for beach renourishment and their suitability for sea turtles are needed. After years of beach renourishment, Miami-Dade County is running out of suitable sand material for future renourishment projects. Broward and Palm Beach counties will also be running out of sand sources in the near future. COE is exploring the potential use of sand from upland sand sources and the importation of sand from the

Bahamas and the Turks and Caicos Islands. Concerns have been raised about the long-term consequences to nesting sea turtles and incubating nests of renourishing beaches with these alternative materials. In order to adequately address these concerns in section 7 consultations, studies must be conducted on the suitability of these materials prior to receiving a proposal for large-scale nourishment of Florida beaches with these alternative sand sources.

Recovery for the Kemp's Ridley Sea Turtle, *Lepidochelys kempii*

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: SUPPORT delisting actions.

Recovery Criteria: The best scientific information available raises questions about whether the Kemp's ridley sea turtle utilizes nesting beaches within the coastal counties of South Florida. Unless new information demonstrates that this species occurs in South Florida, no recovery criteria will be developed or proposed as part of this recovery plan.

Species-level Recovery Actions

S1. Continue standardized surveys of nesting beaches to determine if Kemp's ridley sea turtles nest in South Florida. Nesting surveys are undertaken on the majority of nesting beaches. In the past, beach coverage varied from year to year, as did the frequency of surveys, experience and training of surveyors, and data reporting. Consequently, no determination of nesting population trends had been possible with any degree of certainty. However, in 1989, to better assess trends in nesting, DEP, in cooperation with FWS, initiated an Index Nesting Beach Survey (INBS) program to collect nesting data that can be used to statistically and scientifically analyze population trends. The INBS program should continue to gather a long-term data base on nesting activities in Florida that can be used as an index of nesting population trends.

Recovery for the Leatherback Sea Turtle, *Dermochelys coriacea*

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: SUPPORT delisting actions.

Recovery Criteria: The South Florida recovery contribution parallels the existing recovery plans for sea turtles. South Florida's objective for the loggerhead, green, leatherback and hawksbill sea turtles will be achieved when: the level of nesting for each species is continuously monitored and increases to the species-specific recovery goal; beaches supporting greater than 50 percent of the nesting activity are in public ownership; all important nesting beaches are protected and appropriately managed to prevent further degradation; non-native nuisance species have been controlled or eliminated on public lands; at least 60 percent hatch success is documented on major nesting beaches; effective lighting ordinances or lighting plans are

implemented; and beaches are restored or rehabilitated to be suitable for nesting where appropriate.

Species-level Recovery Actions

- S1. Continue standardized surveys of nesting beaches. Nesting surveys are undertaken on the majority of nesting beaches. In the past, beach coverage varied from year to year, as did the frequency of surveys, experience and training of surveyors, and data reporting. Consequently, no determination of nesting population trends had been possible with any degree of certainty. However, in 1989, to better assess trends in nesting, DEP, in cooperation with FWS, initiated an Index Nesting Beach Survey (INBS) program to collect nesting data that could be used to statistically and scientifically analyze population trends. The INBS program should continue to gather a long-term data base on nesting activities in Florida that can be used as an index of nesting population trends.
- S2. Protect and manage populations on nesting beaches. Predators, poaching, tidal inundation, artificial lighting, and human activities on nesting beaches diminish reproductive success. Monitoring of nesting activity is necessary to implement and evaluate appropriate nest protection measures and determine trends in the nesting population.
 - S2.1. Evaluate nest success and implement appropriate nest protection measures. Nesting and hatching success and hatchling emerging success on beaches occurring on State or Federal lands and all other important local or regional nesting beaches should be evaluated. Appropriate nest protection measures should be implemented by FWS and DEP, and appropriate local governments or organizations, to ensure greater than 60 percent hatch rate. Until recovery is ensured, however, projects on all Federal and State lands and key nesting beaches, such as those in Brevard, Indian River, St. Lucie, Martin, and Palm Beach counties, should strive for a higher rate of hatching success. In all cases, the least manipulative method should be employed to avoid interfering with known or unknown natural biological processes. Artificial incubation should be avoided. Where beach hatcheries are necessary, they should be located and constructed to allow self release, and hatch rates approaching 90 percent should be attained. Nest protection measures should always enable hatchling release the same night of hatching.
 - S2.2. Determine influence of factors such as tidal inundation and foot traffic on hatching success. Tidal inundation can diminish hatching success, depending on frequency, duration, and developmental stage of embryos. Some nests are relocated due to the perceived threat from tides. The extent to which eggs can tolerate tidal inundation needs to be quantified to enable development of guidelines for nest relocation relative to tidal threats. The effect of foot traffic on hatching success is unknown, although many beaches with significant nesting also have high public use. FWS

should support research and, in conjunction with DEP, develop recommendations for nest protection from tidal threat and foot traffic.

- S2.3. Reduce effects of artificial lighting on hatchlings and nesting females. Studies have shown that light pollution can deter female sea turtles from coming onto the beach to nest; in fact, brightly lit beaches have been determined to be used less frequently for nesting. Also, females attempting to return to sea after nesting can be disoriented by beach lighting and have difficulties making it back to the ocean. In some cases, nesting females have ended up on coastal highways and been struck by vehicles. Artificial beach lighting is even more detrimental to hatchling sea turtles, which emerge from nests at night. Under natural conditions, hatchlings move toward the brightest, most open horizon, which is over the ocean. However, when bright light sources are present on the beach, they become the brightest spot on the horizon and attract hatchlings in the wrong direction, making them more vulnerable to predators, desiccation, exhaustion, and vehicles.

- S2.3.1. Implement and enforce lighting ordinances and resolve lighting problems in areas where lighting ordinances have not been adopted. FWS and DEP should identify and resolve artificial lighting impacts to sea turtles in South Florida. Since 1987, hatchling disorientation incidents observed by DEP marine turtle permit holders and park personnel have been reported through standardized reporting forms. Report forms serve as documentation for lighting problems on nesting beaches and allow the identification of specific problem light sources. FWS and DEP should use these report forms to locate and resolve lighting problems, with the help of local governments, through public education efforts, and by directly contacting the owners of the problem lights and making recommendations for their modification. FWS and DEP should also probatively conduct pre-season lighting inspections to identify and make recommendations for correcting problem light sources before they result in disorientation events.

Where lighting ordinances have been adopted and enforced, hatchling disorientation and disorientation have been drastically reduced. All coastal counties and communities with nesting beaches should adopt ordinances (March through October on the Atlantic Coast and May through October on the Gulf Coast). Many incorporated communities within Broward and Palm Beach counties, Florida, are particularly problematic because of the high-density nesting beaches and the lack of effective lighting regulations. DEP should ensure appropriate lighting on new construction projects.

- S2.3.2. Evaluate extent of hatchling disorientation and disorientation on all

important nesting beaches. FWS, DEP, and counties should continue to evaluate hatchling disorientation and disorientation problems on all important nesting beaches. Many lighting ordinance requirements do not become effective until 11 p.m., whereas over 30 percent of hatchling emergence occurs prior to this time (Witherington et al. 1990). FWS, DEP, and county governments should also support research to gather additional quantitative data on hatchling emergence times and nesting times on representative beaches throughout South Florida to support the most effective time requirements for lighting ordinances.

- S2.3.3. Prosecute individuals or entities responsible for hatchling disorientation and disorientation under the Endangered Species Act or appropriate State laws. Hatchling disorientation and disorientation from artificial lights can cause high mortality and be the major source of hatchling mortality on some nesting beaches if not controlled. Law enforcement efforts should be focused where lighting ordinances are not being implemented or enforced on major nesting beaches and where repeated violations are not corrected.
- S2.4. Ensure beach nourishment and coastal construction activities are planned to avoid disruption of nesting and hatching activities. These activities can cause significant disruption of nesting activities during the nesting season when viewed cumulatively over the nesting range. Nest relocation can involve manipulation of large numbers of nests, which can result in lowered hatch success and altered hatchling sex ratios, and therefore is not an acceptable alternative to altering the timing of projects during the peak nesting period. COE, FWS, and DEP should ensure beach nourishment and other beach construction activities are not permitted during the nesting season on important nesting beaches.
- S2.5. Ensure law enforcement activities eliminate poaching and harassment. Poaching, while not a significant cause of nest loss regionally, is occasionally a local problem. Poaching has been repeatedly reported around the Ten Thousand Islands NWR and adjacent islands in southwest Florida. In addition, intentional and unintentional disturbance and harassment of nesting turtles is an increasing problem on many beaches. FWS should work closely with DEP to identify problem areas and focus intensive law enforcement efforts to eliminate poaching and deter harassment of nesting turtles.
- S3. Continue to gather information on species and population biology.
 - S3.1. Determine etiology of fibropapillomatosis. Research on the leatherback sea turtle fibropapilloma disease should be continued and expanded. Fibropapillomatosis (FP) is a disease of sea turtles characterized by the development of multiple tumors

on the skin and also internal organs, most frequently the lungs and kidneys. The tumors interfere with swimming, eating, breathing, seeing, and reproduction, and turtles with heavy tumor burdens become severely debilitated and die. FP has seriously impacted green turtle populations in Florida (about 50 percent of juvenile green turtles in Indian River Lagoon and Florida Bay have fibropapillomas) and is now emerging as a significant threat to the loggerhead as well. FP is a transmissible disease caused by a virus, and, while both a unique herpesvirus and retroviruses have been identified in FP tumors, neither has yet been proven to be the cause of the disease. Researchers are concerned that there may be environmental (contaminant) cofactors for this disease in nearshore areas. Continuation and expansion of research on the disease is essential to developing an approach to remedying the problem.

- S3.2. Maintain the Sea Turtle Stranding and Salvage Network. Most accessible U.S. beaches in the Atlantic and Gulf of Mexico are surveyed for stranded sea turtles by volunteer or contract personnel. Through the Sea Turtle Stranding and Salvage Network, stranding data are archived and summarized by the NMFS Miami Laboratory. These data provide an index of sea turtle mortality, and are thought to be a cost-effective means of evaluating the effectiveness of the Turtle Exclusion Device (TED) regulations. These data also provide basic biological information on sea turtles and are useful in determining other sources of mortality. The systematic stranding surveys of index areas need to be continued in South Florida. Periodic review of the efficacy of surveys should also be conducted.
- S3.3. Centralize administration and coordination of tagging programs. Sea turtle researchers commonly tag turtles encountered during their research projects and usually maintain independent tagging data bases. The lack of centralization for administering these tagging data bases often results in confusion when tagged turtles are recaptured, and delays in reporting of recaptures to the person originally tagging the turtle. NMFS and FWS should investigate the possibilities of establishing a centralized tagging data base, including Passive Integrated Transponder (PIT) tags.
- S3.3.1. Centralize tag series records. A centralized tag series data base is needed to ensure that recaptured tagged turtles can be promptly reported to persons who initially tagged the animal. The tag series data base would include listings of all tag series that have been placed on sea turtles in the wild, including the name and address of the researcher. This would eliminate problems in determining which researcher is using which tag series or types of tags, and would preclude unnecessary delays in reporting of tag returns. NMFS and/or FWS should establish and maintain this data base.

- S3.3.2. Centralize turtle tagging records. In addition to the need for a centralization of tag series records, there are advantages in developing a centralized turtle tagging data base. Such a data base would allow all turtle researchers to trace unfamiliar tag series or types to their source, and also to have immediate access to important biological information collected at the time of original capture. The major disadvantage is that this data base would require frequent editing and updating, and would be costly and somewhat time consuming to maintain. It would also make it possible for unethical researchers to exploit the work of others, while providing no guarantees that such contributions would be acknowledged. NMFS and FWS should determine whether such a data base can be established and is feasible to maintain.
- S3.4. Develop requirements for care and maintenance of turtles in captivity, including diet, water quality, tank size, and treatment of injury and disease. Sea turtles are maintained in captivity for rehabilitation, research, or educational display. Proper care will ensure the maximum number of rehabilitated turtles can be returned to the wild and a minimum number removed from the wild for research or education purposes. None of these requirements has been scientifically evaluated to determine the best possible captive conditions for sea turtles. FWS and NMFS should support the necessary research to develop these criteria, particularly relating to diet and the treatment of injury and disease. These criteria should be published and required for any permit to hold sea turtles in captivity. FWS, NMFS and/or DEP should inspect permitted facilities at least annually for compliance with permit requirements.
- S4. Monitor trends in nesting activity. DEP and FWS should continue to refine standardized nest survey criteria, identify additional index survey beaches to be monitored, and continue to conduct training workshops for surveyors. Surveys in Florida do not routinely cover the first two months of the leatherback nesting season. Consequently, DEP and FWS should ensure that routine monitoring of nesting beaches is done on at least a weekly basis during the time that leatherback turtles are nesting, including any nesting that occurs outside of the regular survey period.
- S5. Continue information and education activities. Sea turtle conservation requires long-term public support over a large geographic area. The public must be factually informed of the issues, particularly when conservation measures conflict with human activities, such as commercial fisheries, beach development, and public use of nesting beaches. Public education is the foundation upon which a long-term conservation program will succeed or fail.
- S5.1. Update existing slide programs and information leaflets on sea turtle conservation

for the general public. FWS has developed a bilingual slide tape program on sea turtle conservation and should keep the program current and available for all public institutions and conservation organizations. FWS and DEP should continually update and supply the public with informational brochures on sea turtle ecology and conservation needs.

- S5.2. Disseminate information from brochures and reports on recommended lighting modifications or measures to reduce hatchling disorientation and disorientation. Recently published literature contains information on the types of light, screening, or shading that is best for turtles (*e.g.*, Witherington and Martin 1996).
- S5.3. Develop public service announcements (PSA) regarding the sea turtle artificial lighting conflict and disturbance of nesting activities by public nighttime beach activities. A professionally produced public service announcement for radio and TV would provide tremendous support and reinforcement of the many coastal lighting ordinances. It would generate greater support through understanding. FWS should develop a high-quality PSA that could be used throughout the Southeast during the nesting season.
- S5.4. Ensure that facilities permitted to hold and display captive sea turtles have appropriate informational displays. Over 50 facilities are permitted to hold sea turtles for rehabilitation, research, and public education. Many are on public display and afford opportunities for public education. Display of accurate information on the basic biology and conservation problems should be a requirement of all permittees. All facilities should be visited by FWS, NMFS and/or DEP to ensure captive sea turtles are being displayed in a way to meet these criteria.
- S5.5. Post informational signs at public access points on nesting beaches. Public access points to nesting beaches provide excellent opportunities to inform the public of necessary precautions for compatible public use on the nesting beach and to develop public support through informational and educational signs. FWS, NPS, DEP and other appropriate organizations should post such educational and informational signs on nesting beaches as appropriate.

Habitat-level Recovery Actions

- H1. Protect and manage nesting habitat. Coastal development has already destroyed or degraded many miles of nesting habitat in South Florida. Although sea turtle nesting occurs on over 2,240 km of beaches within the southeast United States, development pressures are so great that cumulative impacts could result in increased degradation or destruction of nesting habitat and eventually lead to a significant population decline if not properly managed.

- H1.1. Ensure beach nourishment projects are compatible with maintaining good quality nesting habitat. Beach nourishment can improve nesting habitat in areas of severe erosion and is a preferred alternative to beach armoring. However, placement of sand on an eroded section of beach or an existing beach in and of itself may not provide suitable nesting habitat for sea turtles. Although beach nourishment may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during construction.
- H1.1.2. Evaluate sand transfer systems as an alternative to beach nourishment. Sand transfer systems can diminish the necessity for frequent beach renourishment and thereby reduce disruption of nesting activities and eliminate sand compaction. The construction and operation of these systems must be carefully evaluated to ensure important nearshore habitats are not degraded or sea turtles injured or destroyed.
- H1.1.3. Refine a sand budget formulation methodology for Sebastian Inlet. Inlets interrupt the natural flow of longshore sediment transport along the shoreline. The interrupted flow of sand is diverted either offshore in ebb tide shoals, into bays or lagoons in flood tide shoals, or in navigation channels (National Research Council 1990). As a result, erosion occurs downdrift of the interrupted shoreline. There are six man-made inlets on the Atlantic coast from Indian River County to Broward County. In Indian River County, for example, erosion has been nearly 2 m per year at Sebastian Inlet SRA (just south of Sebastian Inlet), when the average erosion rate for the county is just under 0.3 m per year (J. Tabar, Indian River County, personal communication 1996). DEP, Sebastian Inlet Tax District, and Indian River County should conduct engineering studies to refine a sand budget formulation methodology for the Sebastian Inlet. Other needs include: annually bypassing sand to downdrift beaches, conducting further studies of the long-term effects of the flood shoal on the inlet-related sediment budget, identifying the long-term impacts associated with the inlet in terms of sand impoundment and sediment volume deficit to downdrift areas, and determining the area of inlet influence.
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refuge.

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Studies of alternative sand sources for beach renourishment and their suitability for sea

turtles are needed. After years of beach renourishment, Miami-Dade County is running out of suitable sand material for future renourishment projects. Broward and Palm Beach counties will also be running out of sand sources in the near future. COE is exploring the potential use of sand from upland sand sources and the importation of sand from the Bahamas and the Turks and Caicos Islands. Concerns have been raised about the long-term consequences to nesting and incubating sea turtles using these alternative beach renourishing materials. In order to adequately address these concerns in section 7 consultations, studies must be conducted on the suitability of these materials prior to receiving a proposal for large-scale nourishment of Florida beaches with these alternative sand sources.

Recovery for the Loggerhead Sea Turtle, *Caretta caretta*

Recovery Objective: DELIST the species once recovery criteria have been met.

South Florida Contribution: SUPPORT delisting actions.

Recovery Criteria: The South Florida recovery contribution parallels the existing recovery plans for sea turtles. South Florida's objective for the loggerhead, green, leatherback and hawksbill sea turtles will be achieved when: the level of nesting for each species is continuously monitored and increases to the species-specific recovery goal; beaches supporting greater than 50 percent of the nesting activity are in public ownership; all important nesting beaches are protected and appropriately managed to prevent further degradation; non-native nuisance species have been controlled or eliminated on public lands; at least 60 percent hatch success is documented on major nesting beaches; effective lighting ordinances or lighting plans are implemented; and beaches are restored or rehabilitated to be suitable for nesting where appropriate.

Species-level Recovery Actions

- S1. Continue standardized surveys of nesting beaches. Nesting surveys are undertaken on the majority of nesting beaches. In the past, beach coverage varied from year to year, as did the frequency of surveys, experience and training of surveyors, and data reporting. Consequently, no determination of nesting population trends had been possible with any degree of certainty. However, in 1989, to better assess trends in nesting, DEP, in cooperation with FWS, initiated an Index Nesting Beach Survey (INBS) program to collect nesting data that could be used to statistically and scientifically analyze population trends. The INBS program should continue to gather a long-term data base on nesting activities in Florida that can be used as an index of nesting population trends.
- S2. Protect and manage populations on nesting beaches. Predators, poaching, tidal inundation, artificial lighting, and human activities on nesting beaches diminish reproductive success. Monitoring of nesting activity is necessary to implement and evaluate appropriate nest protection measures and determine trends in the nesting population.

- S2.1. Evaluate nest success and implement appropriate nest protection measures. Nesting and hatching success and hatchling emerging success on beaches occurring on State or Federal lands and all other important local or regional nesting beaches should be evaluated. Appropriate nest protection measures should be implemented by FWS and DEP, and appropriate local governments or organizations, to ensure greater than 60 percent hatch rate. Until recovery is ensured, however, projects on all Federal and State lands and key nesting beaches, such as those in Brevard, Indian River, St. Lucie, Martin, and Palm Beach Counties, should strive for a higher rate of hatching success. In all cases, the least manipulative method should be employed to avoid interfering with known or unknown natural biological processes. Artificial incubation should be avoided. Where beach hatcheries are necessary, they should be located and constructed to allow self release, and hatch rates approaching 90 percent should be attained. Nest protection measures should always enable hatchling release the same night of hatching.
- S2.2. Determine influence of factors such as tidal inundation and foot traffic on hatching success. Tidal inundation can diminish hatching success, depending on frequency, duration and developmental stage of embryos. Some nests are relocated due to the perceived threat from tides. The extent to which eggs can tolerate tidal inundation needs to be quantified to enable development of guidelines for nest relocation relative to tidal threats. The effect of foot traffic on hatching success is unknown, although many beaches with significant nesting also have high public use. FWS should support research and, in conjunction with DEP, develop recommendations for nest protection from tidal threat and foot traffic.
- S2.3. Reduce effects of artificial lighting on hatchlings and nesting females. Studies have shown that light pollution can deter female sea turtles from coming onto the beach to nest; in fact, brightly lit beaches have been determined to be used less frequently for nesting. Also, females attempting to return to sea after nesting can be disoriented by beach lighting and have difficulties making it back to the ocean. In some cases, nesting females have ended up on coastal highways and been struck by vehicles. Artificial beach lighting is even more detrimental to hatchling sea turtles, which emerge from nests at night. Under natural conditions, hatchlings move toward the brightest, most open horizon, which is over the ocean. However, when bright light sources are present on the beach, they become the brightest spot on the horizon and attract hatchlings in the wrong direction, making them more vulnerable to predators, desiccation, exhaustion, and vehicles.
- S2.3.1. Implement and enforce lighting ordinances and resolve lighting problems in areas where lighting ordinances have not been adopted. FWS and DEP should identify and resolve artificial lighting impacts to sea turtles in

South Florida. Since 1987, hatchling disorientation incidents observed by DEP marine turtle permit holders and park personnel have been reported through standardized reporting forms. Report forms serve as documentation for lighting problems on nesting beaches and allow the identification of specific problem light sources. FWS and DEP should use these report forms to locate and resolve lighting problems, with the help of local governments, through public education efforts, and by directly contacting the owners of the problem lights and making recommendations for their modification. FWS and DEP should also proactively conduct pre-season lighting inspections to identify and make recommendations for correcting problem light sources before they result in disorientation events. Where lighting ordinances have been adopted and enforced, hatchling disorientation and misorientation have been drastically reduced. All coastal counties and communities with nesting beaches should adopt ordinances (March through October on the Atlantic Coast and May through October on the Gulf Coast). Many incorporated communities within Broward and Palm Beach counties, Florida, are particularly problematic because of the high-density nesting beaches and the lack of effective lighting regulations. DEP should ensure appropriate lighting on new construction projects.

S2.3.2. Evaluate extent of hatchling disorientation and misorientation on all important nesting beaches. FWS, DEP, and counties should continue to evaluate hatchling disorientation and misorientation problems on all important nesting beaches. Many lighting ordinance requirements do not become effective until 11 p.m., whereas over 30 percent of hatchling emergence occurs prior to this time (Witherington et al. 1990). FWS, DEP, and county governments should also support research to gather additional quantitative data on hatchling emergence times and nesting times on representative beaches throughout South Florida to support the most effective time requirements for lighting ordinances.

S2.3.3. Prosecute individuals or entities responsible for hatchling disorientation and misorientation under the Endangered Species Act or appropriate State laws. Hatchling disorientation and disorientation from artificial lights can cause high mortality and be the major source of hatchling mortality on some nesting beaches if not controlled. Law enforcement efforts should be focused where lighting ordinances are not being implemented or enforced on major nesting beaches and where repeated violations are not corrected.

S2.4. Ensure beach nourishment and coastal construction activities are planned to avoid disruption of nesting and hatching activities. These activities can cause significant

disruption of nesting activities during the nesting season when viewed cumulatively over the nesting range. Nest relocation can involve manipulation of large numbers of nests, which can result in lowered hatch success and altered hatchling sex ratios, and therefore is not an acceptable alternative to altering the timing of projects during the peak nesting period. COE, FWS, and DEP should ensure beach nourishment and other beach construction activities are not permitted during the nesting season on important nesting beaches.

- S2.5. Ensure law enforcement activities eliminate poaching and harassment. Poaching, while not a significant cause of nest loss regionally, is occasionally a local problem. Poaching has been repeatedly reported around the Ten Thousand Islands NWR and adjacent islands in southwest Florida. In addition, intentional and unintentional disturbance and harassment of nesting turtles is an increasing problem on many beaches. FWS should work closely with DEP to identify problem areas and focus intensive law enforcement efforts to eliminate poaching and deter harassment of nesting turtles.
- S3. Continue to gather information on species and population biology.
- S3.1. Determine etiology of fibropapillomatosis. Research on the sea turtle fibropapilloma disease should be continued and expanded. Fibropapillomatosis (FP) is a disease of sea turtles characterized by the development of multiple tumors on the skin and also internal organs, most frequently the lungs and kidneys. The tumors interfere with swimming, eating, breathing, seeing, and reproduction, and turtles with heavy tumor burdens become severely debilitated and die. FP has seriously impacted green turtle populations in Florida (about 50 percent of juvenile green turtles in Indian River Lagoon and Florida Bay have fibropapillomas) and is now emerging as a significant threat to the loggerhead as well. FP is a transmissible disease caused by a virus, and, while both a unique herpesvirus and retroviruses have been identified in FP tumors, neither has yet been proven to be the cause of the disease. Researchers are concerned that there may be environmental (contaminant) cofactors for this disease in nearshore areas. Continuation and expansion of research on the disease is essential to developing an approach to remedying the problem.
- S3.2. Maintain the Sea Turtle Stranding and Salvage Network. Most accessible U.S. beaches in the Atlantic and Gulf of Mexico are surveyed for stranded sea turtles by volunteer or contract personnel. Through the Sea Turtle Stranding and Salvage Network, stranding data are archived and summarized by the NMFS Miami Laboratory. These data provide an index of sea turtle mortality and are thought to be a cost-effective means of evaluating the effectiveness of the Turtle Exclusion Device (TED) regulations. These data also provide basic biological information on

sea turtles and are useful in determining other sources of mortality. The systematic stranding surveys of index areas need to be continued in South Florida. Periodic review of the efficacy of surveys should also be conducted.

- S3.3. Centralize administration and coordination of tagging programs. Sea turtle researchers commonly tag turtles encountered during their research projects, and usually maintain independent tagging data bases. The lack of centralization for administering these tagging data bases often results in confusion when tagged turtles are recaptured, and delays in reporting of recaptures to the person originally tagging the turtle. NMFS and FWS should investigate the possibilities of establishing a centralized tagging data base, including Passive Integrated Transponder (PIT) tags.
- S3.3.1. Centralize tag series records. A centralized tag series data base is needed to ensure that recaptured tagged turtles can be promptly reported to persons who initially tagged the animal. The tag series data base would include listings of all tag series that have been placed on sea turtles in the wild, including the name and address of the researcher. This would eliminate problems in determining which researcher is using which tag series or types of tags, and would preclude unnecessary delays in reporting of tag returns. NMFS and/or FWS should establish and maintain this data base.
- S3.3.2. Centralize turtle tagging records. In addition to the need for a centralization of tag series records, there are advantages in developing a centralized turtle tagging data base. Such a data base would allow all turtle researchers to trace unfamiliar tag series or types to their source, and also to have immediate access to important biological information collected at the time of original capture. The major disadvantage is that this data base would require frequent editing and updating, and would be costly and somewhat time consuming to maintain. It would also make it possible for unethical researchers to exploit the work of others, while providing no guarantees that such contributions would be acknowledged. NMFS and FWS should determine whether such a data base can be established and is feasible to maintain.
- S3.4. Develop requirements for care and maintenance of turtles in captivity, including diet, water quality, tank size, and treatment of injury and disease. Sea turtles are maintained in captivity for rehabilitation, research, or educational display. Proper care will ensure the maximum number of rehabilitated turtles can be returned to the wild and a minimum number removed from the wild for research or education purposes. None of these requirements has been scientifically evaluated to

determine the best possible captive conditions for sea turtles. FWS and NMFS should support the necessary research to develop these criteria, particularly relating to diet and the treatment of injury and disease. These criteria should be published and required for any permit to hold sea turtles in captivity. FWS, NMFS and/or DEP should inspect permitted facilities at least annually for compliance with permit requirements.

- S4. Monitor trends in nesting activity. DEP and FWS should continue to refine standardized nest survey criteria, identify additional index survey beaches to be monitored, and continue to conduct training workshops for surveyors. Consequently, DEP and FWS should ensure that routine monitoring of nesting beaches is done on at least a weekly basis during the nesting period of the loggerhead turtle, and any nesting period outside of their regular survey period.
- S5. Continue information and education activities. Sea turtle conservation requires long-term public support over a large geographic area. The public must be factually informed of the issues, particularly when conservation measures conflict with human activities, such as commercial fisheries, beach development, and public use of nesting beaches. Public education is the foundation upon which a long-term conservation program will succeed or fail.
- S5.1. Update existing slide programs and information leaflets on sea turtle conservation for the general public. FWS has developed a bilingual slide tape program on sea turtle conservation and should keep the program current and available for all public institutions and conservation organizations. FWS and DEP should continually update and supply the public with informational brochures on sea turtle ecology and conservation needs.
- S5.2. Disseminate information from brochures and reports on recommended lighting modifications or measures to reduce hatchling disorientation and disorientation. Recently published literature contains information on the types of light, screening or shading that is best for turtles (*e.g.*, Witherington and Martin 1996).
- S5.3. Develop public service announcements (PSA) regarding the sea turtle artificial lighting conflict and disturbance of nesting activities by public nighttime beach activities. A professionally produced public service announcement for radio and TV would provide tremendous support and reinforcement of the many coastal lighting ordinances. It would generate greater support through understanding. FWS should develop a high-quality PSA that could be used throughout the Southeast during the nesting season.
- S5.4. Ensure facilities permitted to hold and display captive sea turtles have appropriate

informational displays. Over 50 facilities are permitted to hold sea turtles for rehabilitation, research, and public education. Many are on public display and afford opportunities for public education. Display of accurate information on the basic biology and conservation problems should be a requirement of all permittees. All facilities should be visited by FWS, NMFS and/or DEP to ensure captive sea turtles are being displayed in a way to meet these criteria.

- S5.5. Ensure standard criteria and recommendations for loggerhead sea turtle nesting interpretive walks are being implemented. Sea turtle walks are popular with the public and afford tremendous opportunities for public education or, if poorly conducted, misinformation. DEP has developed standard criteria for permittees conducting walks. These objective criteria should continue to be used, and DEP should continue to evaluate sea turtle walks to ensure they are professional, provide accurate biological information, convey an accurate conservation message, and are a positive experience. Just as importantly they should not cause unnecessary or significant disturbance to nesting turtles.
- S5.6. Post informational signs at public access points on nesting beaches. Public access points to nesting beaches provide excellent opportunities to inform the public of necessary precautions for compatible public use on the nesting beach and to develop public support through informational and educational signs. FWS, NPS, DEP and other appropriate organizations should post such educational and informational signs on nesting beaches as appropriate.

Habitat-level Recovery Actions

H1. Protect and manage nesting habitat. Coastal development has already destroyed or degraded many miles of nesting habitat in South Florida. Although sea turtle nesting occurs on over 2,240 km of beaches within the southeast United States, development pressures are so great that cumulative impacts could result in increased degradation or destruction of nesting habitat and eventually lead to a significant population decline if not properly managed.

H1.1. Ensure beach nourishment projects are compatible with maintaining good quality nesting habitat. Beach nourishment can improve nesting habitat in areas of severe erosion and is a preferred alternative to beach armoring. However, placement of sand on an eroded section of beach or an existing beach in and of itself may not provide suitable nesting habitat for sea turtles. Although beach nourishment may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during construction.

H1.1.1. Evaluate sand transfer systems as an alternative to beach nourishment.
Sand transfer systems can diminish the necessity for frequent beach

renourishment, thereby reducing disruption of nesting activities. This system also minimizes sand compaction while adding sand to downdrift beaches. The construction and operation of these systems must be carefully evaluated to ensure important nearshore habitats are not degraded or sea turtles injured or destroyed.

H1.1.2. Refine a sand budget formulation methodology for Sebastian Inlet. Inlets interrupt the natural flow of longshore sediment transport along the shoreline. The interrupted flow of sand is diverted either offshore in ebb tide shoals, into bays or lagoons in flood tide shoals, or in navigation channels (National Research Council 1990). As a result, erosion occurs downdrift of the interrupted shoreline. There are six man-made inlets on the Atlantic coast from Indian River County to Broward County. In Indian River County, for example, erosion has been nearly 2 m per year at Sebastian Inlet SRA (just south of Sebastian Inlet), when the average erosion rate for the county is just under .3 m per year. DEP, Sebastian Inlet Tax District, and Indian River County should conduct engineering studies to refine a sand budget formulation methodology for the Sebastian Inlet. Other needs include: annually bypassing sand to downdrift beaches, conducting further studies of the long-term effects of the flood shoal on the inlet-related sediment budget, identifying the long-term impacts of sand impoundment and sediment volume deficit to downdrift areas, and determining the area of inlet influence.

H1.2. Prevent degradation of nesting habitat from seawalls, revetments, sand bags, sand fences or other erosion-control measures. One of the most difficult habitat protection efforts throughout South Florida is trying to minimize or eliminate the construction of seawalls, riprap, groins, sandbags, and improperly placed drift or sand fences. In 1995, the Florida Legislature passed a law giving coastal counties and municipalities the authority to approve construction of coastal armoring during certain emergency situations. (All non-emergency armoring situations must still receive an DEP permit prior to construction.) Although the new law weakened prior regulations on armoring, it does require that emergency armoring structures approved by a coastal county or municipality be temporary and that the structure be removed, or a permit application submitted to DEP for a permanent rigid coastal structure, within 60 days after the emergency installation of the structure. In addition, to implement this new law, DEP finalized a formal agency rule on coastal armoring on September 12, 1996.

H1.2.1. Ensure laws regulating coastal construction and beach armoring are enforced. The 1996 DEP rule recommends that local governments obtain an incidental take permit from FWS under section 10 of the Endangered

Species Act and develop a sea turtle habitat conservation plan prior to authorizing armoring projects. The new rule also requires that several measures be undertaken to address sea turtle concerns for non-emergency armoring and for placement of permanent rigid coastal structures subsequent to an emergency (temporary) armoring event. For example, the new regulations require that (1) special conditions be placed on permitted activities to limit the nature, timing, and sequence of construction, as well as address lighting concerns; (2) structures not be used where the construction would result in a significant adverse impact; and (3) armoring be removed if it is determined to not be effective or to be causing a significant adverse impact to the beach and dune system.

- H1.2.2. Ensure failed erosion control structures are removed. Failed erosion control structures such as uncovered plastic bags or tubes and fragmented concrete or wooden structures degrade nesting habitat and deter nesting activities. DEP should ensure failed structures are removed from nesting beaches.
- H1.2.3. Develop standard requirements for sand fence construction. Sand fences can effectively build dune systems and improve nesting habitat; however, improperly designed sand fences can trap nesting females or hatchlings and prevent access to suitable nesting habitat. DEP and FWS should develop and evaluate sand fencing designs and establish standard requirements for sand fence construction.
- H1.3. Identify important nesting beaches experiencing greater than 40 percent nest loss from erosion and implement appropriate habitat restoration measures. Some important nesting beaches now suffer severe erosion as a result of inlet maintenance or jetty construction. In some situations, limited safe locations for relocating nests place constraints on nest relocation programs. Nest relocation programs should be considered as a short-term measure at best to protect nests in these situations, with primary efforts directed toward habitat restoration. DEP and FWS should review all important nesting beaches and identify those with 40 percent or more nest loss due to erosion or tidal inundation. Habitat restoration plans should be developed and implemented for identified nesting beaches.
- H1.4. Acquire or otherwise ensure the long-term protection of important nesting beaches. Acquisition of important sea turtle nesting beaches would ensure long-term protection of U.S. nesting habitat. Acquisition and protection of undisturbed nesting habitat would enhance sea turtle nesting and hatching success.
 - H1.4.1. Continue to acquire in fee title all undeveloped beaches between

Melbourne Beach and Wabasso Beach, Florida, for the Archie Carr National Wildlife Refuge. The Archie Carr NWR was designated by Congress in 1989 in recognition of the need for long stretches of quiet, undisturbed sandy beaches, with little or no artificial lighting, to ensure the reproductive success and survival of sea turtles. The refuge is located within a 33-km stretch of beach on the barrier islands of Brevard and Indian River Counties on the Atlantic coast of Florida. Approximately 25 percent of all loggerhead nesting in the U.S. occurs along this stretch of beach. The proposed acquisition plan for the refuge set a goal for purchase of 15 km within four sections of this 33-km stretch. Three of the sections are located in Brevard County and one in Indian River County.

Partners in the land acquisition effort for the refuge and adjacent buffer areas on the barrier island include FWS, DEP, Brevard County, Indian River County, Richard King Mellon Foundation, The Conservation Fund, and The Nature Conservancy. To date, contributions from the State of Florida and local county partnerships account for over 70 percent of land acquisition expenditures, while contributions from the Richard King Mellon Foundation account for over 21 percent of acquisition costs for lands on the barrier island. Federal acquisition efforts account for about 8 percent of purchases to date.

About 61 percent of the available beachfront acquisitions for the refuge have been completed. Of the original 15 km of beachfront identified for acquisition, approximately 8 km have been acquired and 5 km are awaiting purchase. The remaining lands have been purchased for private development and are no longer available. Escalating coastal development in Brevard and Indian River counties threatens the remaining parcels identified for acquisition. Ongoing development continues to fragment the remaining habitat and could result in increased lighting and beach armoring, which negatively impact sea turtles. A narrow window of opportunity is left to acquire the last remaining lands required for the refuge.

- H1.4.2. Evaluate the status of the high density nesting beaches on Hutchinson Island, Florida, and develop a plan to ensure its long-term protection. Approximately 10 percent of loggerhead turtle nesting in the United States occurs along this 32-km beach. Development is degrading nesting habitat, and public use is causing significant disturbance to nesting activities. DEP and FWS should evaluate the threats and take appropriate measures, including acquisition, to ensure long-term protection.

- H1.4.3. Evaluate status of other undeveloped beaches that provide important habitat for maintaining the historic nesting distribution and develop a plan for long-term protection. DEP and FWS should evaluate other nesting beaches in the Southeast that contribute significantly to the historic nesting distribution to ensure long-term protection.
- H2. Restore areas to suitable habitat.
- H2.1. Reestablish dunes and native vegetation. Dune restoration and revegetation with native plants should be a required component of all renourishment projects. This will enhance beach stability and nesting habitat and may result in the need for less frequent renourishment activities.
- H2.2. Remove exotic vegetation and prevent spread to nesting beaches. Australian pine trees shade nests and can alter natural hatchling sex ratios. Australian pines also aggressively replace native dune and beach vegetation through shading and chemical inhibition and consequently exacerbate erosion and loss of nesting habitat. Erosion can topple trees and leave exposed roots that can entrap nesting females. Removal of exotics, such as is ongoing at St. Lucie Inlet SP, Hobe Sound NWR, and Dry Tortugas NP, Florida, should continue. DEP, FWS, and NPS should identify other important nesting beaches where exotic vegetation is degrading nesting habitat and work with responsible parties to restore natural vegetation.
- H3. Conduct research to evaluate the relationship of sand characteristics (including aragonite) and female nesting behavior, nesting success, hatching success, hatchling emerging success, hatchling fitness, and sex ratios. Beach nourishment may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand. These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings. Gas diffusion of nests could be affected by sand grain shape, size, and compaction and variations could alter hatching success. Sand color and moisture influence nest incubation temperature and can affect hatchling sex determination. The effect of importing non-native materials, such as aragonite, to U.S. beaches for beach nourishment adds additional unknowns that could conceivably affect female nesting behavior, nesting success, hatching success, hatchling emerging success, hatchling fitness and sex ratios, and should be fully evaluated before large-scale use.

Studies of alternative sand sources for beach renourishment and their suitability for sea turtles are needed. After years of beach renourishment, Miami-Dade County is running out of suitable sand material for future renourishment projects. Broward and Palm Beach

counties will also be running out of sand sources in the near future. COE is exploring the potential use of sand from upland sand sources and the importation of sand from the Bahamas and the Turks and Caicos Islands. Concerns have been raised about the long-term consequences to nesting and incubating sea turtles using these alternative beach renourishing materials. In order to adequately address these concerns in section 7 consultations, studies must be conducted on the suitability of these materials prior to receiving a proposal for large-scale nourishment of Florida beaches with these alternative sand sources.

The Invertebrates

Recovery for the Schaus Swallowtail Butterfly, *Heraclides aristodemus ponceanus*

Recovery Objective: RECLASSIFY TO THREATENED, then delist.

Recovery Criteria: The Schaus swallowtail butterfly has always been a rare species in its historic range of Miami- Dade and Monroe counties. The destruction and degradation of Schaus swallowtail habitat and other human activities, such as collecting and mosquito spraying, increased the vulnerability of this rare species to extinction. Management actions such as acquiring and restoring habitat, enforcing prohibitions against take, reducing the effects of mosquito spraying, and increasing our biological understanding of the butterfly's biology and ecology have helped stabilize this species. Due to the effectiveness of management actions to help its recovery, the objective of this recovery plan is to delist the Schaus swallowtail butterfly. This objective will be achieved when: further loss, fragmentation, or degradation of suitable, occupied habitat within the butterfly's historic range in the Upper Florida Keys and Miami-Dade County has been prevented; when breeding sites of the Schaus swallowtail butterfly have been protected from mosquito spraying; when mosquito spraying in other areas used by the Schaus swallowtail butterfly has been reduced by 90 percent; when all suitable, occupied habitat on priority acquisition lists for the Schaus swallowtail butterfly is protected either through land acquisition or cooperative agreements; when the hardwood hammocks that form the habitat for the Schaus swallowtail butterfly are managed, restored, or rehabilitated on protected lands; and when stable populations of the Schaus swallowtail butterfly are distributed throughout its historic range. These populations will be considered demographically stable when they exhibit a rate of increase (r) equal to or greater than 0.0 as a 3 year running average for 6 years.

Species-level Recovery Actions

- S1. Determine the distribution and status of wild Schaus swallowtail butterfly populations. Schaus swallowtail butterflies are known to occur in hardwood hammock forests in Miami-Dade and Monroe counties. Their exact distribution in these counties is known, but is not being publicized due to the possible adverse effects of collectors visiting the sites while populations are still small. From 1995-1997, captively bred butterflies were released

in new areas to re-establish populations. Annual monitoring of the status, location, and distribution of pre-existing wild population sites has been carried out in Biscayne NP and on Key Largo since 1984. Additional surveys to determine the distribution and status of the wild Schaus swallowtail butterfly populations are necessary in subsequent years to follow the fate of both the wild populations and the reintroduced populations.

- S1.1. Determine the status of wild butterflies within current range. Survey hardwood hammocks in Deering Estate (and other suitable areas in Miami), Biscayne NP, and north Key Largo to determine the status of wild butterfly populations. Quantitatively determine the number and distribution of larvae, juveniles, and adult butterflies. The Crocodile Lake NWR is planning on conducting annual wild butterfly surveys during peak adult emergence from April through June.
- S1.2. Determine the status of captively reared Schaus swallowtail butterflies. Compile all information on the locations in which captive-reared Schaus swallowtail butterflies were released and determine the reproductive success of these populations. Surveys to determine interactions between captively reared and wild populations of the Schaus swallowtail butterflies may be critical to determining possible genetic effects of captively reared individuals on wild populations. Investigate how butterflies are spatially distributed within habitat patches and their relation to other occupied habitat patches.
- S1.3. Survey natural butterfly habitat and determine habitat characterization and use by both wild and captive-bred butterflies. Identify occupied and unoccupied habitat patches. Quantify habitat structure including canopy structure, species composition and diversity, and distribution, and assess the condition. Determine why butterflies are absent in areas with suitable habitat.
 - S1.3.1. Survey butterflies along ecotonal regions. Survey populations along edges of roads, housing developments, and other habitat types (mangroves). Evaluate status of butterflies in remote contiguous habitat as compared to fragmented habitat or areas near human habitation.
 - S1.3.2. Survey the amount of light or closed canopy and its effects on species numbers, etc.
 - S1.3.3. Determine species composition and abundance between different stands of forest.
 - S1.3.4. Survey hammock microclimate during breeding and flight time. Previous surveys extrapolated physical environmental conditions from historic records. Survey microclimate (rainfall, temperatures, photoperiod,

humidity, etc.) of occupied habitat during breeding and flight times.

- S1.3.5. Survey the distribution of adult butterflies and the distribution of host plants.
 - S1.4. Determine the status of habitat at release sites. Captively bred butterflies have been released at seven different sites in Monroe and Miami-Dade counties. For each site, survey spatial coordinates, spatial relation to other patches, abundance of host plants, canopy structure, open and semi-open habitat, amount of habitat degradation (*e.g.*, exotics, trash), and susceptibility to human impacts.
 - S1.5. Survey other butterfly populations in occupied Schaus swallowtail butterfly habitat. Identify additional butterfly species that occur in occupied Schaus swallowtail butterfly habitat. Select a species that is relatively common, yet is habitat-specific. Survey the presence/absence of these species to determine population dynamics and habitat interaction. Surveying other selected species will provide information to help assess habitat quality.
 - S1.6. Maintain and improve the GIS database for butterflies information. Compile additional survey information into existing FWS GIS database. Use GIS to identify spatial relationships between occupied and unoccupied habitat patches.
 - S1.7. Conduct presence/absence surveys for Schaus swallowtail butterfly in suitable habitat throughout the Florida Keys. Historic reports suggest butterflies may have occurred in such areas as southern of Key Largo, Key West, Lower and Upper Matecumbe, Big Pine Key, and Lignumvitae Key. Because many of these reports are old or unconfirmed, these surveys are of lower priority. Conduct butterfly surveys in these other areas in conjunction with other listed species recovery work.
- S2. Protect and enhance existing, wild populations of the Schaus swallowtail butterfly.
- S2.1. Assign a biologist responsibility for implementing recovery actions for the threatened or endangered species of the Upper Florida Keys and Miami-Dade County (Deering Estate and Biscayne NP). Recovery actions that benefit one of the threatened or endangered species in the Florida Keys (such as actions to recover the Schaus swallowtail butterfly) will benefit other threatened or endangered species in the same area. At the same time, the number of actions that will be necessary to recover threatened or endangered species in the Florida Keys and Miami-Dade County will require the attention of a biologist or similarly trained professional who is dedicated to addressing these recovery needs.
 - S2.2. Utilize Federal regulatory mechanisms for protection. Conduct section 7

consultations on Federal activities that may affect the Schaus swallowtail butterfly and determine a jeopardy threshold. Coordinate with law enforcement to prevent take under section 9. Identify what activities could result in take of butterflies, such as habitat loss and collecting.

- S2.3. Provide Schaus swallowtail butterfly information to Federal, State, county, and city agencies. Provide information including GIS information regarding the presence of butterflies, their protection under the ESA, and ways to minimize impacts. Non-Federal agencies that may influence the Schaus swallowtail butterfly include DEP, DCA, GFC, DACS, Florida Keys Aqueduct Authority, and Monroe County government.
- S2.4. Reduce human-related mortalities of Schaus swallowtail butterflies. Levels of Schaus swallowtail butterfly mortality have not been quantified, although sources of mortality are documented. Implement management actions that reduce causes of mortality. Mortality is primarily a result of habitat modification such as clearing for residential and commercial construction, fires, introduction of pesticides and other hazardous chemicals, and deaths from vehicular collisions, predators, parasites, and collectors.
- S2.4.1. Eliminate the negative effects of pesticides and other biocides. One of the greatest current threats to butterflies is the negative effect from mosquito spraying and other biocides. Develop a Memorandum of Agreement with Miami-Dade and Monroe county mosquito control groups to eliminate mosquito spraying effects on the Schaus swallowtail butterfly. Enforce regulations that prohibit spraying over Federal and State lands. Eliminate any adverse affects on the Schaus swallowtail butterfly.
- S2.4.2. Reduce the effects of habitat loss, destruction, and modification on Schaus swallowtail butterflies in the Florida Keys. Several areas in north Key Largo are in private ownership and subject to habitat modification. Acquire suitable habitat to prevent mortality of butterflies. Coordinate with landowners to reduce habitat modification effects on the Schaus swallowtail butterfly.
- S2.4.3. Eliminate illegal collecting of the Schaus swallowtail butterfly. Enforce regulations that prohibit the collection of adults, larvae, or eggs of the Schaus swallowtail butterfly.
- S2.4.4. Minimize the effects of contaminants on the Schaus swallowtail butterfly. Investigate the effects of contaminants around the old missile site on the refuge, the firing range at Harbor Course, and illegal dumpsites. Remove

contaminants that pose a threat to the Schaus swallowtail butterfly.

S2.5. Develop a captive propagation protocol for the Schaus swallowtail butterfly and implement as warranted. Methods to breed and raise Schaus swallowtail butterflies in captivity have been established. Although several releases of captive bred butterflies have been conducted, the effects of these animals on wild Schaus swallowtail butterfly populations are still being examined. Develop captive propagation and release guidelines.

S2.6.1. [sic] Develop criteria for captive propagation protocol. Use the IUCN/SSC Guidelines for Reintroductions, if appropriate, as a basis for developing criteria that determine the type of release to be conducted, the selection of a release site, the source and health of release stock, short and long-term success indicators, and monitoring protocol.

S2.6.2. [sic] Develop threshold criteria to act as a trigger for future captive propagations. These criteria, based on a variety of biological factors (*e.g.*, population number, distribution, habitat), would be used to ensure that the Schaus swallowtail butterfly range and population status was sufficient to ensure that a catastrophic event, such as a hurricane, would not lead to the extinction of the species in the wild.

S2.6.3. [sic] All future efforts to captive breed Schaus swallowtail butterflies should be conducted in situ in as natural conditions as possible. Preferably, butterflies should be raised in enclosures in suitable habitat within the historic range. Captive propagation efforts closer to release sites are preferable for many species. This would limit transport time and possible difficulties in achieving a successful release.

S2.6.4. [sic] Conduct appropriate health screenings of all release stock prior to reintroduction. IUCN guidelines recommend individuals should not be removed from a wild population until the effects of translocation on the donor population have been assessed and after it is guaranteed that these effects are not negative. Ensure all captive stock are free of possible health problems.

S2.5..5. [sic] Monitor introduced populations to determine survival, growth, and reproductive success. Conduct additional demographic, ecological, and behavioral monitoring of wild and released butterflies. Investigate extent and causes of mortality of released and wild butterflies.

S3. Conduct research on the biology and life history of the Schaus swallowtail butterfly.

Conduct additional studies on the reproductive success, productivity, longevity, population size, movements, and dispersal of wild populations of Schaus swallowtail butterfly, if needed.

- S3.1. Determine if the total population size is large enough to prevent functional extinction and genetic extinction. Determine what is the effective population size necessary for survival. Conduct population modeling, (*e.g.*, spatially explicit models, PVA risk assessment) to predict the persistence of this species.
- S3.2. Determine the number of subpopulations necessary to maintain a stable or increasing population.
 - S3.3.1. Determine subpopulations vulnerable to extinction. Determine which populations are the most critical for survival. Determine if populations on ecotonal areas or near human habitation are more vulnerable to extinction.
 - S3.3.2. Determine the necessary number of subpopulations and level of exchange that will enable the Schaus swallowtail butterfly to persist for 100 years.
- S3.3. Examine factors that affect the abundance and distribution of the Schaus swallowtail butterfly. Although extensive studies have been undertaken on factors affecting this species' distribution and abundance, the results should be assessed to determine what additional aspects of this species' ecology affects abundance and density and makes it most vulnerable to extinction (*e.g.*, predation, lack of food, inability to find a mate). If this assessment identifies aspects of the Schaus life history and ecology in need of additional investigation, then those investigations should be initiated.
- S3.4. Evaluate the effect of releasing captive-bred butterflies into the wild the persistence of the Schaus swallowtail butterfly. Determine if augmentation is effective in establishing stable populations throughout the Schaus swallowtail butterfly's range. Investigate if released butterflies are enhancing existing wild populations and the overall stability of the Schaus swallowtail butterfly in the long term. Continuation of existing monitoring programs is essential to assess the effectiveness of this recovery tool.
- S3.5. Investigate the effects of insecticides used for mosquito control on surrogate species closely related to the Schaus swallowtail. This research is needed to evaluate the exact effects of these chemicals on butterflies in the Keys, and determine toxicity levels.

S4. Monitor the status of the Schaus swallowtail butterfly and its habitat. Monitor

demographic, ecological, and behavioral studies of wild and released butterflies.

- S4.1. Monitor demographic parameters. Monitor sex ratios, age class structure, survivorship, home range size, and dispersal distance of the Schaus swallowtail butterfly. Continue development of an adaptable model for biologists and managers to use to survey and monitor the Schaus swallowtail butterfly to help guide management efforts.
- S4.2. Continue long-term monitoring of the Schaus swallowtail butterfly. Monitor presence/absence and degree of abundance every year until the Schaus swallowtail butterfly is recovered. Investigate extent and causes of mortality in released and wild populations.
- S5. Increase public awareness and stewardship. Inform public, especially butterfly collectors about the butterfly, its protections under Federal law, and its importance as an integral part of the ecosystem. Have an incentive or reward system to encourage homeowners to plant native host plants and protect butterflies. Inform butterfly collectors on the importance of reducing the amount of illegal butterfly collecting or manipulation. Develop educational materials and host public workshops to increase awareness about butterflies and instill a sense of stewardship for the protection of this endangered species.
- S6. Establish reclassification criteria. Develop measurable reclassification criteria based on factors that result in a stable or increasing population including total population size, number of subpopulations, sex ratio, age structure, habitat condition and availability, and level of threats. Evaluate and monitor the Schaus swallowtail butterfly's status in relation to reclassification criteria.

Habitat-level Recovery Actions

- H1. Prevent further loss or degradation of existing Schaus swallowtail butterfly habitat. The primary threat to the Schaus swallowtail butterfly is habitat loss and fragmentation caused by increasing urbanization. Suitable habitat remaining for this species is estimated as 43 percent Biscayne NP and 17 percent for north Key Largo.
 - H1.1. Acquire unprotected Schaus swallowtail butterfly habitat. Identify priority areas for acquisition. The first priority is acquiring unprotected, suitable, occupied habitat, the second priority is suitable, or potentially restorable unoccupied habitat. Unoccupied, but suitable habitat is important for future reintroduction activities. Inholding areas are also high priority.
 - H1.1.1. Continue Federal acquisition efforts. Continue acquisition efforts within the Crocodile Lake NWR. The Crocodile Lake NWR is developing a priority acquisition and restoration list. Priority areas include land-fill,

trailer park, cock-fighting ring, and military land.

H1.1.2. Support State, local, and non-government organizations acquisition efforts. Support entities to protect Schaus swallowtail butterfly habitat through the use of conservation easements, Florida Conservation's CARL and Recreational Land acquisition program, Monroe County Land Authority, Florida Community Trust, Florida Keys Land Trust, and The Nature Conservancy. Support the acquisition of lands to be incorporated into the Key Largo State Botanical Site.

H1.2. Protect and manage Schaus swallowtail butterfly habitat.

H1.2.1. Protect butterflies on private lands. Protect Schaus swallowtail butterfly populations on private land through acquisition, conservation easements or agreements, and education of landowners. Develop agreements (*e.g.*, Memorandum of Agreement) between the FWS and private landowners to minimize impacts of exotics, plant or animal species.

H1.2.2. Protect butterflies on public lands. Develop a habitat management plan that outlines priority habitat for acquisition and methods to protect, restore, and minimize impacts on butterflies and their habitat.

H1.2.3. Utilize Federal mechanisms to protect and prevent degradation of Schaus swallowtail butterfly habitat. Coordinate with all Federal agencies to ensure Federal actions do not impact Schaus swallowtail butterfly habitat.

H1.2.4. Coordinate with State and Monroe County agencies and private entities to develop management actions to protect Schaus swallowtail butterfly habitat. Coordinate with these entities to ensure proposed construction activities that result in land clearing or alteration do not impact the Schaus swallowtail butterfly and its habitat. Coordinate with the Audubon Society to develop a management plan for Parcel 22. Coordinate with the Trailer Park to protect and manage habitat and minimize impacts to the Schaus swallowtail butterfly.

H1.2.5. Avoid clearing or disturbing hammocks. Prevent direct clearing of hardwood hammock. Direct new construction activities to areas already cleared or previously disturbed.

H1.2.6. Restrict access to Schaus swallowtail butterfly habitat. Restrict access to remote habitat areas to prevent damage caused by campers, homesteaders, trash dumpers, and vehicular traffic.

- H1.2.7. Establish and protect 500 m buffers around priority habitat. The necessity for 500 m protection buffer zones is based on the likelihood that human influences encroach and impact the Schaus swallowtail butterfly.
- H1.2.8. Prevent fires. Wildfires can quickly destroy large areas of hardwood hammocks. Develop effective fire management plans. Prohibit fires and smoking in or near hardwood hammocks.
- H1.2.9. Eliminate exotic vegetation. Remove exotic vegetation in Schaus swallowtail butterfly habitat and in adjacent upland buffers. Use deed restrictions, covenants, or other means to minimize the likelihood that exotic plants will invade hardwood hammocks. Special consideration may be necessary for guava (*Psidium guajava*) which is listed by the State as one of Florida's most invasive exotic species, but has also been shown in recent studies to be a preferred nectar source for Schaus butterflies (R. Hammer, personal communication 1998). Eradication of this pest species by resource managers in Schaus habitat may adversely affect recovery of the butterfly.
- H2. Restore both suitable occupied and unoccupied Schaus swallowtail butterfly habitat. Several areas are suitable for restoration. Restoration efforts will benefit the hammock habitat, existing butterfly populations, and future released populations. Conduct and support restoration activities in Schaus swallowtail butterfly habitat.
- H2.1. Restore Schaus swallowtail butterfly habitat. Restore Crocodile Lake NWR habitat near the missile site, borrow pit, gun range, cock fighting ring, and radio tower. Support the restoration of habitat on State and county lands.
- H2.2. Improve habitat by planting or encouraging native plant species. Plant native vegetation in areas that have been scarified or degraded. Restore habitat along ecotones by planting early successional vegetation along ecotonal areas to encourage use by the Schaus swallowtail butterfly.
- H2.3. Improve habitat by conducting selective trimming. Manage habitat to provide open spaces to encourage courtship, mating, and foraging behaviors.
- H2.4. Remove exotic vegetation. Remove exotic vegetation in refuge boundaries. Support the removal of exotics in other Schaus swallowtail butterfly habitat including Port Bougainvillea and Ocean Forest Tract (Ocean side of Harrison Tract).
- H2.5. Remove trash debris. Several old roads into the Crocodile Lake NWR are littered

with trash and debris. Remove trash and debris from these and other areas in Schaus swallowtail butterfly habitat.

- H3. Conduct research to determine habitat needs for the Schaus swallowtail butterfly. Develop a spatially explicit or incidence function model (Hanski et al. 1996) to predict metapopulation dynamics and evaluate habitat patches important for the survival of the Schaus swallowtail butterfly.
- H3.1. Investigate how butterflies use different habitat components for survival. (*e.g.*, food, shelter, nesting, traveling). Investigate habitat preferences and adaptations to local ecological conditions.
- H3.1.1. Determine minimum area requirements. Determine optimum and suboptimal hammock size, character, and configuration for colony viability.
- H3.1.2. Identify host plants, their status and role in the hammock community, effects from natural factors, and how the Schaus swallowtail butterfly is dependent on them. Previous work provides data on relative abundance of host plants and not quantitative data of density and distribution. Investigate the distribution, extent and status of host plants of Schaus swallowtail butterfly. Determine if Schaus swallowtail butterflies are facultative or obligatory users of host plants.
- H3.1.3. Determine the effects of forest canopy structure and light conditions on the Schaus swallowtail butterfly. Investigate optimal amounts of diffuse and direct light. Determine if management regimes (*e.g.*, thinning, opening canopy layer) can benefit Schaus swallowtail butterfly populations.
- H3.1.4. Investigate the effect of habitat change. Determine how the Schaus swallowtail butterfly's distribution and abundance is affected by habitat or microclimate modification and forest maturation.
- H3.2. Determine an index of habitat fragmentation. Determine optimum landscape design for long-term survival of the Schaus swallowtail butterfly.
- H3.2.1. Investigate flight patterns and the spatial utilization of habitat to identify important core areas and corridors.
- H3.2.2. Determine if the amount and configuration of habitat is sufficient to support a stable or increasing population of Schaus swallowtail butterflies.

Investigate the number and size of habitat patches, both occupied and unoccupied as well as any barriers, and determine if habitat patches are interconnected or isolated. Investigate the capacity of habitat patch networks to support populations of Schaus swallowtail butterflies and determine if some fragmented habitats may be too isolated or small to allow for adequate recolonization. Determine rates of recolonization in different habitat patches. Determine the minimum number of habitat patches necessary for long-term survival of the Schaus swallowtail butterfly.

- H4. Monitor the status of Schaus swallowtail butterfly habitat and examine ecological processes. Conduct yearly monitoring evaluations of the status of the Schaus swallowtail butterfly's habitat. Overlay habitat quality with GIS mapping of habitat locations, including habitat alteration and loss each year. Monitor the availability of Schaus swallowtail butterfly habitat through GIS by updating the loss or change of habitat due to residential or commercial construction.
- H4.1. Conduct long-term monitoring of habitat patches. Determine the rate and sequence of vegetative composition in maturing or regenerating forests.
- H4.2. Monitor primary and edge forest habitat. Determine how different habitat compositions affect the distribution and abundance of the Schaus swallowtail butterfly within primary forest and along edged habitat.
- H4.3. Monitor ongoing and proposed habitat restoration efforts. Restoration efforts in north Key Largo include efforts to remove and eradicate exotic species, remove trash debris, recreate habitat in scarified or degraded areas, and open canopy layer. Monitor habitat response from restoration efforts and determine the response of Schaus swallowtail butterfly.
- H5. Increase public awareness of Schaus swallowtail butterfly habitat and instill stewardship. Conduct workshops with the public to inform private landowners on appropriate management practices to preserve Schaus swallowtail butterfly habitat. Encourage private landowners to remove exotics, plant native vegetation, refrain from destroying butterfly habitat, and restore disturbed areas. Prepare literature to provide information regarding the Schaus swallowtail butterfly's habitat and ways to protect and conserve it.

The Plants

Recovery for the Crenulate Lead-plant, *Amorpha crenulata* (=herbacea Walt. var. *crenulata*)

(Rydberg) Isley)

Recovery Objective: PREVENT extinction, then stabilize.

Recovery Criteria: *Amorpha crenulata* will, most likely, never reach a level at which reclassification could be possible. The objective of this recovery plan is to increase existing populations and prevent extinction. *Amorpha crenulata* may be considered stabilized when existing populations, within the historic range, are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. These sites must also be managed to maintain areas to support *A. crenulata*. Monitoring programs should demonstrate that populations of *A. crenulata* on these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing a sufficient rate to maintain the population. Further, seedling establishment must be documented in the wild. This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be developed if new information identifies ways of re-establishing populations of this species to expand its distribution within its historic range.

Species-level Recovery Actions

- S1. Conduct surveys to determine distribution of crenulate lead-plants. Crenulate lead-plants on county-owned pine rockland sites have been thoroughly surveyed in Miami-Dade County. However, other populations may be noted during pine rockland purchase and restoration program implementation. Fire may eliminate litter concealing listed species, or enable seeds in the seed bank to germinate. For that reason, pine rocklands that did not contain listed species when unmanaged should be resurveyed after fire events.
- S2. Protect and enhance existing populations. It is imperative for the stabilization of crenulate leadplants that additional populations not be lost. The existing populations should be mapped, including obtaining GPS coordinates and developing GIS coverage. Herbarium voucher specimens should be collected and archived for all populations.
 - S2.1. Augment natural populations of crenulate lead-plants, where appropriate. Because many pine rockland plant species are in a precarious situation, *ex situ* collections exist for *A. crenulata*. If possible, additional collections should be established. These may be used to cultivate this species and augment sparse populations in protected areas. Experiments with reintroductions will be useful in the future, and could be essential for the recovery of the crenulate lead-plant species.
 - S2.2. Continue work with *ex situ* propagation and seed storage banks. Seeds should continue to be banked for all the listed species possible, and should be identified precisely as to collection location. Fairchild Tropical Garden has submitted seeds of crenulate lead-plant to the National Seed Storage Laboratory at Fort Collins,

Colorado to initiate studies on seed storage potential and methods. Propagation and cultivation methods have been developed by Fairchild Tropical Garden (D. Garvue et al., Fairchild Tropical Garden, personal communication 1998).

- S2.3. Continue to identify potential reintroduction sites and reintroduce pine rockland plants, where appropriate. Sites identified as suitable for reintroduction within the known historic range should be surveyed and prepared to receive plants. Federal lands under proper management regimes may be good recipient sites. These sites should receive reintroduction stock.
- S2.4. Enforce available protective legislation. State, Federal, and local regulations should be used to protect the pine rockland ecosystem and the listed plants. Use existing standard monitoring protocols.
 - S2.4.1. Initiate section 7 consultation when applicable. Section 7 of the ESA applies to Federal activities which might impact listed species, especially on Federal lands (former Richmond Naval Air Station lands, and the Perrine USDA site).
 - S2.4.2. Encourage implementation of management plans. Federal agencies are obligated under section 7(a)(1) of the ESA to conduct positive conservation programs for the benefit of listed species. Implementation of the Richmond Pine Rocklands Management Plan (DERM 1994) would constitute such a positive conservation program and should be implemented by the U.S. Army Reserve Center in Perrine, the U.S. Coast Guard site, the Department of Correctionís Miami Correctional Center, and any other Federal agency property owner in this area.
 - S2.4.3. Continue to enforce take and trade prohibitions. The listed pine rockland plants are protected by take and trade restrictions of the ESA and the Preservation of Native Flora Act. Since these are inconspicuous plants, take and trade are nonexistent or uncommon.
- S3. Collect biological information important to species recovery. Additional information on the ecology and life history of pine rockland plants needs to be collected. Determine size and viability of all populations. Known populations of the listed pine rockland plants should be evaluated. Population viability needs to be investigated and determined for each listed plant species.
 - S3.1. Continue to investigate and refine the habitat needs of crenulate leadplant.
 - S3.2. Determine population size and viability of all populations.

- S3.3. Study the reproductive biology of crenulate lead-plant.
 - S3.4. Conduct genetic studies to document the genetic variation within and between populations.
 - S3.5. Study the fire ecology of *A. crenulata*.
 - S3.6. Study the response of crenulate lead-plant to habitat management treatments.
- S4. Develop standardized monitoring. Standardized monitoring based upon the protocols developed by FNAI should be used for pine rockland species in order to determine the effect of management actions on these species and make the data compatible to existing databases.
- S4.1. Collect existing and historical data, and place in a central location. Contact former researchers for historical data, gather information from herbaria and museums, and contact all present researchers to compile data and place in GIS database in South Florida Ecosystem Office. This location will allow all researchers access to both historic and current data, and provide the FWS with a means to monitor the success of recovery tasks.
 - S4.2. Monitor status and success of all populations; change management practices if so indicated. Because of the varying vegetation conditions and fire histories, different management may be required at different pine rockland sites. Different prescribed burn intervals may be necessary for best results. Intervals should be adjusted over the years to promote pine re-establishment and hardwood reduction.
 - S4.3. Convene a meeting of researchers and land managers. A meeting of current pine rockland researchers and land managers would enable the FWS to locate information sources, and begin the process of compiling those data. The meeting would also afford cooperators an opportunity to discuss monitoring and management procedures and set realistic species level goals.
 - S4.4. Monitor reintroduction success and modify procedures as necessary. Plant reintroductions should be monitored to determine the success of the procedure. The goal of reintroduction should be to establish a viable population. Management of the reintroduction sites should be modified as necessary to improve results. The experimental outplanting conducted by Fairchild Tropical Garden at the Deering Estate should continue to be monitored for information that will help design future reintroductions.
- S5. Continue to provide public information about pine rocklands and their unique flora. Public

support will increase the chances of recovery for pine rockland species. Informational and educational materials have been produced. DERM and Miami-Dade County Parks and Recreation Department's Natural Areas Management have developed flyers, displays, newsletters, and press releases, and have held workshops with the general public. Organizations best able to carry out information and education programs include: Metropolitan Miami-Dade County Parks and Recreation Department, the Florida Native Plant Society, Everglades National Park, and Miami-Dade County DERM. Support of local press coverage should continue. DERM has developed a web that will also aid in disseminating information about this endangered plant community to the public.

Habitat-level Recovery Actions

- H1. Develop a GIS database on all listed pine rockland species and their habitats, and distribute the database to researchers, land managers, and conservationists.
 - H1.1. Assess the available GIS data.
 - H1.2. Create coverage of population locations.
 - H1.3. Acquire recent imageries of the sites.
 - H1.4. Distribute the coverage.
- H2. Continue to protect and prevent degradation of pine rockland plant habitat. The decline of the five listed pine rockland plants is due to the almost complete elimination or alteration of pine rocklands in South Florida. Without protection and proper management, the remaining rockland sites will be developed or will deteriorate.
 - H2.1. Protect pine rockland habitat. Acquisition of remaining private sites may be the only effective way to protect or conserve pine rockland habitat. Miami-Dade County's Environmentally Endangered Lands program and the State of Florida's CARL program have acquired over 450 acres of pine rocklands since 1990. It should be noted that public lands may still be subject to development for recreational, maintenance, or other purposes. Such disturbances, unless carefully planned, may directly destroy pine rockland and may secondarily result in exotic plant infestations as well as destructive human uses.
 - H2.2. Protect or acquire privately owned sites. Less than fee simple acquisition should be used, where appropriate, as an alternative means of protecting pine rockland habitat. Covenants, as provided for under Miami-Dade County regulations, provide tax incentives for private landowners to protect pine rockland sites. A site owned by Florida Power and Light Company may be maintained through cooperation with that utility. This avenue of protection should also be pursued with the railroad

company that owns the site of one of the three largest populations. Miami-Dade County DERM is developing a private lands management and grant program for pine rockland protection and restoration. This program should be implemented as soon as possible.

H2.3. Implement additional management to meet habitat needs.

H2.3.1. Eliminate human-caused degradation. Preventing trash dumping or other destructive human activities in pine rocklands is important. In order to accomplish this task, fencing and access restrictions may be necessary. Mowing of the crenulate lead-plant habitat at A.D. Park should be halted and the habitat allowed to recover.

H2.3.2. Control invasive plant species, particularly exotics. Burma reed, or persistent hardwoods need to be controlled and may require special techniques including herbicide, fire, mechanical, and hand clearing at most sites. Other management needs indicated by ongoing research should also be implemented. The two crenulate lead-plants at Matheson Hammock are being suppressed by a closed hardwood canopy.

H3. Restore areas to suitable habitat.

H3.1. Eliminate physical degradation of habitat and restore to optimal conditions. Physical degradation of pine rocklands continues to occur, and hurricane Andrew in 1992 killed most of the adult pines in the Richmond tract and elsewhere in Miami-Dade County. The continued degradation of these areas should be curtailed and restoration of uneven-aged pine stands should be undertaken. Tubelings, or direct seeding experiments may be used to accomplish this task. In order to use direct seeding techniques, collection of local pine seeds must continue.

H3.2. Develop best management practices for pine rocklands. This would include development of fire management strategies that would best benefit pine rockland species. Studies specifically on the response of crenulate lead-plant to alternative fire management treatments should be implemented.

H3.3. Implement necessary management. Without active fire and exotic plant management, pine rocklands will continue to disappear or degrade. Because of the highly fragmented and restricted nature of remaining pine rocklands, intensive management may be necessary at many of the remaining sites. The existing management plans for sites that include crenulate lead-plant should continue to be implemented and modified as necessary for the benefit of this species.

- H3.4. Continue to expand prescribed burning. Prescribed fire should be conducted at crenulate lead-plant sites at the appropriate times of the year to lower fuel loads. Growing season burns should then be employed after fuel levels are under control. The response to crenulate lead-plant to prescribed burns should be studied. Special consideration must be incorporated when planning prescribed fire for pine rocklands invaded by Burma reed. Incorporate appropriate actions to minimize additional Burma reed infestations in these areas. Due to the highly urbanized lands surrounding some of the pine rockland sites, burning involves risks of smoke damage and annoyance, or worse, losing control of the fire. The Florida Division of Forestry has expertise in carrying out controlled burns in Miami-Dade County, and should be contacted to assist with burns. Fire management is necessary for all Federal and County lands. Miami-Dade County is composing a Strategic Fire Management Plan. This plan should be implemented once approved.
- H4. Monitor habitat and ecological processes.
- H4.1. Monitor sites with crenulate lead-plant populations to determine success. A protocol developed by Fairchild Tropical Garden for monitoring the plant communities at crenulate lead-plant sites should be implemented.
- H4.2. Investigate fire history and incorporate into management strategies. Look at fire history for pine rocklands in Miami-Dade County, incorporate into GIS database and analyze relative to healthy populations. This exercise will provide adequate information on fire history and intervals in urbanized and non-urbanized settings and enable assessment of the appropriateness of proposed management regimes in Miami-Dade County.
- H4.3 Rehydrate soils where feasible. A monitoring protocol should be developed and implemented that examines the relationship between hydric soils and the recruitment and survival of seedlings at these sites.
- H5. Continue implementation of the fire education program and modify as necessary any fire management education program that has been developed. Future modifications to this program may include tri-lingual language (Spanish, English, and Haitian Creole).

Recovery for the Florida Bonamia, *Bonamia grandiflora* (A. Gray) Heller

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: STABILIZE and increase the population.

Recovery Criteria: The South Florida Recovery objective can be achieved when: sites within the historic range of *B. grandiflora*, are adequately protected from habitat loss, degradation,

and fragmentation; when these sites are managed to maintain the seral stage of xeric oak scrub communities to support *B. grandiflora*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species. Currently, most protected *B. grandiflora* individuals are protected on the Ocala National Forest. To adequately conserve the species, protected sites are needed throughout its entire range, including South Florida.

Species-level Recovery Actions

- S1. Determine current distribution of *B. grandiflora*. Some portions of *B. grandiflora*'s range have been well surveyed (Ocala NF and the southern Lake Wales Ridge), yet a distribution has not been ascertained for this species. Lack of survey knowledge in much of its range makes defining distribution difficult.
 - S1.1. Conduct surveys for additional populations of *B. grandiflora*.
 - S1.1.1. Survey scrub habitat in Osceola, Charlotte, Hardee, and Hendry counties. Adequate survey work has not been performed off the Lake Wales Ridge. Sites on private property should be surveyed and we should work with landowners to protect them.
 - S1.1.2. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has probably been adequately surveyed, though new sites for *B. grandiflora* may still be found.
 - S1.1.3. Continue surveys for *B. grandiflora* on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
 - S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases,

isolated. For this reason, existing populations are in need of protection from a variety of threats.

- S2.1. Acquire or otherwise protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.
- S2.2. Protect populations of *B. grandiflora* on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable habitat, both unoccupied and occupied of *B. grandiflora*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *B. grandiflora*.
 - S2.4.1. Conserve germ plasm. The seed for this species is not presently in longterm storage.
 - S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *B. grandiflora* as part of the National Collection.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from overcollecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *B. grandiflora* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from state lands.

- S3. Conduct research on life history characteristics of *B. grandiflora*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *B. grandiflora*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *B. grandiflora*.
- S4.1. Develop monitoring protocol to assess population trends for *B. grandiflora*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *B. grandiflora*. Assess any changes in demographic characteristics of *B. grandiflora* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *B. grandiflora*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's microsite (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.
- S5. Provide public information about *B. grandiflora*. It is important for the recovery of this

species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *B. grandiflora* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both development and fire suppression have decreased the available habitat. To date, there are five protected sites for *B. grandiflora* in Polk and Highlands counties; however there are no protected sites in Charlotte, Hendry, Hardee, or Osceola counties.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *B. grandiflora* populations by preventing damage from off-road vehicle use, and from over collection, and by providing proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *B. grandiflora*.
- H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.

- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *B. grandiflora* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *B. grandiflora* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Four-petal Pawpaw, *Asimina tetramera* Small

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: *Asimina tetramera* may be reclassified from endangered to threatened when enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to ensure 20 to 90 percent probability of persistence for 100 years;

when sites within the historic range of *A. tetramera* are adequately protected from further habitat loss, degradation, and fragmentation; when these sites are managed to maintain the coastal sand pine scrub communities to support *A. tetramera*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed periodically based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

- S1. Determine current distribution of *A. tetramera*. Some portions of *A. tetramera*'s range have been well surveyed yet a total distribution has not been ascertained for this species. A thorough survey is needed to determine the distribution for this species.
- S1.1. Conduct surveys for additional populations of *A. tetramera*.
 - S1.1.1. Continue surveys in Palm Beach and Martin counties. Although the range of this species has been surveyed, sites may still be located that have *A. tetramera* populations.
 - S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
 - S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate with the Florida Natural Areas Inventory to update their database.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Atlantic Coastal Ridge has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Acquire or otherwise protect privately-owned habitat through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations of *A. tetramera* on public lands. Develop management

- guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available Regional and county planning processes to encourage protection of suitable, unoccupied, and occupied habitat of *A. tetramera*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collecting can preserve genetic diversity, preventing loss of the species, and determine ecological characteristics and habitat management needs. These collections will be instrumental in the recovery of *A. tetramera*. Since long-term seed storage is impossible for this species, cultivated populations are very important. *Asimina tetramera* is easily grown from seed, but cannot be grown from cuttings. Seeds should be periodically planted to maintain populations for study and to be used as seed sources for reintroduction.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from overcollecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *A. tetramera* occurs.
- S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
- S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from state lands.
- S2.6. Augment natural populations of *A. tetramera*. Augmentation of populations on protected land is appropriate because there is little prospect for protecting additional sites.
- S2.6.1. Establish a protocol for reintroduction. Records for source plants, techniques for establishing new populations, and protocols for monitoring are needed.
- S2.6.2. Locate potential (re)introduction sites. Survey habitat within the historic range of *A. tetramera* and identify protected lands, both public and private, that will be suitable for (re)introduction.

- S2.6.3. (Re)introduce plants to protected sites. Plant seeds from nearby stable populations to re-establish plants in suitable habitat.
- S3. Continue research on life history characteristics of *A. tetramera*. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality. Observations of the relationship of flowering to fire, pollination, seed production, and seedling biology will help to guide reintroduction efforts.
- S3.2. Once demographic data are known, conduct a population viability and risk assessment analysis to determine the number of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.3. Conduct research to assess management requirements of *A. tetramera*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring will provide information contributing to a better understanding of population increases or declines for each site. Population monitoring should be in relation to various habitat management practices. Site-specific management guidelines should be provided to land managers. Close coordination among land managers is essential to develop appropriate management techniques.
- S3.4. Assess feasibility of relocating *A. tetramera*. Removing plants threatened with destruction has only been marginally successful. Information on transplant techniques and plant survival is needed to assess whether transplanting should be pursued in the future. Seeds should be collected from reproductive plants and planted on reintroduction sites.
- S4. Monitor existing populations of *A. tetramera*.
- S4.1. Develop monitoring protocol to assess population trends for *A. tetramera*.
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
- S4.1.2. Monitor the effects of various land management actions on *A. tetramera*. Assess any changes in demographic characteristics of *A. tetramera* in

response to land management activities, such as prescribed fire, exotic plant control, etc.

- S4.2. Develop a quantitative description of the population structure of *A. tetramera*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's microsite (vegetation cover, litter depth, substrate, and closest neighbors) may prove helpful in future management.
- S4.3. Monitor introduced plants. Monitoring of reintroduced plants will be essential for assessing the status of new plants and their contribution to the population as a whole. Compare adult survival, seed production, germination rates, seed survival, seedling survival, and growth rates between transplanted plants and natural plants. Where monitoring indicates that the introduction has been unsuccessful, reevaluate protocol and methodology.
- S5. Provide public information about *A. tetramera*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *A. tetramera* and other rare species requires self-sustaining, secure, natural populations in existing native scrub habitat.
- S6. Establish delisting criteria. Once reclassification is achieved, research and monitoring results may provide data necessary to develop delisting criteria.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are two protected sites in Martin County and eight protected sites in Palm Beach County.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *A. tetramera* populations

by preventing damage by off-road vehicle use, prohibiting seed collection, and providing proper management of habitat, including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and an integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of a heterogeneous matrix of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible. *A. tetramera* appears to benefit from burning at irregular intervals of several decades or more.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not major threats in sand pine scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *A. tetramera*.

H1.2.3. Control access to areas where listed plants are growing. Trampling and off-road vehicles can severely threaten individual populations. Fencing may be needed for some sites, and clearing around individual *A. tetramera* plants has been suggested.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire and too frequent fires may shift the species composition and alter the structure of scrub habitats. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites seed banks may exist that could include other rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. On these sites, seed banks may exist for other rare endemic species, but if fire has been excluded for too long or applied too often, seed banks may not be present. Although *Asimina tetramera* does not have a seed bank, areas of unburned vegetation may provide refugia for *A. tetramera* seed dispersal by small animals.

H3. Continue habitat-level research projects. A current study at Jonathan Dickinson State Park is looking at the response of *A. tetramera* to various land management practices, such as

prescribed fire regimes, mechanical chopping, and biomass removal. Researchers are hoping to provide answers to optimal disturbance interval, under conditions which mechanical alternatives will work, and the reproductive responses of *A. tetramera* to management applications.

- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, mechanical disturbance, etc., on the habitats where *A. tetramera* occurs.
- H5. Provide public information about xeric vegetative communities and their unique biota. Educational efforts, especially those conducted by private conservation organizations, have been successful in providing important information about xeric plant communities to the public. The State's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations and others such as the Florida Park Service, the Florida Native Plant Society, and local garden clubs play crucial roles in increasing public appreciation of xeric plant communities and *A. tetramera*.

Recovery for the Garber's Spurge, *Chamaesyce garberi* (Engelman ex Chapman) Small

Recovery Objective: STABILIZE, then delist.

Recovery Criteria: *Chamaesyce garberi* may be considered stabilized when existing populations, within the historic range of *C. garberi*, are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. These sites must also be managed to maintain pine rocklands to support *C. garberi*. Once the existing populations are stabilized, *C. garberi* may be considered for delisting. Delisting will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 95 percent probability of persistence for 100 years; when these populations, within the historic range of *C. garberi*, are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression; when these sites are managed to maintain the pine rocklands to support *C. garberi*; and when monitoring programs demonstrate that populations of *C. garberi* on these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information on the species. Delisting criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its distribution within its historic range.

Species-level Recovery Actions

- S1. Conduct surveys to determine distribution of pine rockland plants. Pine rockland plants were thoroughly surveyed in Miami-Dade County; however, the status of *Chamaesyce garberi* is not known over its entire range.
 - S1.1. Inventory known populations. Conduct thorough ground surveys to determine the distribution of *C. garberi*. Collect and archive herbarium voucher specimens for all populations. Initiate a quarterly monitoring program. Use existing standardized monitoring protocols developed by the Florida Natural Areas Inventory to record baseline data regarding the biology and ecology of *C. garberi*.
 - S1.2. Resurvey historic locations. Search for additional populations of *C. garberi* in the Florida Keys. Resurvey historic locations. Conduct thorough ground surveys to locate unrecorded individuals and populations of *C. garberi*.
 - S1.3. Map distribution of known populations and suitable habitat. Map populations, including obtaining GPS coordinates and developing GIS coverages.
- S2. Protect and enhance existing populations. It is imperative for the recovery of pine rockland plants that additional populations not be lost.
 - S2.1. Augment natural populations of listed pine rockland plants, where appropriate. *Ex situ* collections exist for many rare pine rockland species. These collections should be used to cultivate pine rockland plants and augment sparse populations in protected areas. These experiments with reintroductions will be useful in the future, and could be essential for the recovery of pine rockland plant species. The principles of restoration genetics should be understood and applied when carrying out this task.
 - S2.1.1. Continue work with *ex situ* propagation and seed banks. Seeds should continue to be banked for all the listed species possible, and should be identified precisely as to collection location. A genetic ally representative *ex situ* conservation collection does not exist for *C. garberi*. Initiate work with *ex situ* propagation and seed storage banks. Identify seed storage potential and methods. Identify germination and propagation protocols.
 - S2.1.2. Identify potential reintroduction sites and reintroduce *C. garberi*, where appropriate. Sites identified as suitable for reintroduction within the known historic range of *C. garberi* should be surveyed and prepared to receive plants. Study the feasibility of translocating propagules into historically appropriate and protected natural habitats. Federal lands under proper management regimes may be good recipient sites. Use

reintroduction protocols established by the conservation community.

- S2.1.3. Monitor the experimental outplantings. Monitoring of reintroduced plants is essential for assessing the success of recovery efforts. Growth and survivorship should be measured.
- S2.2. Enforce available protective legislation. State, Federal, and local regulations should be used to protect the pine rockland ecosystem and the listed plants.
 - S2.2.1. Initiate section 7 consultation when applicable. Section 7 of the Endangered Species Act applies to Federal activities which might impact listed species, especially on Federal lands (Everglades NP, National Key Deer Refuge).
 - S2.2.2. Encourage implementation of management plans. Federal agencies are obligated under section 7(a)(1) of the ESA to perform positive conservation programs for the benefit of listed species. Development of management plans to benefit pine rocklands in Everglades NP and areas in the Florida Keys would constitute positive conservation programs.
 - S2.2.3. Continue to enforce take and trade prohibitions. The listed pine rockland plants are protected by take and trade restrictions of the ESA, the Preservation of Native Flora Act, and the regulations of Everglades NP. Since these are inconspicuous plants, take and trade are nonexistent or uncommon.
- S3. Collect biological information important to species recovery. Additional information on the ecology and life history of pine rockland plants needs to be collected. The size and viability of known populations of *C. garberi* needs to be evaluated.
 - S3.1. Investigate the reproductive biology of *C. garberi*. A better understanding of the genetics and reproduction of this species is needed.
 - S3.2. Identify demographics and gene flow in *C. garberi*. Determine the size and viability of all populations. Conduct studies to document the genetic variation within and between populations.
 - S3.3. Study the response of *C. garberi* to habitat management treatments. Study the fire ecology of *C. garberi*.
 - S3.4. Characterize the habitat and identify suitable sites for experimental outplantings. Apply and modify, if need be, reintroduction protocols established by the

conservation community.

- S4. Monitor *C. garberi* populations. Use existing standardized monitoring protocols developed by the Florida Natural Areas Inventory to record baseline data regarding the biology and ecology of *C. garberi*. Determine the effects of management actions on *C. garberi*. Initiate quarterly monitoring programs.
- S4.1. Collect existing and historical data and place in a central location. Contact former researchers for historical data, gather information from herbaria and museums, and contact all present researchers to compile data and place in GIS database in the FWS South Florida Ecosystem Office. This location will allow all researchers access to both historic and current data, and provide the FWS with a means to monitor the success of recovery tasks.
- S4.2. Convene a meeting of all researchers. A meeting of current pine rockland researchers and land managers would enable the FWS to locate information sources, and begin the process of compiling those data. The meeting would also afford cooperators an opportunity to discuss monitoring and management procedures and set realistic species-level goals.
- S4.3. Monitor status and success of all populations and change management practices if so indicated. Because of the varying vegetation conditions and fire history, different management may be required at different pine rockland sites. Different prescribed burn intervals may be necessary for best results. Intervals should be adjusted over the years to promote pine re-establishment and hardwood reduction.
- S4.4. Monitor reintroduction success and modify procedures as necessary. Plant reintroductions should be monitored to determine the success of the procedure. The goal of reintroduction should be to establish a viable population. Management of the reintroduction sites should be modified as necessary to improve results.
- S5. Continue implementation of the fire education program and modify as necessary any fire management education program that has been developed. Future modifications to this program may include tri-lingual distribution (Spanish, English, and Haitian Creole).

Habitat-level Recovery Actions

- H1. Continue to protect pine rockland plant habitat in order to prevent degradation. The decline of the five listed pine rockland plants is due to alteration of pine rocklands in South Florida. Without protection and proper management, the rockland sites in the Keys may undergo the same destruction.
- H1.1. Protect pine rockland habitat. Acquisition of remaining private sites is an effective

way to protect or conserve pine rockland habitat. Purchase of additional parcels in the Lower Keys would also benefit the Key deer. It should be noted that public lands may still be subject to development for recreational, maintenance, or other purposes. Such disturbances, unless carefully planned, may directly destroy pine rockland and may secondarily result in exotic plant infestations as well as destructive human uses.

- H1.2. Protect or acquire privately owned sites. Less-than-fee-simple acquisition should be used where appropriate as an alternative means of protecting pine rockland habitat. Miami-Dade County DERM is developing a private lands management and grant program for pine rockland protection and restoration. Monroe County should develop and implement a similar program.
- H1.3. Develop and implement best management practices for pine rocklands. This would include development of fire management strategies that would best benefit pine rockland species. Without active fire and exotic plant management, pine rocklands will continue to disappear or degrade. Because of the restricted nature of pine rocklands, intensive management may be necessary at many of the remaining sites.
- H1.4. Continue to conduct prescribed burns. Fire should be conducted at appropriate times of year to lower fuel loads. Growing season burns should be employed most often after fuel levels are under control. Special consideration must be included when planning prescribed fire for pine rocklands invaded by Burma reed or Cogon grass (*Imperata cylindrica*). Incorporate appropriate actions to minimize additional Burma reed or Cogon grass infestations in these areas. Due to the highly urbanized lands surrounding some of the pine rockland sites in the Keys, burning involves risks of smoke damage and annoyance, or worse, losing control of the fire. The Florida Division of Forestry has expertise in carrying out controlled burns in Miami-Dade County, and should be contacted to assist with burns in Monroe County. A regional pine rockland burn plan needs to be developed between the Federal, State, and County resource agencies and funding provided.
- H1.5. Implement additional management to meet habitat needs.
 - H1.5.1. Eliminate human-caused degradation. Preventing trash dumping or other destructive human activities in pine rocklands is important. In order to accomplish this task, fencing and access restrictions may be necessary.
 - H1.5.2. Control invasive plant species, particularly exotics. Burma reed, cogon grass, and persistent hardwoods need to be controlled and may require special techniques including herbicide, fire, mechanical, and hand clearing at most sites. Other management needs indicated by ongoing research

should also be implemented.

H2. Restore areas to suitable habitat.

- H2.1. Eliminate physical degradation of habitat and restore to optimal conditions. Physical degradation of pine rocklands continues to occur. Hurricane Andrew, in 1992, killed most of the adult pines in Miami-Dade County. The adult pines on Long Pine Key in Everglades NP were not as severely damaged (Herndon, 1998). The continued degradation of these areas should be curtailed and restoration of uneven-aged pine stands undertaken. Tubelings or direct seeding experiments may be used to accomplish this task. In order to use direct seeding techniques, collection of local pine seeds must continue.
- H2.2. Continue to refine management practices for pine rocklands. Management plans for sites including *C. garberi* should be implemented and modified as necessary for the benefit of this species.
- H2.3. Continue to conduct prescribed burns. Prescribed burns should be conducted at sites where *C. garberi* occurs at appropriate time of the year to lower fuel loads. Growing season burns should then be employed after fuel loads are under control. The response to *C. garberi* to prescribed burns should be studied.

H3. Conduct habitat-related research.

- H3.1. Continue to investigate and refine the habitat needs of each species. The habitat needs of these species have been studied, but are still not completely understood. The pollination, germination, and growth requirements have not been fully investigated. Research should address how light levels affect survival and how fire management affects light levels, reproduction, and regeneration of these species.
- H3.2. Investigate fire history and incorporate into management strategies. Look at fire history for pine rocklands in Miami-Dade County, Everglades NP, and Monroe County. Incorporate results into GIS database and analyze fire history relative to healthy populations. This exercise will provide adequate information on fire history and intervals in urbanized and non-urbanized settings and enable assessment of the appropriateness of proposed management regimes.
- H3.3. Monitor sites with *C. garberi* to determine success. A protocol developed by Fairchild Tropical Garden for monitoring plant communities at sites where *C. garberi* occur should be implemented.
- H3.4. Develop a GIS database on the five listed pine rockland species and their habitats.

Distribute the database to researchers, land managers, and conservationists.

H3.2.1. [sic] Assess the availability of GIS data. Create coverage of population locations, acquire recent imageries of the sites, and distribute the coverages to researchers, land managers, and conservationists.

Recovery for the Pygmy Fringe-tree, *Chionanthus pygmaeus* Small

Recovery Objective: STABILIZE, then reclassify to threatened.

Recovery Criteria: *Chionanthus pygmaeus* may be considered stabilized when existing populations, within the historic range of *C. pygmaeus*, are adequately protected from further habitat loss, degradation, and fire suppression. Large areas of land are needed to support populations of this tree/shrub species. These sites must also be managed to maintain xeric oak scrub to support *C. pygmaeus*. Habitat destruction is occurring at an alarming rate. To ensure the survival of this species, actions must be taken to protect its remaining habitat. Difficulty in conserving this species may be compounded by the low seed germination rates that could affect this plant's ability to rebound from a reduction of adult individuals.

Once the existing populations are stabilized, *C. pygmaeus* may be considered for reclassification to threatened. Delisting will only be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 95 percent probability of persistence for 100 years; when these populations, within the historic range of *C. pygmaeus*, are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the serial stage of xeric oak scrub to support *C. pygmaeus*; and when monitoring programs demonstrate that these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *C. pygmaeus*. This species' distribution is somewhat questionable for taxonomic reasons and ease of overlooking individuals. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for additional populations of *C. pygmaeus*.

S1.1.1. Survey scrub habitat in Hardee County. Adequate survey work has not been performed off the Lake Wales Ridge. Sites on private property

cannot be protected without survey knowledge, yet they may be difficult to survey.

- S1.1.2. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has been well surveyed, though new sites may still be found. In Highlands County, the area south of Saddle Blanket Lakes needs more surveying.
- S1.1.3. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
- S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
 - S2.1. Protect populations on private land through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that results in the formation of a mosaic of successional stages.
 - S2.3. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *C. pygmaeus*.
 - S2.3.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
 - S2.3.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation

coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *C. pygmaeus* as part of the National Collection.

- S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species from overcollecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *C. pygmaeus* lives.
- S2.4.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species. Enforce take and trade prohibitions. This species is protected by take S2.4.2. provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species, more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as number of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality. Information is especially needed on reproduction, pollination biology, and recruitment in this species.
- S3.2. Identify the relationship *C. pygmaeus* has with the weevils that infest its fruits. This infestation is believed not to affect the species, but with such low recruitment, the weevils should be researched to verify their role in recruitment.
- S3.3. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.4. Conduct research to assess management requirements of *C. pygmaeus*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should

be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.

- S4. Monitor existing populations of *C. pygmaeus*.
 - S4.1. Develop monitoring protocol to assess population trends for *C. pygmaeus*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *C. pygmaeus*. Assess any changes in demographic characteristics of *C. pygmaeus* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *C. pygmaeus*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's microsite (vegetation cover, litter depth, substrate, and closest neighbors) may prove to be helpful in future management.
- S5. Provide public information about *C. pygmaeus*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. However, caution should be taken to avoid revealing specific locality information of *C. pygmaeus*. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *C. pygmaeus* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are 13 protected or acquisition sites for *C. pygmaeus*.
 - H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Little xeric scrub habitat is remaining for this species. Any method of

securing protected populations should be sought.

H1.2. Manage and enhance habitat. Manage habitat to maintain *C. pygmaeus* populations by preventing damage from off-road vehicle use and overcollection, and by providing proper management of habitat, including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established, and agricultural conversions are becoming more prevalent. Without control, exotic/invasive plants may become a threat to the survival and recovery of *C. pygmaeus*.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

H3. Conduct habitat-level research projects. Study the response of *C. pygmaeus* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *C. pygmaeus* occurs.

H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Florida Perforate Cladonia, *Cladonia perforata* Evans

Recovery Objective: RECLASSIFY to threatened.

Conduct surveys for additional populations of *C. perforata* in South Florida.

Recovery Criteria: *Cladonia perforata* may be reclassified from endangered to threatened when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 20 to 90 percent probability of persistence for 100 years; when these sites, within the historic range of *C. 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 *C. perforata*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies new ways of re-establishing populations of this species to expand its distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *C. perforata*. This species' known distribution is scattered from the panhandle area of Florida south to Martin and Palm Beach counties in South Florida with large areas having no individuals. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for additional populations of *C. perforata* in South Florida.

S1.1.1. Survey scrub and high pine habitat for *C. perforata* in Osceola, Hardee,

and Hendry counties. Adequate survey work has not been performed off the Lake Wales Ridge. Sites on private property cannot be protected without survey knowledge.

- S1.1.2. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has been well surveyed, though new sites are still being found. This species by nature is hard to identify and dispersed sparsely. Survey work should continue for this species.
- S1.1.3. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites.
- S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population areas and cover, and status. This information should also be used for project review and in land acquisition activities.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
 - S2.1. Protect populations on private land through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
 - S2.3. Prepare post-hurricane restoration plans for the southeast Florida counties.
 - S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species from overcollecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *C. perforata* lives.
 - S2.4.1. Initiate section 7 consultations when Federal activities may affect this species. In particular, it will be important to consult with the Florida DOT and the Federal Highway Administration to protect occupied habitat of *C. perforata* from further fragmentation and the secondary effects of road

construction.

- S2.4.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S2.5. Initiate *ex situ* conservation of *C. perforata*. *Ex situ* collections can preserve genetic diversity, prevent loss of the species, and determine ecological characteristics and habitat management needs. These collections may be instrumental in the recovery of *C. perforata*, although lichens are known to be quite difficult to culture. The efforts of organizations like the Center for Plant Conservation of the Missouri Botanical Gardens, which collect, store, and maintain the germ plasm of rare species should continue to be supported. Emphasis should be placed on culturing techniques rather than trying to maintain living symbioses.
- S3. Conduct research on life history characteristics of *C. perforata*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
- S3.2. Continue research to better understand the mechanisms of establishment of *C. perforata*, the effects of translocations of fragments, and the effects of fire on survival.
- S3.3. Once demographic data are known, conduct population viability and risk assessment analysis to determine the spatial distribution needed to ensure persistence of the species.
- S3.4. Conduct research to assess management requirements of *C. perforata*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring will provide information on the localities of *C. perforata* sites, and on the factors contributing to any declines at each site. Site-specific management guidelines should be provided to land managers.

- S4. Monitor existing populations of *C. perforata*.
- S4.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for herbivory, disease and injury.
 - S4.2. Monitor the effects of various land management actions on *C. perforata*. Assess any changes in demographic characteristics of *C. perforata* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.3. Develop a quantitative description of the population structure of *C. perforata*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's (or fragment's) microsite (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.
- S5. Provide public information about *C. perforata*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about where *C. perforata* is found. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *C. perforata* and other rare species requires a self-sustaining, secure, number of natural populations.
- S6. Establish delisting criteria. Once reclassification is achieved, research and monitoring results may provide data necessary to develop delisting criteria.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are 15 protected sites for *C. perforata* in South Florida.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Little xeric scrub habitat is remaining for this species; any method of securing in situ protected populations should be sought.
 - H1.2. Manage and enhance habitat. Manage habitat to maintain *C. perforata* populations

by preventing damage from off-road vehicle use and overcollection, and by providing proper management of habitat including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. The scrub landscape is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in this species habitat as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *C. perforata*.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

H3. Conduct habitat-level research projects. Study the response of *C. perforata* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation. Although recently studied, questions still exist on management reactions.

H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *C. perforata* occurs.

H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. The

State's system of biological preserves depends for its funding and future success on a broad base of public understanding and support. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, the Florida Park Service, the Florida Native Plant Society and local garden clubs play crucial roles in increasing public appreciation of scrub, high pineland vegetation, and their plant species.

Recovery for the Pigeon Wings, *Clitoria fragrans* Small

Recovery Objective: DELIST the species once recovery criteria are met.

Recovery Criteria: *Clitoria fragrans* may be delisted when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to ensure 95 percent probability of persistence for 100 years; when these sites, within the historic range of *C. fragrans*, are adequately protected from habitat loss, degradation, and fragmentation; when these sites are managed to maintain the ecotone between xeric oak scrub and high pine that supports *C. fragrans*; and when monitoring programs demonstrate that populations of *C. fragrans* on these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

Species-level Recovery Actions

S1. Determine current distribution of *C. fragrans*. Some portions of *C. fragrans*'s range have been well surveyed, yet a total distribution has not been ascertained for this species. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for additional populations of *C. fragrans*.

S1.1.1. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has probably been adequately surveyed, though new sites for *C. fragrans* may still be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This

information would show potential habitat for scrub endemics based on their habitat needs.

- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Acquire or otherwise protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
 - S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable habitat, both unoccupied and occupied of *C. fragrans*.
 - S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *C. fragrans*.
 - S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
 - S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *C. fragrans* as part of the National Collection.
 - S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from overcollecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *C. fragrans* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and

reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.

- S3. Conduct research on life history characteristics of *C. fragrans*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species, more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
- S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.3. Conduct research to assess management requirements of *C. fragrans*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor populations of *C. fragrans*.
- S4.1. Develop monitoring protocol to assess population trends for *C. fragrans*.
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
- S4.1.2. Monitor the effects of various land management actions on *C. fragrans*. Assess any changes in demographic characteristics of *C. fragrans* in response to land management activities, such as prescribed fire, exotic plant control, etc.
- S4.2. Develop a quantitative description of the population structure of *C. fragrans*. This description will provide a baseline for monitoring population dynamics in response

to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's microsite (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.

- S5. Provide public information about *C. fragrans*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about where *C. fragrans* is found. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *C. fragrans* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are eight protected sites for *C. fragrans* in Polk and Highlands counties.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *C. fragrans* populations by preventing damage from off-road vehicle use, and overcollection, and by providing proper management of habitat, including prescribed fire.
- H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *C. fragrans*.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *C. fragrans* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *C. fragrans* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Short-leaved Rosemary, *Conradina brevifolia* Shinnery

Recovery Objective: STABILIZE, then reclassify to threatened.

Recovery Criteria: The short-leaved rosemary may be considered stabilized when existing populations, within its historic range, are adequately protected from further habitat loss, degradation, and fire suppression. These sites must also be managed to maintain sand pine scrub. Land acquisition is critical for this species. The most important sites for acquisition are the Carter Creek scrub tract and Avon Park Lakes site.

Reclassification to threatened of this species will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *C. brevifolia*, are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain sand pine scrub; and when monitoring demonstrates that these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *C. brevifolia*. Some portions of *C. brevifolia*'s range have been well surveyed yet a total distribution has not been ascertained for this species. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for additional populations of *C. brevifolia*.

S1.1.1. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has probably been adequately surveyed, though new sites for *C. brevifolia* may still be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Map existing populations and assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This

information would show potential habitat for scrub endemics based on their habitat needs.

- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection.
- S2.1. Acquire or protect privately owned habitat through acquisition, conservation easements, or agreements with landowners. Acquisition of Saddle Blanket Lakes, Carter Creek, and Avon Park Lakes is crucial to the survival of this species.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable habitat, both unoccupied and occupied of *C. brevifolia*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *C. brevifolia*.
- S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
- S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *C. brevifolia* as part of the National Collection.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *C. brevifolia* is found.
- S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
- S2.5.2. Enforce take and trade prohibitions. This species is protected by take

provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.

- S3. Conduct research on life history characteristics of *C. brevifolia*. Little is known of the basic biology and ecology of this species. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
- S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.3. Conduct research to assess management requirements of *C. brevifolia*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor populations of *C. brevifolia*.
- S4.1. Develop monitoring protocol to assess population trends for *C. brevifolia*.
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
- S4.1.2. Monitor the effects of various land management actions on *C. brevifolia*. Assess any changes in demographic characteristics of *C. brevifolia* in response to land management activities, such as prescribed fire, exotic plant control, etc.
- S4.2. Develop a quantitative description of the population structure of *C. brevifolia*. This

description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data are also needed about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors).

- S5. Provide public information about *C. brevifolia*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit, since the recovery of *C. brevifolia* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. Of the 30 sites known to support *C. brevifolia* in Polk and Highlands counties, only five are protected.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of protecting habitat that supports *C. brevifolia* should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *C. brevifolia* populations by preventing habitat damage from off-road vehicle use and overcollection, and by providing proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. Appropriate seasonality and a variable interval in fire return are important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. Scrub vegetation is naturally made up of islands of suitable and unsuitable habitat. To replicate this landscape pattern, sites should be burned to create a mosaic of successional stages when possible.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared

to other habitats in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *C. brevifolia*.

- H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer areas remaining, they may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species may be reintroduced if natural colonization is no longer possible.
- H3. Conduct habitat-level research projects. Study the response of *C. brevifolia* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *C. brevifolia* occurs.
- H5. Provide public information about scrub and its unique biota. Educational programs, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing programs by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating information about these unique communities.

Recovery for the Avon Park Harebells, *Crotalaria avonensis* (K.R. DeLaney and Wunderlin)

Recovery Objective: PREVENT EXTINCTION, then stabilize.

Recovery Criteria: The Avon Park harebells will, most likely, never reach a level at which reclassification could be possible. The objective of this recovery plan is to increase existing populations and prevent extinction. This species may be considered stabilized when existing populations, within the historic range, are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. These sites must also be managed to support *C. avonensis*.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be developed if new information identifies ways of re-establishing populations of this species to expand its distribution within its historic range.

Species-level Recovery Actions

- S1. Determine current distribution of *C. avonensis*. This species' known distribution is isolated to Polk and Highlands counties. Additional surveys of scrub habitat with appropriate soils should be conducted in these two counties. A geographic information systems database should be developed to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review and in land acquisition activities.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or residential development. The remaining habitat is fragmented into small parcels and in many cases, isolated.
 - S2.1. Protect populations on public lands. Develop land management plans that incorporate prescribed burning, invasive/exotic vegetation control, and controlled off-road vehicle access.
 - S2.2. Continue *ex situ* conservation. Collections held *ex situ* will be instrumental for preserving the genetic diversity, evaluating the ecological requirements, and preventing the loss of *C. avonensis*.
 - S2.3. Conserve germ plasm.
 - S2.4. Enforce available protective legislation. State, Federal, tribal and local regulations should be used to protect this species from overcollection and damage from

off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *C. avonensis* is found.

- S2.4.1. Initiate section 7 consultation when applicable. Section 7 of the Endangered Species Act applies to Federal activities that may affect listed species.
 - S2.4.2. Encourage implementation of management plans. Federal agencies are obligated under section 7(a)(1) of the ESA to use their authorities to further the purposes of the Act. For example, an agency could develop a conservation program which incorporated prescribed burning to improve habitat for the benefit of listed species.
 - S2.4.3. Continue to enforce take and trade prohibitions. This species is protected by take provisions of the Endangered Species Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species, more specific biological information is needed.
- S3.1. Continue research to determine species demographics. Additional information is needed on the number of populations this species has in the wild, and factors which influence its survival such as recruitment, dispersal, growth, and mortality. Data on pollinators, herbivory, disease and injury are also lacking.
 - S3.2. Develop population viability and risk assessment. The demographic information collected from research should be used to develop models to evaluate spatial distribution and population size necessary to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *C. avonensis*. Evaluate management practices (*e.g.*, prescribed burning, mowing, exotic plant control) for their effects upon this species. Provide the results to land managers.
- S4. Develop standardized monitoring. Standardized monitoring needs to be developed for this and other listed scrub species to determine the effect of management actions.

- S4.1. Collect existing and historical data, and place in a central location. Contact former and present researchers for historical data, gather information from herbaria and museums, and compile the data for placement in a geographic information system database. The South Florida Field Office could maintain the database. This location would allow all researchers access to both historic and current data, and provide the FWS with a means to monitor the success of recovery tasks.
- S5. Provide public information about *C. avonensis*. It is important that governmental agencies, conservation organizations, and private land owners be appropriately informed about this species.
- S6. Establish reclassification criteria. Once the population is stabilized, research and monitoring results may provide data necessary to develop reclassification criteria.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. To date, there is only one protected site for *C. avonensis* in South Florida.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Little xeric scrub habitat remains for this species; any method of securing land to protect populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *C. avonensis* populations by preventing competition from exotic or invasive species, off-road vehicles, over-collection. Provide proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. The frequency of fire return and seasonality are important to mimic the natural fire regime. The scrub landscape is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned to create a mosaic when possible to allow for variation.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in areas supporting populations of *C. avonensis* compared to other areas in South Florida. Without control however, exotic or invasive plants may become a threat to the survival and recovery of this species.
- H1.2.3. Evaluate the effects of off-road vehicles on sensitive lands and limit access where damage to the habitat is documented.

- H1.2.4. Restore areas to suitable habitat. Native habitats that have been disturbed and have the appropriate soils may be prime candidate sites for restoration.
- H1.2.5. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *C. avonensis* occurs.
- H2. Provide public information about scrub and its unique biota. Educational programs, especially those conducted by Archbold Biological Station, have been successful. Without these efforts, the Lake Wales Ridge National Wildlife Refuge would not have been created. The State's system of biological preserves depends on a broad base of public understanding and support for its funding and future success.

Recovery for the Okeechobee Gourd, *Cucurbita okeechobeensis* ssp. *okeechobeensis* Small

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: The Okeechobee gourd has an extremely limited distribution; it is vulnerable to the highly managed hydrologic conditions in Lake Okeechobee. A significant portion of the Kissimmee River-Lake Okeechobee-Everglades watershed that once supported the gourd has been irreversibly lost, and information on the gourd's tolerance to specific environmental stressors is lacking. Consequently, the FWS can only define general conditions that could allow reclassification from endangered to threatened.

This objective will be achieved when: the Okeechobee gourd is protected at all known sites within Lake Okeechobee; when plants on Kreamer, Torry and Ritta islands and the southern Rim Canal of Lake Okeechobee produce fruit at each of these locations at least every other year (their absence for a period of two or more consecutive years will violate this requirement); when the distribution of fruiting plants is expanded within Lake Okeechobee either by the discovery of additional sites or by translocation; when one or two sites are established outside of the southeastern quadrant of Lake Okeechobee (outside of Palm Beach County); when a stable, self-sustaining population of the Okeechobee gourd is established within the South Florida Ecosystem outside of Lake Okeechobee; when measures of vitality are developed and monitored at each of the sites described above; and when based on the results of research on the viability of seeds following prolonged submergence and the survival of plants under rising water stages, the water regulation schedule for Lake Okeechobee is found not to jeopardize the continued existence of the Okeechobee gourd.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. It may be possible to delist the Okeechobee gourd if there is sufficient, restorable habitat that can be recolonized by additional populations; however, the feasibility of such a restoration and recolonization is still uncertain. This recovery objective will be reassessed annually based on new research, management, and monitoring

information. These criteria will be refined when new information identifies ways of re-establishing populations of this species and expanding its current distribution. This recovery narrative covers recovery actions only within the South Florida Ecosystem; recovery actions for the Okeechobee gourd along the St. Johns River must be added for a complete recovery plan.

Species-level Recovery Actions

S1. Maintain information on the distribution and status of the Okeechobee gourd.

- S1.1. Conduct regularly scheduled surveys. Past surveys for the Okeechobee gourd have been sporadic and not comprehensive. More thorough searching of Lake Okeechobee is needed at least once per year, preferably 3 times (spring, summer, fall) a year. Airboats are the most efficient vehicles for conducting surveys.
- S1.2. Individuals should be encouraged to provide information on sightings of the Okeechobee gourd. Due to the size of Lake Okeechobee, the difficult access to interior portions of its littoral zone, and the potentially wide dispersal of floating gourds that start germination, it is impossible for professional biologists to search all potential habitat in the lake. Private citizens involved in a number of activities on the lake can provide useful information to help locate plants.

S2. Protect and enhance existing populations.

- S2.1. Ensure that spraying for control of aquatic vegetation does not harm or kill Okeechobee gourd plants. The regularly scheduled surveys provide information on locations of the Okeechobee gourd; this information (using maps and GPS coordinates) must be conveyed to spray crews to reduce the likelihood of damage to the gourd. Spray crews must also be trained to recognize the gourd and the need to avoid impacts on the species.
- S2.2. Assess the effect of Melaleuca and Brazilian pepper control efforts (both cut-and-squirt and aerial spraying methods); use techniques to avoid direct impact on Okeechobee gourd plants. Although control of Melaleuca and Brazilian pepper is needed for ecosystem restoration, the climbing stems of the Okeechobee gourd now use both species as support. Train crews to identify the Okeechobee gourd. Where exotic trees or shrubs are supporting living Okeechobee gourd plants, instruct the crew to avoid killing the Okeechobee gourd plants and to inject herbicide in the exotic species without cutting it down.
- S2.3. Use provisions of section 7 of the ESA to protect the Okeechobee gourd. Water management of the COE's C&SF project will affect survival and recovery of the Okeechobee gourd, particularly the water regulation schedule for Lake

Okeechobee. Field monitoring and experimental research are needed to determine the gourd's tolerance of water levels to effectively evaluate alternative water regulation schedules and provide effective conservation recommendations.

S2.4. Augment natural populations of the Okeechobee gourd.

S2.4.1. Establish a protocol for translocation. Source plants must be cultivated and recorded at a nursery or botanical garden.

S2.4.2. Locate potential translocation sites. First, more thorough surveys of the present range of the species are needed within Lake Okeechobee. Later, potential sites for translocation within the lake need to be assessed. Some of these are Little Rocky Island (Hendry County), Observation Island (Glades County) and other sites in Okeechobee County. Other potential translocation sites should be selected north of Lake Okeechobee, with emphasis on the islands in Lake Istokpoga and public lands along the Kissimmee River.

S2.3.3. Translocate plants to the selected sites.

S3. Initiate research on the life history and genetics of the Okeechobee gourd.

S3.1. Test experimentally the viability of Okeechobee gourd seeds kept submerged for long periods (1 to 3 years). The tolerance of Okeechobee gourd seeds to extended periods of submergence in the waters of Lake Okeechobee is a critical parameter needed to assess the potential risk to the species from extended periods of high water under various lake regulation schedules.

S3.2. Characterize the range of soil conditions where the Okeechobee gourd currently grows and provide detailed mapping of soil types in southeastern Lake Okeechobee. Although distribution of the Okeechobee gourd in Lake Okeechobee appears to be associated with the presence of muck soils formed historically in the pond apple forests that once bordered the lake, the soil profile appears to be modified in some areas where the gourd grows. Dredging of flood control canals (and lining them with revetment), construction of levees, and construction of farm roads and drainage ditches have evidently altered the soil at many of the Okeechobee gourd sites. Presence of some native organic soil appears to be necessary, but the range of soil profiles should be determined to characterize occupied habitat and assess unoccupied, but potentially suitable, habitat.

S3.3. Through field surveys, determine dates of germination under natural conditions. Because the specific locations for germination may vary from year to year, it may

be difficult to identify areas to search for germinating plants, but some areas of consistently suitable habitat may be identifiable to obtain this information. Areas may need to be revisited for several years to account for interannual variation in response to water levels and temperature patterns. Timing of water management decisions relative to germination and growth of young Okeechobee gourd plants is important to survival and recovery of the species.

- S3.4. Test experimentally the effect of seasonally rising water level on the survival of young plants. Determine rates of rising water level and/or depths that may reduce survival of young plants. Identify at what stage their growth rate and ability to climb adjacent vegetation make them less vulnerable to rising water level.
 - S3.5. After information is available from the research studies described above and the annual field surveys, conduct population viability and risk assessment studies particularly with respect to water regulation schedule alternatives for Lake Okeechobee.
 - S3.6. Investigate the role of animals in dispersing seeds of the Okeechobee gourd.
 - S3.7. Document the potential ecological relationship between the American alligator and the Okeechobee gourd. The mounds of soil around alligator nests may serve as favorable germination sites for the gourd. This relationship should be investigated, determining whether indeed gourds preferentially germinate around nests and how frequently these seedlings produce at least one mature plant at a nest.
 - S3.8. Investigate the genetic distance between the two known populations of the Okeechobee gourd. Isozyme analysis has indicated a single population of the gourd in southeastern Lake Okeechobee. Additional analysis should be performed on specimens from the St. Johns River. Researchers should make a recommendation to the FWS regarding the desirability of cross-breeding gourds from the two populations to provide additional variability within the populations. If a third population is established geographically between the two existing populations, a decision must be made on the genetic source of the specimens.
- S4. Monitor existing populations of the Okeechobee gourd.
- S4.1. Determine the most effective approach to monitor the condition of the Okeechobee gourd. Because the Okeechobee gourd generally grows in a tangle of vines and sprawling over other vegetation, it is difficult to distinguish individual plants to estimate a total population size. The sprawling growth habit also makes the plant vulnerable to inadvertent damage by people conducting the monitoring, so the method should minimize intrusion and disruption. A combination of condition

indices may be needed, such as area covered, average leaf size, and number of fruit at each site.

- S4.2. After determining the most effective methods and indices, conduct monitoring on an annual basis. In addition to monitoring of condition indices at each site, the overall distribution of sites should also be recorded. Selected individual vines should be marked to determine if they are annual or persist into the following growing season. Water stage should be recorded for each day of monitoring, noting any extremes of drought or high water. Freezes should also be noted, as they will influence the condition of the population.
- S5. Increase public awareness about the Okeechobee gourd. Public awareness can be addressed through a variety of strategies, including, but not limited to, classroom programs, newspaper and magazine articles, public information displays at boat ramps in Lake Okeechobee, and outreach to fishing and airboating clubs.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing Okeechobee gourd habitat.
- H1.1. Determine water regulation practices promoting recovery of the Okeechobee gourd, assess the implications on an ecosystem-wide scale, and make appropriate recommendations to water managers. The preference and tolerance of the species to specific water regimes must first be researched and monitored as described above. This information should be evaluated in the context of the overall ecosystem health of the lake before making water management decisions.
- H1.2. Control or remove exotic vegetation in wetlands. The main species of vegetation needing control are *Melaleuca quinquenervia* and *Hydrilla verticillata*. Although crews conducting control measures must be instructed to avoid impacts on the Okeechobee gourd, adjustment of the methods, timing, and pace of control measures to accommodate the gourd are required, rather than prohibition of the control program over large areas. Since populations of the Okeechobee gourd will shift from one specific location to another from year to year, areas not treated during one year could likely be treated in the following year. This added caution will require flexibility in planning control of exotic vegetation in the general range of the Okeechobee gourd.
- H1.3. Plant native trees or shrubs to replace exotics. Removal of exotic trees and shrubs in areas where the Okeechobee gourd occurs should be compensated by planting of native trees and shrubs, such as willow and pond apple, to provide potential supporting vegetation.

- H1.4. Use controlled burns to open up areas of overly dense herbaceous and/or shrubby vegetation in lake littoral zones and marshes. Such actions are beneficial for a variety of fish and wildlife, not just the Okeechobee gourd, which is a pioneer species in disturbed areas. Because Lake Okeechobee is too large for practical application of scheduled extreme drawdowns, burning must take place at times of naturally occurring low water levels. If the range of the species is extended to other lakes, riverine swamps, or marshes, managed extreme drawdowns may be an effective management tool in conjunction with burning.
- H1.5. Prevent cultural eutrophication of lakes and marshes. Addition of nitrogen and phosphorus from agricultural and residential areas is accelerating eutrophication of Florida's lakes and marshes, particularly Lake Okeechobee. Long-term degradation of habitat caused by eutrophication leads to buildup of organic muck, overly dense herbaceous and shrubby vegetation, and oxygen depletion. Moderate eutrophication may not harm the Okeechobee gourd, but in the long term, dense growth of vegetation will impede dispersal of seeds, germination, and growth of the Okeechobee gourd. Reduction of nutrient inputs at the source needs to be addressed by best management practices, including rates of application and stormwater retention on site. Construction and maintenance of wastewater treatment plants must be improved to control discharge of nutrients in lakes and streams.
- H2. Restore areas to suitable habitat.
- H2.1. Restoration of Kreamer, Torrey, and Ritta islands within Lake Okeechobee was included by the Governor's Commission for a Sustainable South Florida among "40 Preferred Options" in their conceptual plan for the C&SF Restudy. The FWS is unaware of any existing design criteria for restoration of these islands. Any proposal to restore these islands must consider the present habitat conditions for the Okeechobee gourd, fish, and wildlife, relative to proposed future conditions, before claiming any net benefits. Levels of contaminant residues in the soil from historic agricultural activities must be determined prior to any plan for earth movement.
- H2.2. Restoration of the Kissimmee River (as presently proposed, or with inclusion of the Paradise Run segment) will affect any attempt to translocate the Okeechobee gourd to the Kissimmee floodplain. Selection of potential translocation sites must account for anticipated conditions following restoration, and monitoring of the Okeechobee gourd would be added to the monitoring program established for the restoration project.
- H3. Research the acute and long-term tolerance of the Okeechobee gourd and other wetland

plants to herbicides commonly used to control nuisance species of aquatic vegetation. The principal herbicides used in control of Hydrilla are SONAR (fluridone) and AQUATHOL K (dipotassium endothall). Rodeo (glyphosate) is occasionally used to control dense growths of emergent vegetation, such as cattails. The acute toxicity of each of these chemicals to the Okeechobee gourd must be determined; since fluridone is used in greater quantity and repeatedly at the same sites, its long-term toxicity to a variety of plants and animals should also be determined.

- H4. Monitor habitat/ecological processes. The SFWMD, GFC, and other agencies have well-established research and monitoring activities in Lake Okeechobee. These existing efforts need to be modified or expanded to conform with the adaptive assessment strategy that will be required for the C&SF Restudy. Prior research and monitoring has included a broad range of parameters, including vegetation of the littoral zone, fish, benthic invertebrates, wading birds, phytoplankton, and water chemistry. Continued monitoring of wetland vegetation in the littoral zone of Lake Okeechobee is particularly relevant to recovery of the Okeechobee gourd. This should include assessment of the influence of dominant stressors, such as water regulation and fire, on the emergent plant communities of the littoral zone.
- H5. Increase public awareness of ecological relationships, environmental stressors, and restoration activities in the South Florida Ecosystem. Among the themes of significance to the Okeechobee gourd are the ecological and economic importance of natural resources in the littoral zone of Lake Okeechobee and awareness of the environmental issues associated with protection of the littoral zone. These issues involve a balance of potentially competing interests, including water supply, flood control, recreation, biodiversity, and productivity of the ecosystem. Information on the Okeechobee gourd's status, threats, and its ecological relationship with other species should be integrated in public education on restoration activities. Public outreach can include newsletters, newspapers, magazines, the worldwide web, and classroom materials.

Recovery for the Beautiful Pawpaw, *Deeringothamnus pulchellus* Small

Recovery Objective: RECLASSIFY to threatened, then delist.

Recovery Criteria: *Deeringothamnus pulchellus* may be reclassified from endangered to threatened when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to ensure 20 to 90 percent probability of persistence for 100 years; when these sites, within the historic range of *D. pulchellus*, are adequately protected from further habitat loss, degradation, and fragmentation; when these sites are managed to maintain pine flatwoods to support *D. pulchellus*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S.1. Determine current distribution of *D. pulchellus*.

S1.1. Conduct surveys for *D. pulchellus*.

S1.1.1. Continue surveys in Lee and Charlotte counties. Though the range of this species has been thoroughly surveyed, current survey work is needed. An accurate survey of all suitable habitat would maximize the possibilities for protection, by enabling agency personnel to work with individual landowners as projects are proposed.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database.

S2. Protect and enhance existing populations. Much of the native pine flatwood community in Florida has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.

S2.1. Acquire or otherwise protect habitat through acquisition, conservation easements, or agreements with landowners.

S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.

S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable unoccupied and habitat occupied habitat of *D. pulchellus*. Protecting this species on private

property in Lee County is possible due to county ordinances that require conservation of listed plants.

- S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *D. pulchellus* lives.
 - S2.4.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.4.2. Enforce take and trade prohibitions. This species is protected by take provisions of the Endangered Species Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S2.5. Develop an *ex situ* collection. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *D. pulchellus*. Since long-term seed storage seems impossible for this species, cultivated populations are very important. Although *D. pulchellus* is not easily grown from cuttings, young plants should be kept for study and reintroduction material.
- S2.6. Augment natural populations of *D. pulchellus*.
 - S2.6.1. Establish a protocol for reintroduction. Records for source plants, techniques for establishing new populations, and protocols for monitoring are needed.
 - S2.6.2. Locate potential (re)introduction sites. Survey habitat within the historic range of *D. pulchellus* and identify protected lands, both public and private, that will be suitable habitat.
 - S2.6.3. (Re)introduce plants to protected sites. Use plants under cultivation to (re)establish plants in suitable habitat.
- S3. Conduct research on life history characteristics of *D. pulchellus*. To effectively recover this species more specific biological information is needed.

- S3.1. Conduct research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality. Observations of the relation of flowering to fire, pollination, seed production, and seedling biology will help to guide reintroduction efforts.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *D. pulchellus*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
 - S3.4. Assess feasibility of relocating *D. pulchellus*. Removing plants threatened with destruction may be the only conservation strategy available in some situations. Information on transplant techniques and plant survival are needed to assess whether transplanting should be pursued.
- S4. Monitor existing populations of *D. pulchellus*.
- S4.1. Develop monitoring protocol to assess population trends for *D. pulchellus*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *D. pulchellus*. Assess any changes in demographic characteristics of *D. pulchellus* in response to land management activities, such as prescribed fire, [and] exotic plant control.
 - S4.2. Develop a quantitative description of the population structure of *D. pulchellus*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter

depth, substrate, and closest neighbors) may prove helpful in future management.

- S4.3 Monitor reintroduced plants. Monitoring of reintroduced plants will be essential for assessing the status of new plants and their contribution to the population as a whole. Compare adult survival, seed production, germination rates, seed survival, seedling survival, and growth rates between transplanted plants and natural plants. Where monitoring indicates that the introduction has been unsuccessful, reevaluate protocol and methodology.
- S5. Provide public information about *D. pulchellus*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *D. pulchellus* and other rare species requires a self-sustaining, secure, number of natural populations.
- S6. Establish delisting criteria. Once reclassification is achieved, research and monitoring results may provide data necessary to develop delisting criteria.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Urbanization, fire suppression, and agricultural land uses have decreased the available habitat.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little undisturbed pine flatwoods habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *D. pulchellus* populations by preventing damage from off-road vehicle use and overcollection, and by providing proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the pine flatwood community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. Pine flatwoods are naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation. *D.*

pulchellus appears to benefit from burning at the short intervals of a natural pine flatwood community.

- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida high pine as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *D. pulchellus*.
 - H1.2.3. Control access to areas where listed plants are growing. Trampling and off-road vehicles can severely threaten individual populations. Fencing may be needed for some sites, and clearing around individual *D. pulchellus* plants has been suggested.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
 - H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Continue habitat-level research projects. Study the response of *D. pulchellus* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, mechanical disturbance, etc., on the habitats where *D. pulchellus* occurs.
- H5. Provide public information about pine flatwood vegetative communities and their unique biota. Educational efforts, especially those conducted by private conservation organizations, have been successful in providing important information about pine flatwood plant communities to the public. The State's system of biological preserves depends for its funding and future success on a broad base of public understanding and

support. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, the Florida Park Service, the Florida Native Plant Society and local garden clubs will play crucial roles in increasing public appreciation of pine flatwood plant communities and *D. pulchellus*.

Recovery for the Garrett's Mint, *Dicerandra christmanii* Huck and Judd

Recovery Objective: STABILIZE, then reclassify to threatened.

Recovery Criteria: *Dicerandra christmanii* may be considered stabilized when existing populations, within the historic range of *D. christmanii*, are adequately protected from further habitat loss, degradation, and fire suppression. These sites must also be managed to maintain xeric oak scrub to support *D. christmanii*.

Once the existing populations are stabilized, *D. christmanii* may be considered for reclassification to threatened status. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *D. christmanii* are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the seral stage of xeric oak scrub that supports *D. christmanii*; and when monitoring programs demonstrate that these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Delisting criteria may be defined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *D. christmanii*.

S1.1. Conduct surveys for additional populations of *D. christmanii*.

S1.1.1. Continue surveys in Highlands County. Though the range of this species has been thoroughly surveyed, it should be periodically resurveyed to learn the status of the species on private lands.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

- S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Acquire or otherwise protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable, unoccupied, and occupied habitat of *D. christmanii*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *D. christmanii*.
- S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
- S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *D. christmanii* as part of the National Collection.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to

protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *D. christmanii* lives.

- S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
- S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from state lands.
- S2.6. Augment natural populations of *D. christmanii*. Augmentation of populations on protected land is appropriate because there is little prospect for protecting additional sites.
 - S2.6.1. Establish a protocol for reintroduction. Records for source plants, techniques for establishing new populations, and protocols for monitoring are needed.
 - S2.6.2. Locate potential (re)introduction sites. Survey habitat within the historic range of *D. christmanii* and identify protected lands, both public and private, that would be suitable habitat.
 - S2.6.3. (Re)introduce plants to protected sites. Use plants under cultivation to (re)establish plants in suitable habitat.
- S3. Continue research on life history characteristics of *D. christmanii*. Although recent work on *D. christmanii* can be used to infer answers to some life history questions, much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, pollinators, dispersal, growth, survival, and mortality.
 - S3.2. Assess genetic variability in the *Dicerandra*. Work on this topic is underway. *Dicerandra* species are taxonomically difficult to distinguish without genetic work.

- S3.3. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.4. Conduct research to assess management requirements of *D. christmanii*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information on the localities of *D. christmanii* will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *D. christmanii*.
- S4.1. Develop monitoring protocol to assess population trends for *D. christmanii*.
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
- S4.1.2. Monitor the effects of various land management actions on *D. christmanii*. Assess any changes in demographic characteristics of *D. christmanii* in response to land management activities, such as prescribed fire, exotic plant control, etc. At present, the burn frequency for this species is unknown. Though *D. christmanii* grows more vigorously in areas burned within the last 10 years, it can be found in areas that were last burned from 3 to 65 years ago. More information is needed on the role of fire for this species.
- S4.2. Develop a quantitative description of the population structure of *D. christmanii*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) may prove valuable in future management actions.
- S4.3. Monitor re-introduced plants. Monitoring of reintroduced plants will be essential for assessing the status of new plants and their contribution to the population as a whole. Compare adult survival, seed production, germination rates, seed survival,

seedling survival, and growth rates between transplanted plants and natural plants. Where monitoring indicates that the introduction has been unsuccessful, reevaluate protocol and methodology.

- S5. Provide public information about *D. christmanii*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. However, caution should be taken to avoid revealing specific locality information of *D. christmanii*. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *D. christmanii* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there is one protected site characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

for *D. christmanii*.

- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *D. christmanii* populations by preventing habitat damage from off-road vehicle use and over collection by providing proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. *D. christmanii* is experiencing competition from tall grasses. Without control, exotic/invasive plants may become a threat to the survival and recovery of *D. christmanii*.
- H1.2.3. Control access to areas where listed plants are growing. Trampling, trash dumping, and off-road vehicles can severely threaten individual populations. Presently, the one protected site for this species is threatened by trash dumping and off-road vehicle use. This property may require fencing or other protection to eliminate this threat.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *D. christmanii* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *D. christmanii* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida

Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Scrub Mint, *Dicerandra frutescens* Shinnery

Recovery Objective: STABILIZE, then reclassify to threatened

Recovery Criteria: *Dicerandra frutescens* may be considered stabilized when existing populations, within the historic range of *D. frutescens*, are adequately protected from further habitat loss degradation and fire suppression. These sites must also be managed to maintain xeric oak scrub to support *D. frutescens*.

Once the existing populations are stabilized, *D. frutescens* may be considered for reclassification to threatened status. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *D. frutescens*, are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the seral stage of xeric oak scrub that supports *D. frutescens*; and when monitoring programs demonstrate that these sites support populations of sufficient sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Delisting criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *D. frutescens*.

S1.1. Conduct surveys of *D. frutescens*.

S1.1.1. Continue surveys in Highlands County. Though the Lake Wales Ridge has been thoroughly surveyed, it should be periodically resurveyed to learn the status of the species on private lands.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

- S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S1.3. Determine identity of *Dicerandra* population outside accepted scrub mint range.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Acquire or otherwise protect privately owned habitat through acquisition, conservation easements, or agreements with landowners. *D. frutescens* has been found on the right-of-way of Highway 27. Here working with the DOT on management needs, such as altering mowing schedules until after flowering and seed set, should be explored.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that fosters a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable, unoccupied, and occupied habitat of *D. frutescens*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *D. frutescens*.
- S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
- S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution,

maintains and propagates *D. frutescens* as part of the National Collection.

- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *D. frutescens* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S2.6. Augment natural populations of *D. frutescens*. Augmentation of populations on protected land is appropriate because there is little prospect for protecting additional sites.
 - S2.6.1. Establish a protocol for reintroduction. Records for source plants, techniques for establishing new populations, and protocols for monitoring are needed.
 - S2.6.2. Locate potential (re)introduction sites. Survey habitat within the historic range of *D. frutescens* and identify protected lands, both public and private, that will be suitable habitat.
 - S2.6.3. Reintroduce plants to protected sites. Use plants under cultivation to re-establish plants in suitable habitat.
- S3. Continue research on life history characteristics of *D. frutescens*. Although recent work on *D. frutescens* can be used to infer answers to some life history questions, much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, pollinators, dispersal, growth, survival, and mortality.

- S3.2. Assess genetic variability for the genus *Dicerandra*. Work on this topic is underway. *Dicerandra* species are taxonomically difficult to distinguish without genetic work.
- S3.3. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.4. Conduct research to assess management requirements of *D. frutescens*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring at *D. frutescens* sites, will provide information about factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should well provide to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing and reintroduced populations of *D. frutescens*.
- S4.1. Develop monitoring protocol to assess population trends for *D. frutescens*.
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease and injury.
- S4.1.2. Monitor the effects of various land management actions on *D. frutescens*. Assess any changes in demographic characteristics of *D. frutescens* in response to land management activities, such as prescribed fire, exotic plant control, etc. At present, the burn frequency for this species is unknown. Though *D. frutescens* grows more vigorously in areas burned within the last 10 years, it can be found in areas that were last burned from 3 to 65 years ago More information is needed on the role of fire for this species.
- S4.2. Develop a quantitative description of the population structure of *D. frutescens*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) may prove valuable in future management actions.

- S4.3. Monitor reintroduced plants. Monitoring of reintroduced plants will be essential for assessing the status of new plants and their contribution to the population as a whole. Compare adult survival, seed production, germination rates, seed survival, seedling survival, and growth rates between transplanted plants and natural plants. Where monitoring indicates that the introduction has been unsuccessful, reevaluate protocol and methodology.
- S5. Provide public information about *D. frutescens*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. However, caution should be taken to avoid revealing specific locality information of *D. frutescens*. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *D. frutescens* and other rare species require a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are two protected sites characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches are necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

for *D. frutescens*.

- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *D. frutescens* populations by preventing habitat damage from off-road vehicle use and over collection, and by providing proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire

landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *D. frutescens*.

H1.2.3. Control access to areas where listed plants are growing. Trampling, trash dumping, and off-road vehicles can severely threaten individual populations. Research has shown that *D. frutescens* recovers from disturbance only by reseedling. As such, this species is very sensitive to trampling and other types of frequent disturbance.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

H3. Conduct habitat-level research projects. Study the response of *D. frutescens* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *D. frutescens* occurs.

H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding

and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Scrub Buckwheat, *Eriogonum longifolium* (Nutt. var. *gnaphalifolium* Gandog.)

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: STABILIZE and increase the population.

Recovery Criteria: The South Florida recovery objective can be achieved when sites within the historic range of *E. longifolium* var. *gnaphalifolium* are adequately protected from further habitat loss, degradation, and fragmentation; when these sites are managed to maintain the scrub and sandhill communities to support *E. longifolium* var. *gnaphalifolium*; and when monitoring programs demonstrate that populations of *E. longifolium* var. *gnaphalifolium* on these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species. The recovery narrative identifies management recommendations, such as translocations, that are necessary to accomplish this objective.

Species-level Recovery Actions

S1. Determine current distribution of *E. longifolium* var. *gnaphalifolium*. A survey has not been made of the Lake Wales Ridge for this species, making defining a complete distribution in South Florida difficult.

S1.1. Conduct surveys of *E. longifolium* var. *gnaphalifolium*.

S1.1.1. Conduct additional surveys in Polk, Highlands, and Osceola counties. New locations for this species may be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species may be found on protected lands.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, number of individuals, population sizes, and status. This information should also be used for

project review and land acquisition activities.

- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases is isolated.
- S2.1. Protect habitat through acquisition, conservation easements, or agreements with landowners. The Warea Archipelago is a series of small properties that are being purchased through CARL that are designed to protect *E. longifolium* var. *gnaphalifolium* and the unique community in which it lives.
- S2.2. Protect populations on public lands.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable unoccupied and occupied habitat, both of *E. longifolium* var. *gnaphalifolium*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *E. longifolium* var. *gnaphalifolium*.
- S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
- S2.4.2. Maintain *ex situ* collection. Research ways to propagate *E. longifolium* var. *gnaphalifolium*.
- S2.5. Augment natural populations of *E. longifolium* var. *gnaphalifolium*.
- S2.5.1. Establish a protocol for reintroduction. Records for source plants, techniques for establishing new populations, and protocols for monitoring are needed.
- S2.5.2. Locate potential (re)introduction sites. Survey habitat within the historic range of *E. longifolium* var. *gnaphalifolium* and identify protected lands, both public and private, that will be suitable habitat.
- S2.5.3. (Re)introduce plants to protected sites. Use plants under cultivation to (re)establish plants in suitable habitat.

- S2.6. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *E. longifolium* var. *gnaphalifolium* lives.
- S2.6.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
- S2.6.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Continue research on life history characteristics of *E. longifolium* var. *gnaphalifolium*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine biology and demographic information, such as numbers of sites and populations, numbers of individuals in a population, morphology, reproduction, recruitment, dispersal, growth, survival, and mortality.
- S3.2. Continue research to assess management requirements of *E. longifolium* var. *gnaphalifolium*. Continue to assess site-specific management requirements of *E. longifolium* var. *gnaphalifolium*. At this time, the survival and recovery of this species is dependent upon the implementation of site-specific management techniques that favor *E. longifolium* var. *gnaphalifolium*. Site-specific management guidelines should be provided to land managers.
- S4. Continue monitoring the existing populations of *E. longifolium* var. *gnaphalifolium*.
- S4.1. Evaluate the effectiveness of the monitoring protocol used to assess population trends for *E. longifolium* var. *gnaphalifolium*. As more information is gained about *E. longifolium* var. *gnaphalifolium*, monitoring protocols may need to be altered to make use of new information.
- S4.2. Monitor and detect changes in demographic characteristics, such as growth, survival, mortality. Herbivory, pollinators, disease, and injury should also be monitored. Characteristics such as reproduction, recruitment, and dispersal cannot truly be monitored in the wild at this time, but should be included as introductions

make reproduction possible.

- S4.3. Monitor the effects of various land management actions on *E. longifolium* var. *gnaphalifolium*. Assess any changes in demographic characteristics of *E. longifolium* var. *gnaphalifolium* in response to land management activities, such as prescribed fire, exotic plant control, etc.
- S4.4. Continue to work with private landowners. The successful recovery of this species will be influenced by the participation of private landowners. To date a varying amount of support has been gained among the individual landowners.
- S4.5. Monitor introduced plants. Monitoring of reintroduced plants will be essential for assessing the status of new plants and their contribution to the population as a whole. Compare adult survival, seedling production, germination rates, seed survival, seedling survival, and growth rates between transplanted and natural plants. Where monitoring indicates that introduction has been unsuccessful, reevaluate protocol and methodology developed.
- S5. Provide public information about *E. longifolium* var. *gnaphalifolium*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed. Public outreach efforts must also continue to address the increasing concern that horticultural demand for rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *E. longifolium* var. *gnaphalifolium* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss has already occurred throughout the range of this species. Both development and fire suppression have decreased the available habitat.
 - H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
 - H1.2. Manage and enhance habitat. Manage habitat to maintain *E. longifolium* var. *gnaphalifolium* populations by preventing damage from off-road vehicle use and collection, and by providing proper management of habitat including prescribed fire.

- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the high pine community. A variable interval in fire return and in season is important to mimic the natural fire regime.
 - H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat as compared to other communities in South Florida.
 - H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery.
 - H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *E. longifolium* var. *gnaphalifolium* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *E. longifolium* var. *gnaphalifolium* occurs.
- H5. Provide public information about high pine and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Department of Forestry, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their

associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Department of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Snakeroot, *Eryngium cuneifolium* Small

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: *Eryngium cuneifolium* may be reclassified from endangered to threatened when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 20 to 90 percent probability of persistence for 100 years; when these sites, within its historic range, 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 *E. cuneifolium*; and when monitoring programs demonstrate that populations of *E. cuneifolium* on these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies new ways of re-establishing populations of this species or expanding its current range.

Species-level Recovery Actions

S1. Determine current distribution of *E. cuneifolium*. This species has been relatively well surveyed and a distribution has been ascertained. Additional surveys will confirm the species' distribution and locate new sites.

S1.1. Conduct surveys of *E. cuneifolium*.

S1.1.1. Continue surveys in Highlands County. The Lake Wales Ridge has probably been adequately surveyed, though new sites for *E. cuneifolium* may still be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review and in land

acquisition activities.

- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Protect habitat through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
 - S2.3. Use local or regional planning to protect habitat. Utilize available regional and County planning processes to encourage protection of suitable habitat, both unoccupied and occupied of *E. cuneifolium*.
 - S2.4. Conserve germ plasm. The Center for Plant Conservation provides long-term seed storage for this species. Long-term storage of seeds and live collections decreases the likelihood of extinction due to natural stochastic events. Germ plasm conservation also preserves genetic diversity and provides valuable information regarding the reproductive biology of rare species. The local abundance of this species makes an *ex situ* garden collection a low priority for this species.
 - S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *E. cuneifolium* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics of *E. cuneifolium*. Continue the study of

basic biology and ecology of this species. To effectively recover this species, more specific biological information is needed.

- S3.1. Continue research to determine demographic information, such as numbers of populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *E. cuneifolium*. Determine which natural populations can be stabilized or increased by habitat management. Data from surveys, research, and monitoring will yield information about *E. cuneifolium* sites and will provide factors contributing to any declines at each site. Site-specific management guidelines should be provided to land managers.
- S4. Monitor existing populations of *E. cuneifolium*.
- S4.1. Develop monitoring protocol to assess population trends for *E. cuneifolium*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *E. cuneifolium*. Assess any changes in demographic characteristics of *E. cuneifolium* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *E. cuneifolium*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Include data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors).
- S5. Provide public information about *E. cuneifolium*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care

is needed, though, to avoid revealing specific locality information about *E. cuneifolium*. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *E. cuneifolium* and other rare species requires a self-sustaining, secure, number of natural populations.

- S6. Develop delisting criteria. Once reclassification is achieved, research and monitoring results may provide data necessary to develop delisting criteria.

Habitat-level Recovery Actions

H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both development and fire suppression have decreased the available habitat. To date, there are three protected sites for *E. cuneifolium* in Highlands County.

H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.

H1.2. Manage and enhance habitat. Manage habitat to maintain *E. cuneifolium* populations by preventing damage from off-road vehicle use and by providing proper management of habitat, including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. The scrub landscape is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in xeric scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *E. cuneifolium*.

H1.2.3. Control access to areas where snakeroot is growing. Trampling and off-road vehicles can severely threaten individual populations.

- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Continue habitat-level research projects. Study the response of *E. cuneifolium* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *E. cuneifolium* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these efforts, the Lake Wales Ridge NWR would not have been created. The State's system of biological preserves depends for its funding and future success on a broad base of public understanding and support. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, the Florida Park Service, the Florida Native Plant Society and local garden clubs play crucial roles in increasing public appreciation of scrub, high pine vegetation, and their plant species.

Recovery for the Highlands Scrub Hypericum, *Hypericum cumulicola* (Small) P. Adams

Recovery Objective: STABILIZE, then reclassify to threatened.

Recovery Criteria: *Hypericum cumulicola* may be considered stabilized when existing populations, within its historic range are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. These sites must also be managed to maintain the rosemary phase of sandpine scrub to support *H. cumulicola*.

Once the existing populations are stabilized, *H. cumulicola* may be considered for reclassification to threatened. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites

needed to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *H. cumulicola* are adequately protected from further habitat loss, degradation, fragmentation, and fire suppression; when these sites are managed to maintain the rosemary phase of sandpine scrub to support *H. cumulicola*; when monitoring programs demonstrate that populations of *H. cumulicola* on these sites support sufficient population sizes; when those populations are stable and distributed throughout the historic range; and when *H. cumulicola* are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *H. cumulicola*. This species has been relatively well-surveyed and a distribution has been ascertained. Additional surveys will confirm the species' distribution and locate new sites.

S1.1. Conduct surveys of *H. cumulicola*.

S1.1.1. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has probably been adequately surveyed, though new sites for *H. cumulicola* may still be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are acquired.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases,

isolated. For this reason, existing populations are in need of protection from a variety of threats.

- S2.1. Protect habitat through acquisition, conservation easements, or agreements with landowners.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages. *Hypericum cumulicola* would require a burn regime that had an average burn cycle of around 20 years.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable, unoccupied, and occupied habitat of *H. cumulicola*.
- S2.4. Conserve germ plasm. The seed for this species is not presently in long-term storage. Germ plasm conservation preserves genetic diversity and provides valuable information regarding the reproductive biology of rare species. *Hypericum cumulicola* has a very high genetic diversity among populations. This unusual characteristic would require that any effort for seed storage be made of samples from a large number of populations. The local abundance of this species makes an *ex situ* garden collection a low priority for this species.
- S2.5. Enforce available protective measures. Use local, State, and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *H. cumulicola* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the Endangered Species Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics of *H. cumulicola*. Continue the study of basic biology and ecology of this species. To effectively recover this species more specific biological information is needed.

- S3.1. Continue research to determine demographic information, such as numbers of populations, numbers of individuals in a population, recruitment, growth, survival, and mortality. The current research indicates that the seedbank may be the key for this species' survival.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *H. cumulicola*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information on the localities of *H. cumulicola* sites will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers. Close coordination among land managers is essential in the development of adaptive management techniques.
- S4. Monitor existing populations of *H. cumulicola*.
- S4.1. Develop monitoring protocol to assess population trends for *H. cumulicola*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, seed dormancy, germination, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *H. cumulicola*. Assess any changes in demographic characteristics of *H. cumulicola* in response to land management activities, such as prescribed fire, exotic plant control, etc. The number of individuals in a population is highly variable through the burn cycle.
 - S4.2. Develop a quantitative description of the population structure of *H. cumulicola*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.
- S5. Provide public information about *H. cumulicola*. It is important for the recovery of this

species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private land owners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about where *H. cumulicola* is found.

- S6. Develop delisting criteria. Once reclassification is achieved, research and monitoring results may provide data necessary to develop delisting criteria.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. *H. cumulicola* is particularly sensitive to habitat fragmentation from a genetic standpoint, as well as a metapopulation perspective. Both development and fire suppression have decreased the available habitat. To date, there are 13 protected sites for *H. cumulicola* in Polk and Highlands counties.

- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.

- H1.2. Manage and enhance habitat. Prevent habitat damage from off-road vehicle use and provide proper management of habitat including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation. *Hypericum cumulicola* is a species that needs a fire return interval of less than 20 years to safeguard against a failure in the seedbank.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *H. cumulicola*.

H1.2.3. Control access to areas where listed plants are growing. Trampling and off road vehicles can severely threaten individual populations.

- H2.1. Restore natural fire regime. Long periods without fire can change the species

composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.

- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H3. Continue habitat-level research projects. Study the response of *H. cumulicola* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *H. cumulicola* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the South Florida Water Management District, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Scrub Blazing Star, *Liatris ohlingerae* (Blake) Robinson

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: *Liatris ohlingerae* may be reclassified from endangered to threatened when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 20 to 90 percent probability of persistence for 100 years; when these sites, within the historic range of *L. ohlingerae*, are adequately protected from

further habitat loss, degradation, and fragmentation; when these sites are managed to maintain the rosemary bald of the xeric oak scrub community to support *L. ohlingerae*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *L. ohlingerae*. This species is difficult to survey. It is easily overlooked when not in bloom and does not grow in the typical open gaps of scrub. A thorough survey is needed to determine the distribution for this species. Survey efforts should be focused from August through October.

S1.1. Conduct surveys for additional populations of *L. ohlingerae*.

S1.1.1. Continue surveys in Polk and Highlands counties. Although the Lake Wales Ridge has been well surveyed, new sites may still be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are acquired.

S1.2. Maintain distribution of known populations and suitable habitat in a GIS database. Use the database to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection.

S2.1. Protect populations on private land through acquisition, conservation easements, or

- agreements with landowners.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of a species. These collections will be instrumental in the recovery of *L. ohlingerae*.
- S2.3.1. Conserve germ plasm. The seed of this species is not presently in long-term storage.
- S2.3.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *L. ohlingerae* as part of the National Collection.
- S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *L. ohlingerae* is found.
- S2.4.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
- S2.4.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics. Though recent work has greatly increased the base of knowledge for this species, more work on its basic biology and ecology is necessary for effective recovery.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, dormancy, survival, and mortality.

- S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
- S3.3. Conduct research to assess management requirements of *L. ohlingerae*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring will provide information on the factors which contribute to population declines. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *L. ohlingerae*.
- S4.1. Develop monitoring protocol to assess population trends for *L. ohlingerae*. Since recruitment may be uncommon, the lifespan of adult plants is a key parameter.
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, seed dormancy, germination, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
- S4.1.2. Monitor the effects of various land management actions on *L. ohlingerae*. Assess any changes in demographic characteristics of *L. ohlingerae* in response to land management activities, such as prescribed fire, exotic plant control, etc.
- S4.2. Develop a quantitative description of the population structure of *L. ohlingerae*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.
- S5. Provide public information about *L. ohlingerae*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific location information. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of

endangered species provide little benefit to species, since the recovery of *L. ohlingerae* and other rare species requires a self-sustaining, secure, number of natural populations.

- S6. Develop delisting criteria. Once reclassification is achieved, research and monitoring results may provide data necessary to develop delisting criteria.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are nine sites that are either protected or proposed for acquisition.

H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Little xeric scrub habitat remains for this species; any method of securing protected populations should be sought.

H1.2. Manage and enhance habitat. Manage habitat to maintain *L. ohlingerae* populations by preventing habitat damage from off-road vehicle use, and overcollection, and by providing prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval of frequency and seasonality is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To replicate this landscape pattern, sites should be burned in a mosaic when possible. This species is probably resilient to a range of fire regimes.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of this species.

H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.

- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

- H2.1. Restore a natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites, a seed bank may exist that could include rare endemic species.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *L. ohlingerae* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *L. ohlingerae* occurs.
- H5. Provide public information about scrub and its unique biota. Educational programs, especially those conducted by Archbold Biological Station, have been successful. Without these efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing programs by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Britton's Beargrass, *Nolina brittoniana* Nash

Recovery Objective: DELIST the species once recovery criteria are met.

South Florida Contribution: STABILIZE and increase the population.

Recovery Criteria: The South Florida recovery objective can be achieved when sites, within the historic range of *N. brittoniana*, are adequately protected from further habitat loss, degradation, and fragmentation; when these sites are managed to maintain the seral stages of high pine and xeric oak scrub communities to support *N. brittoniana*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

- S1. Determine current distribution and status of *N. brittoniana*. Some portions of *N. brittoniana*'s range have been well surveyed yet a total distribution has not been ascertained for this species. A thorough survey is needed to determine the distribution of this species.
- S1.1. Conduct surveys for populations of *N. brittoniana*.
 - S1.1.1. Survey scrub habitat in Osceola County. Adequate survey work has not been performed off the Lake Wales Ridge. Sites on private property cannot be protected without survey knowledge.
 - S1.1.2. Continue surveys in Polk and Highlands counties. This species is found sparsely in scrub, high pine, and hammock. During surveys, this species could be overlooked. Many sites with *N. brittoniana* may still be undiscovered.
 - S1.1.3. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
 - S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.

- S2.1. Protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for an appropriate fire regime for *N. brittoniana* habitats that includes a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable habitat, both unoccupied and occupied, of *N. brittoniana*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species.
 - S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
 - S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *N. brittoniana* as part of the National Collection.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *N. brittoniana* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take prohibitions. This species is protected by trade provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Continue research on life history characteristics of *N. brittoniana*. Although recent work has answered some life history questions, much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species, more specific

biological information is needed.

- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, gender structure, recruitment, dispersal, growth, survival, and mortality.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *N. brittoniana*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information on the localities of *N. brittoniana* sites will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *N. brittoniana*.
- S4.1. Develop monitoring protocol to assess population trends for *N. brittoniana*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as gender structure, clonal growth, reproduction, recruitment, growth, seed dormancy, germination, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease and injury.
 - S4.1.2. Monitor the effects of various land management actions on *N. brittoniana*. Assess any changes in demographic characteristics of *N. brittoniana* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *N. brittoniana*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.
- S5. Provide public information about *N. brittoniana*. It is important for the recovery of this

species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *N. brittoniana* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are 19 protected sites for *N. brittoniana* in Polk and Highlands counties.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *N. brittoniana* populations by preventing damage from off-road vehicle use and overcollection, and by providing proper management of habitat including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible. *N. brittoniana* can withstand a wide range of fire frequencies within its diverse habitats.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *N. brittoniana*. Cogon grass is present in some of the high pine and hammock habitats with *N. brittoniana*.
- H1.2.3. Control access to areas where listed plants are growing. Trampling and off-road vehicles can severely threaten individual populations.

- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *N. brittoniana* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation. Although recently studied, questions still exist on management reactions. For example after a burn, the plants experience a flowering peak one year post burn, but no recruitment increase has been detected. More information is needed on the response to management activities for this species.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *N. brittoniana* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Papery Whitlow-wort, *Paronychia chartacea* Fern

Recovery Objective: DELIST the species once recovery criteria are met.

Recovery Criteria: *Paronychia chartacea* may be delisted when: enough demographic data are

available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 95 percent probability of persistence for 100 years; when these sites, within the historic range of *P. chartacea*, are adequately protected from habitat loss, degradation, and fragmentation; when these sites are managed to maintain the rosemary phase of xeric oak scrub communities to support *P. chartacea*; and when monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

Species-level Recovery Actions

- S1. Determine current distribution of *P. chartacea*. Some portions of *P. chartacea*'s range have been well surveyed yet a total distribution has not been ascertained for this species. A thorough survey is needed to determine the distribution for this species.
- S1.1. Conduct surveys for additional populations of *P. chartacea*.
 - S1.1.1. Continue surveys in Polk, Osceola, and Highlands counties. The Lake Wales Ridge has probably been adequately surveyed, though new sites for *P. chartacea* may still be found.
 - S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
 - S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, has been isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Protect privately-owned habitat through acquisition, conservation easements, or agreements with landowners.

- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable habitat both unoccupied and occupied of *P. chartacea*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *P. chartacea*.
 - S2.4.1. Conserve germ plasm. The seed for this species is not presently in long term storage.
 - S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *P. chartacea* as part of the National Collection.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *P. chartacea* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics of *P. chartacea*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species, more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal,

growth, survival, and mortality.

- S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *P. chartacea*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques. This species experiences a dramatic increase in flowering the first year after a burn, yet can bloom up to 30 years without fire. More information is needed on the response to management activities for this species.
- S4. Monitor populations of *P. chartacea*.
- S4.1. Develop monitoring protocol to assess population trends for *P. chartacea*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *P. chartacea*. Assess any changes in demographic characteristics of *P. chartacea* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *P. chartacea*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Collect data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors).
- S5. Provide public information about *P. chartacea*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about *P. chartacea*.

Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *P. chartacea* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. This species is ubiquitous in the scrub preserves in Polk and Highlands counties.
 - H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
 - H1.2. Manage and enhance habitat. Manage habitat to maintain *P. chartacea* populations by preventing damage from off-road vehicle use, over collection, and provide proper management of habitat including prescribed fire.
 - H1.2.1. Perform prescribed fires. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches are necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.
 - H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *P. chartacea*.
 - H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off road vehicles can severely threaten individual populations.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.
- H3. Conduct habitat-level research projects. Study the response of *P. chartacea* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *P. chartacea* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the South Florida Water Management District, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been successful in disseminating knowledge about these unique communities.

Recovery for the Lewton's Polygala, *Polygala lewtonii* Small

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: *Polygala lewtonii* may be reclassified from endangered to threatened when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 20 to 90 percent probability of persistence for 100 years; when these sites, within the historic range of *P. lewtonii*, are adequately protected from further habitat loss, degradation, and fragmentation; when these sites are managed to maintain the seral stages of high pine and xeric oak scrub to support *P. lewtonii*; and when monitoring programs

demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution and status of *P. lewtonii*. This species' distribution is somewhat questionable since individuals are easily overlooked. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for populations of *P. lewtonii*.

S1.1.1. Survey scrub, high pine, and turkey oak habitats in Osceola and Hardee counties. Adequate survey work has not been performed off the Lake Wales Ridge. Sites on private property cannot be protected without survey knowledge.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, has become isolated. For this reason, existing populations are in need of protection from a variety of threats.

S2.1. Protect populations on private land through acquisition, conservation easements, or agreements with landowners.

- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Develop *ex situ* collection. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species.
- S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *P. lewtonii* lives.
 - S2.4.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.4.2. Enforce take prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species, more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *P. lewtonii*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring on the localities of *P. lewtonii* sites, will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close

coordination among land managers is essential to develop adaptive management techniques.

S4. Monitor existing populations of *P. lewtonii*.

S4.1. Develop monitoring protocol to assess population trends for *P. lewtonii*.

S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.

S4.1.2. Monitor the effects of various land management actions on *P. lewtonii*. Assess any changes in demographic characteristics of *P. lewtonii* in response to land management activities, such as prescribed fire, exotic plant control, etc.

S4.2. Develop a quantitative description of the population structure of *P. lewtonii*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for collect individual plants, data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors).

S5. Provide public information about *P. lewtonii*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about *P. lewtonii*. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *P. lewtonii* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are six protected or acquisition sites for *P. lewtonii* in South Florida.

H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Since little xeric scrub habitat is remaining for this species, any method

of securing protected populations should be sought.

H1.2. Manage and enhance habitat. Manage habitat to maintain *P. lewtonii* populations by preventing damage from off-road vehicle use and overcollection, and by providing proper management of habitat including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *P. lewtonii*.

H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

H3. Conduct habitat-level research projects. Study the response of *P. lewtonii* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *P. lewtonii* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Tiny Polygala, *Polygala smallii* Smith and Ward

Recovery Objective: PREVENT extinction, then stabilize.

Recovery Criteria: *Polygala smallii* will, most likely, never reach a level at which reclassification could be possible. The objective of this recovery plan should be to increase existing populations and prevent extinction. *Polygala smallii* may be considered stabilized when existing populations, within the historic range, are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. These sites must also be managed to maintain pine rocklands and scrub flatwoods to support *P. smallii*. Monitoring programs should demonstrate that populations of *P. smallii* on these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Genetic information is of particular importance to the recovery of *P. smallii*, especially considering the recently identified populations in Martin and St. Lucie counties. Reclassification criteria may be developed if new information identifies ways of re-establishing populations of this species to expand its distribution within its historic range.

Species-level Recovery Actions

- S1. Conduct surveys to determine distribution and status of *Polygala smallii*. Pine rocklands have been thoroughly surveyed in Miami-Dade County. Additional surveys in the historic range of this plant should be performed in the scrub, sandhill, and open coastal spoil of Broward, Palm Beach, Martin, and St. Lucie counties. Fire eliminates litter concealing

species, it may kill seeds in the litter or soil surface, or it may enable seeds in the seed bank to germinate. For that reason, suitable habitats which did not contain listed species when unmanaged should be resurveyed after fire events.

S2. Protect and enhance existing populations. It is imperative for the recovery of this species that populations not be lost.

S2.1. Augment natural populations of *P. smallii*, where appropriate. The known populations of *P. smallii* are in a precarious situation; therefore, *ex situ* collections of *P. smallii* should be established, if possible. These collections should be used to cultivate plants and augment sparse populations in protected areas. These experiments with reintroductions will be useful in the future, and could be essential for the recovery of this species. Kennedy (1998) was able to germinate *P. smallii* seeds with high germination rates, and grow them through their entire life cycle *ex situ* at Fairchild Tropical Garden.

S2.1.1. Continue work with *ex situ* propagation and seed banks. Seeds should be banked for tiny polygala and should be identified precisely as to collection location.

S2.1.2. Continue to identify potential reintroduction sites and reintroduce plants, where appropriate. Sites identified as suitable for reintroduction, within the known historic range of this species should be surveyed and prepared to receive plants. Federal lands under proper management regimes may be good recipient sites. These sites should receive reintroduction stock.

S2.2. Enforce available protective legislation. State, Federal, and local regulations should be used to protect the pine rockland ecosystem and listed plants.

S2.2.1. Initiate section 7 consultation when applicable. Section 7 of the ESA applies to Federal activities which might impact listed species, especially on Federal lands.

S2.2.2. Encourage implementation of management plans. Federal agencies are obligated under section 7(a)(1) of the ESA to perform positive conservation programs for the benefit of listed species. Implementation of the Miami-Dade County's Richmond Pine Rocklands Management Plan (DERM 1994) constitutes such a positive conservation program. The Jupiter Ridge Natural Area Management Plan, prepared by Palm Beach County DERM, is another positive conservation program for this species (S. Farnsworth, Palm Beach County DERM, personal communication 1998). The FWS is available to meet with these agencies to discuss and

assist in developing management plans for areas not under current management programs.

S2.2.3. Continue to enforce take prohibitions. *P. smallii* is protected by take and trade restrictions of the ESA and the Preservation of Native Flora Act.

S3. Collect biological information important to species recovery. Additional information on the ecology and life history of *P. smallii* plants needs to be collected.

S3.1. Determine population size and viability of all populations. Known populations of *P. smallii* should continue to be evaluated. Population viability needs to be investigated and determined for this species. This work has been initiated by Fairchild Tropical Garden for 2 populations in Miami-Dade County.

S3.2. Investigate the genetic relationship of distinct *Polygala* populations. Populations of *P. smallii* have been identified outside of Miami-Dade County. However, some researchers question the genetic relationship between these populations, since morphological characters alone were used to identify the populations. It is essential to identify their relationship since the plants appear to occur under somewhat similar habitat (dry, well-drained sites), although with different soil types.

S4. Develop standardized monitoring. Standardized monitoring needs to be developed for scrub species in order to determine the effect of management actions on these species.

S4.1. Collect existing and historical data, and place in a central location. Contact former researchers for historical data, gather information from herbaria and museums, and contact all present researchers to compile data and place in GIS database in the South Florida Ecosystem Office. This location will allow all researchers access to both historic and current data and provide the FWS with a means to monitor the success of recovery tasks.

S4.2. Convene a meeting of all researchers. A meeting of current researchers and land managers would enable the FWS to locate information sources and begin the process of compiling those data. The meeting would also afford cooperators an opportunity to discuss monitoring and management procedures and set realistic species-level goals.

S4.3. Monitor status and success of all populations; change management practices if so indicated. Because of the varying vegetation conditions and fire histories, different management may be required at different scrub sites. Different prescribed burn intervals may be necessary for best results. Intervals should be adjusted over the

years to promote pine re-establishment and hardwood reduction.

- S4.4. Monitor reintroduction success and modify procedures as necessary. Plant reintroductions should be monitored to determine the success of the procedure. The goal of reintroduction should be to establish a viable population. Management of the reintroduction sites should be modified as necessary to improve results.
- S5. Continue to provide public information about scrub, sandhill, and open coastal spoil habitat and its unique flora. Public support will increase the chances of recovery for these species. Informational and educational materials have been produced. DERM and Miami-Dade County Parks and Recreation Department's Natural Areas Management have developed flyers, displays, newsletters, and press releases for pine rockland habitats, and have held workshops with the general public. Organizations best able to carry out information and education programs include: Metropolitan Miami-Dade County Parks and Recreation Department, the Florida Native Plant Society, Everglades National Park, Miami-Dade County DERM, and Palm Beach County DERM Support of local press coverage should continue.

Habitat-level Recovery Actions

- H1. Continue to protect existing pine rockland, scrub, sandhill, and open coastal spoil plant habitats. The decline of the five federally listed pine rockland plants in Miami-Dade County is due to the almost complete elimination or alteration of pine rocklands in South Florida. The coastal scrub, sandhill and open spoil habitats in Palm Beach, Martin, and St. Lucie counties are also undergoing extensive development. Without protection and proper management, the remaining scrub habitat will be developed or will deteriorate.
- H1.1. Protect pine rockland habitat. Acquisition of remaining private sites may be the only effective way to protect or conserve pine rockland habitat. Miami-Dade County's Environmentally Endangered Lands program and the State of Florida's CARL program have acquired over 180 ha of pine rocklands in Miami-Dade County since 1990. The State of Florida's CARL program has also purchased sensitive scrub habitat in Palm Beach, Martin, and St. Lucie counties. It should be noted that public lands may still be subject to development for recreational, maintenance, or other purposes. Such disturbances, unless carefully planned, may directly destroy preserved habitats and may secondarily result in exotic plant infestations as well as destructive human uses.
- H1.2. Protect or acquire privately owned sites. Less-than-fee-simple acquisition should be used, where appropriate, as an alternative means of protecting scrub, sandhill, and open coastal spoil habitat. Covenants, as provided for under Miami-Dade County regulations, provide tax incentives for private landowners to protect pine rockland sites. A site owned by Florida Power and Light Company may be

maintained through cooperation with that utility. Similar programs are being developed for Broward, Palm Beach, Martin, and St. Lucie counties.

H2. Restore areas to suitable habitat.

H2.1. Eliminate physical degradation of habitat and restore to optimal conditions.

Physical degradation of scrub, sandhill, and open coastal spoil continues to occur. Hurricane Andrew in 1992 killed most of the adult pines in southern Miami-Dade County, excluding pine stands at Long Pine Key in Everglades NP. The continued degradation of these areas should be curtailed and restoration of uneven-aged pine stands undertaken. Tubelings, or direct seeding experiments may be used to accomplish this task. In order to use direct seeding techniques, collection of local pine seeds must continue.

H2.2. Develop best management practices for scrub, sandhill, and open coastal spoil.

This would include development of fire management strategies that would benefit scrub, sandhill, and open coastal spoil species.

H2.2.1. Implement necessary management. Without active fire and exotic plant management, scrub, sandhill, and open coastal spoil will continue to disappear or degrade. Because of the highly fragmented and restricted nature of the remaining scrub, sandhill, and open coastal spoil, intensive management may be necessary at many of the remaining sites.

H2.2.2. Continue to conduct prescribed burns. Fire should be conducted at appropriate times of year to lower fuel loads, although growing season burns should be employed most often after fuel levels are under control. Due to the highly urbanized lands surrounding many of the remaining scrub, sandhill, and open coastal spoil sites, burning involves risks of smoke damage and annoyance, or worse, losing control of the fire. The Florida Division of Forestry has expertise in carrying out controlled burns in these habitats and can assist with burns. Fire management is necessary for all Federal and County scrub lands. Burning sites with *P. smallii* will take extra preparation and monitoring.

H.2.3. Implement additional management to meet habitat needs.

H2.3.1. Eliminate human-caused degradation. Preventing trash dumping or other destructive human activities in scrub, sandhill, and open coastal spoil habitats is important. In order to accomplish this task, fencing and access restrictions may be necessary.

H2.3.2. Control invasive plant species, particularly exotics. Burma reed, Cogon grass (*Imperata cylindrica*) and persistent hardwoods need to be controlled and may require special techniques, including herbicide, fire, mechanical, and hand clearing at most sites. Other management needs indicated by ongoing research should also be implemented.

H3. Research additional habitat relationships.

H3.1. Continue to investigate and refine the habitat needs of *P. smallii*. The habitat needs of scrub species have been studied, but are still not completely understood. The pollination, germination, or other requirements of *P. smallii* have not been fully investigated. Research should address how light levels affect survival and how fire management affects light levels, reproduction, and regeneration of these species.

H3.2. Investigate fire history and incorporate into management strategies. Look at fire history for pine rocklands and scrub, sandhill, and open coastal spoil sites in Miami-Dade, Broward, Palm Beach, Martin, and St. Lucie counties, incorporate into GIS database and analyze relative to healthy populations. This exercise will provide adequate information on fire history and intervals in urbanized and non-urbanized settings and enable assessment of the appropriateness of proposed management regimes in each of the counties.

H4. Monitor sites with pine restoration programs to determine success. A monitoring protocol should be developed and implemented at these sites.

H5. Continue implementation of the fire education program and modify as necessary, any fire management education program that has been developed. Future modifications to this program may include tri-lingual distribution (Spanish, English, and Haitian Creole).

Recovery for the Wireweed, *Polygonella basiramia* (= *ciliata* var. *b.*) (Small) Nesom and Bates

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria: *Polygonella basiramia* may be reclassified from endangered to threatened when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to assure 20 to 90 percent probability of persistence for 100 years; when these sites, within the historic range of *P. basiramia*, 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 *P. basiramia*; and when monitoring programs demonstrate that populations of *P. basiramia* on these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species. Individuals growing

opportunistically in unnatural areas, for example fire lanes, should be excluded from consideration when determining the status of this species.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution status of *Polygonella basiramia*. This species' distribution is somewhat questionable for taxonomic reasons. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for populations of *P. basiramia*.

S1.1.1. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has been well surveyed, but because it is quite common within this region, new sites may still be found. Polk County should be the focus of survey work.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. *Polygonella basiramia* identification. Some uncertainty remains over the identification of this plant (versus *Polygonella ciliata* and *P. gracilis*), and therefore its geographic range is somewhat unclear. Herbarium specimens from as many protected sites as possible (especially Avon Park AFR) should be evaluated by a systematist to assure that they have been identified correctly. If they are not already available, voucher specimens must be collected from protected sites, especially in Polk County where the distributions of the two species might overlap. The systematics of these species was reviewed by Nesom and Bates (1984), and there is no apparent need for further systematic investigations.

S1.3. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat

needs.

- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Protect populations on private land through acquisition, conservation easements, or agreements with landowners.
- S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
- S2.3. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *P. basiramia*.
- S2.3.1. Conserve germ plasm. The seed of this species is not presently in long-term storage.
- S2.3.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *P. basiramia* as part of the National Collection.
- S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species. Regulations should also be used to protect xeric vegetative communities where *P. basiramia* lives.
- S2.4.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
- S2.4.2. Enforce take prohibitions. This species is protected by take provisions of the Endangered Species Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.

- S3. Conduct research on life history characteristics. Though much of the basic biology and ecology of this species is understood, to effectively recover this species additional biological information is needed.
- S3.1. Conduct research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, survival, microhabitat requirements, and mortality. Dispersal is an important issue for this species.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *P. basiramia*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring information on the localities of *P. basiramia* sites will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *Polygonella basiramia*.
- S4.1. Develop monitoring protocol to assess population trends for *P. basiramia*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival, and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *P. basiramia*. Assess any changes in demographic characteristics of *P. basiramia* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *P. basiramia*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. It should also include data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors).

- S5. Provide public information about *P. basiramia*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both development and fire suppression have decreased the available habitat. To date, there are 13 protected or planned acquisition sites for *P. basiramia*.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Since little xeric scrub habitat remains for this species, any method of securing unprotected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *P. basiramia* populations by providing proper management of habitat, including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. A 15 to 40 year cycle is recommended for *Polygonella basiramia*. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *P. basiramia*.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire.
- H2.2. Ensure natural populations. This species grows readily in fire lanes and old road

beds. These should not be considered natural populations and should not be counted toward the recovery of this species.

- H3. Conduct habitat-level research projects. Study the response of *P. basiramia* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation. More information is needed on the response to management activities for this species.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *P. basiramia* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Sandlace, *Polygonella myriophylla* (Small) Horton

Recovery Objective: RECLASSIFY to threatened, then delist.

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

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to

expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *P. myriophylla*. A thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for populations of *P. myriophylla*.

S1.1.1. Continue surveys in Polk, Osceola, and Highlands counties. The Lake Wales Ridge has been well surveyed, though sites may still be found.

S1.1.2. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties have been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.

S2.1. Protect populations on private land through acquisition, conservation easements or agreements with landowners. Carter Creek and Flamingo Villas on the Lake Wales Ridge are crucial to the recovery of this species. Flamingo Villas is currently being acquired by the FWS, but Carter Creek acquisition will be difficult due to a number of factors.

S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.

S2.3. Develop *ex situ* and germ plasm collections of *P. myriophylla*. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and

determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *P. myriophylla*.

- S2.4. Enforce available protective measures. Use local, State and Federal regulations to protect this species. Regulations should also be used to protect xeric vegetative communities where *P. myriophylla* lives.
 - S2.4.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.4.2. Enforce take prohibitions. This species is protected by take provisions of the Endangered Species Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics. Though much of the basic biology and ecology of this species is understood, to recover this species more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *P. myriophylla*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *P. myriophylla*.
 - S4.1. Develop monitoring protocol to assess population trends for *P. myriophylla*.

- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease and injury.
- S4.1.2. Monitor the effects of various land management actions on *P. myriophylla*. Assess any changes in demographic characteristics of *P. myriophylla* in response to land management activities, such as prescribed fire, exotic plant control, etc.
- S4.2. Develop a quantitative description of the population structure of *P. myriophylla*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data should also be gathered about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors).
- S5. Provide public information about *P. myriophylla*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about where *P. myriophylla* is found. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *P. myriophylla* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are 15 protected or acquisition sites for *P. myriophylla*.
 - H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. Little xeric scrub habitat is remaining for this species. Any method of securing unprotected populations should be sought.
 - H1.2. Manage and enhance habitat. Manage habitat to maintain *P. myriophylla* populations by preventing damage from off-road vehicle use and overcollection, and by providing proper management of habitat including prescribed fire.
 - H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of

the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

H3. Conduct habitat-level research projects. Study the response of *P. myriophylla* to various of *P. myriophylla*.

H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, on the habitats where *P. myriophylla* occurs.

H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the SFWMD, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Scrub Plum, *Prunus geniculata*

Recovery Objective: RECLASSIFY to threatened, then delist.

South Florida Contribution: STABILIZE, and support reclassification.

Recovery Criteria: *Prunus geniculata* may be considered stabilized when existing populations, within the historic range of *P. geniculata*, are adequately protected from further habitat loss, degradation, and fire suppression. These sites must also be managed to maintain high pine and xeric oak scrub communities to support *P. geniculata*. Proper management for this species will include verification that this long-lived species is in fact reproducing. Currently, seedlings for this species are not being found. The status of *P. geniculata* cannot be determined until adequate reproduction is verified among all populations. Once the existing populations are stabilized, *P. geniculata* may be considered for reclassification and, ultimately, delisting.

Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *P. geniculata* are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the high pine and xeric oak scrub communities to support *P. geniculata*; and when monitoring programs demonstrate that these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information.

Species-level Recovery Actions

S1. Determine current distribution of *P. geniculata*.

S1.1. Conduct surveys for *P. geniculata*.

S1.1.1. Survey scrub habitat in Osceola County. Adequate survey work has not been conducted off the Lake Wales Ridge.

S1.1.2. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge has probably been adequately surveyed, though new sites may still be found for *P. geniculata*.

S1.1.3. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database.

Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the FNAI database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
 - S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable, unoccupied, and occupied habitat of *P. geniculata*.
 - S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *P. geniculata*.
 - S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
 - S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *P. geniculata* as part of the National Collection.
 - S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *P. geniculata* lives.

- S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics of *P. geniculata*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality. Given that no seedlings have been confirmed in the wild, recruitment and survival are of primary concern for this species.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.2.1. Conduct research to assess management requirements of *P. geniculata*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring at *P. geniculata* sites will provide information about factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential in the development of management techniques. *Prunus geniculata* grows in both scrub and high pine communities. In each of these habitats, *P. geniculata* is exposed to a different fire regime and the species reacts differently to these burn cycles. More information on these reactions is needed to develop management recommendations.
- S4. Monitor existing populations of *P. geniculata*.
- S4.1. Develop monitoring protocol to assess population trends for *P. geniculata*.

- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease and injury.
- S4.1.2. Monitor the effects of various land management actions on *P. geniculata*. Assess any changes in demographic characteristics of *P. geniculata* in response to land management activities, such as prescribed fire, exotic plant control, etc.
- S4.2. Develop a quantitative description of the population structure of *P. geniculata*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.
- S5. Provide public information about *P. geniculata*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *P. geniculata* and other rare species requires a self sustaining, secure number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are six protected sites for *P. geniculata* in Polk and Highlands counties.
 - H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
 - H1.2. Manage and enhance habitat. Manage habitat to maintain *P. geniculata* populations by preventing damage from land off-road vehicle use, overcollection, and by providing proper management of habitat, including prescribed fire.
 - H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is

important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *P. geniculata*.

H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites, a seed bank may exist that could include rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were historic, may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

H3. Conduct habitat-level research projects. Study the response of *P. geniculata* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *P. geniculata* occurs.

H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding

and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the South Florida Water Management District, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful.

Recovery for the Scrub Plum, *Prunus geniculata*

Recovery Objective: RECLASSIFY to threatened, then delist.

South Florida Contribution: STABILIZE, and support reclassification.

Recovery Criteria: *Prunus geniculata* may be considered stabilized when existing populations, within the historic range of *P. geniculata*, are adequately protected from further habitat loss, degradation, and fire suppression. These sites must also be managed to maintain high pine and xeric oak scrub communities to support *P. geniculata*. Proper management for this species will include verification that this long-lived species is in fact reproducing. Currently, seedlings for this species are not being found. The status of *P. geniculata* cannot be determined until adequate reproduction is verified among all populations. Once the existing populations are stabilized, *P. geniculata* may be considered for reclassification and, ultimately, delisting. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *P. geniculata* are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the high pine and xeric oak scrub communities to support *P. geniculata*; and when monitoring programs demonstrate that these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information.

Species-level Recovery Actions

S1. Determine current distribution of *P. geniculata*.

S1.1. Conduct surveys for *P. geniculata*.

S1.1.1. Survey scrub habitat in Osceola County. Adequate survey work has not been conducted off the Lake Wales Ridge.

S1.1.2. Continue surveys in Polk and Highlands counties. The Lake Wales Ridge

has probably been adequately surveyed, though new sites may still be found for *P. geniculata*.

- S1.1.3. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
- S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the FNAI database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
 - S2.1. Protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.
 - S2.2. Protect populations on public lands. Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages.
 - S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable, unoccupied, and occupied habitat of *P. geniculata*.
 - S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *P. geniculata*.
 - S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
 - S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the

National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *P. geniculata* as part of the National Collection.

- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *P. geniculata* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics of *P. geniculata*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, dispersal, growth, survival, and mortality. Given that no seedlings have been confirmed in the wild, recruitment and survival are of primary concern for this species.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations/populations, and spatial distribution needed to ensure persistence of the species.
 - S3.2.1. Conduct research to assess management requirements of *P. geniculata*. Determine which natural populations can be stabilized or increased by habitat management. Surveys, research, and monitoring at *P. geniculata* sites will provide information about factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers and close coordination among land managers is essential in the development of management techniques. *Prunus geniculata* grows in both scrub and high pine communities. In

each of these habitats, *P. geniculata* is exposed to a different fire regime and the species reacts differently to these burn cycles. More information on these reactions is needed to develop management recommendations.

S4. Monitor existing populations of *P. geniculata*.

S4.1. Develop monitoring protocol to assess population trends for *P. geniculata*.

S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease and injury.

S4.1.2. Monitor the effects of various land management actions on *P. geniculata*. Assess any changes in demographic characteristics of *P. geniculata* in response to land management activities, such as prescribed fire, exotic plant control, etc.

S4.2. Develop a quantitative description of the population structure of *P. geniculata*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) should also be included.

S5. Provide public information about *P. geniculata*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *P. geniculata* and other rare species requires a self sustaining, secure number of natural populations.

Habitat-level Recovery Actions

H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are six protected sites for *P. geniculata* in Polk and Highlands counties.

H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected

populations should be sought.

H1.2. Manage and enhance habitat. Manage habitat to maintain *P. geniculata* populations by preventing damage from land off-road vehicle use, overcollection, and by providing proper management of habitat, including prescribed fire.

H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation.

H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic/invasive plants may become a threat to the survival and recovery of *P. geniculata*.

H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.

H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.

H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites, a seed bank may exist that could include rare endemic species.

H2.2. Enhance sites with native plant species. Because of logging or long periods without fire, certain native plant species that were historic, may now be absent from the natural composition of the community. These species can be reintroduced if natural colonization is not possible.

H3. Conduct habitat-level research projects. Study the response of *P. geniculata* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *P. geniculata* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge NWR would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the South Florida Water Management District, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful.

Recovery for the Carter's Mustard, *Warea carteri* Small

Recovery Objective: STABILIZE, then reclassify to threatened.

Recovery Criteria: *Warea carteri* may be considered stabilized when existing populations, within the historic range of *W. carteri*, are adequately protected from further habitat loss, degradation, and fire suppression. These sites must also be managed to maintain scrubby flatwoods and turkey oak dominated high pine to support *W. carteri*.

Once the existing populations are stabilized, *W. carteri* may be considered for reclassification. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to assure 95 percent probability of persistence for 100 years; when these populations, within the historic range of *W. carteri* are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the scrubby flatwoods and turkey oak dominated high pine to support *W. carteri*; and when monitoring programs demonstrate these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

- S1. Determine current distribution of *W. carteri*. Some portions of *W. carteri*'s range have been well surveyed, yet a total distribution has not been ascertained for this species. A

thorough survey is needed to determine the distribution for this species.

S1.1. Conduct surveys for additional populations of *W. carteri*. The distribution of this species may be among the hardest to ascertain. *W. carteri*'s sparse and patchy occurrence make surveying very difficult. In addition, the seed bank must be considered for this species. Plants may occur for only a few years following a burn, not to return until another disturbance.

S1.1.1. Survey scrub habitat in the coastal counties. Adequate survey work has not been conducted off the Lake Wales Ridge. Given that this species has historically been found in both Miami-Dade and Brevard counties, more thorough survey work is warranted to determine its distribution.

S1.1.2. Continue surveys in Polk and Highlands counties. This species is found sparsely in scrub and high pine, as well as hammock. During surveys, this species could be overlooked. Many sites may still be unfound. September is the best month in which to conduct surveys.

S1.1.3. Continue surveys on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.

S2.1. Protect privately-owned habitat through acquisition, conservation easements, or agreements with landowners.

S2.2. Protect populations on public lands. Develop management guidelines that allow

for a fire regime that includes a mosaic of successional stages. This species can probably survive with fire regimes in the 3 to 20 year range.

- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable habitat unoccupied and occupied both of *W. carteri*.
- S2.4. Conserve germ plasm. The seed for this species is not presently in long-term storage.
- S2.5. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *W. carteri* lives.
 - S2.5.1. Initiate section 7 consultation when applicable. Initiate section 7 consultations when Federal activities may affect this species.
 - S2.5.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida State Park rules regarding removal of plants from State lands.
- S3. Conduct research on life history characteristics of *W. carteri*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species' more specific biological information is needed.
 - S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, long-term seed bank, germination, seedling mortality, dispersal, growth, survival, and mortality.
 - S3.2. Once demographic data are known, conduct population viability and risk assessment analysis to determine the numbers of plants, sites, subpopulations and populations, and spatial distributions needed to ensure persistence of the species.
 - S3.3. Conduct research to assess management requirements of *W. carteri*. Determine which natural populations can be increased by habitat management. Monitoring information on the localities of *W. carteri* sites will identify factors contributing to

any declines at these sites. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers. Close coordination among land managers is essential to develop adaptive management techniques.

- S4. Monitor existing populations of *W. carteri*.
 - S4.1. Develop monitoring protocol to assess population trends for *W. carteri*.
 - S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, long-term seed bank, germination, seedling mortality, dispersal, survival and mortality. Also monitor for pollinators, herbivory, disease, and injury.
 - S4.1.2. Monitor the effects of various land management actions on *W. carteri*. Assess any changes in demographic characteristics of *W. carteri* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.2. Develop a quantitative description of the population structure of *W. carteri*. This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's macrocyte (vegetation cover, litter depth, substrate, and closest neighbors) should also be recorded. Data about survivorship and mortality should only be taken for a given year or for the seed bank since this species is a seed bank annual.
- S5. Provide public information about *W. carteri*. It is important for the recovery of this species that governmental agencies, conservation organizations, and private landowners be appropriately informed about this species.
 - S5.1. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *W. carteri* and other rare species requires a self-sustaining, secure, number of natural populations.
 - S5.2. Private land owners should also be made aware of the rarity of *W. carteri* and its specialized habitat needs. Conservation easements, habitat management plans, and other methods of protecting and enhancing scrub habitat should be developed with

private land owners as a means of increasing the number of protected and managed populations of *W. carteri*.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are six protected sites for *W. carteri* in Polk and Highlands counties.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat. Manage habitat to maintain *W. carteri* populations by providing proper management of habitat, including prescribed fire.
- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. Scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation. This species can live in a range of burn regimes with burn cycles from 3 to 20 years.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic and invasive plants may become a threat to the survival and recovery of *W. carteri*.
- H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist

that could include *W. carteri*.

- H2.2. Enhance sites with native plant species. Because of lack of habitat management and long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. *Warea carteri*, as well as other species of rare scrub plants should be reintroduced, if natural colonization is not possible. Wiregrass and longleaf pine should also be reintroduced to sandhill sites in locations where these species have been displaced by hardwood hammock species (C. Weekley, Lake Wales Ridge SF, personal communication 1998).
- H3. Conduct habitat-level research projects. Study the response of *W. carteri* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic and invasive vegetation. More information is needed on the response to management activities for this species.
- H4. Monitor habitat and ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *W. carteri* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge National Wildlife Refuge would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the South Florida Water Management District, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

Recovery for the Florida Ziziphus, *Ziziphus celata* Judd and D. Hall

Recovery Objective: PREVENT EXTINCTION, then stabilize.

Recovery Criteria: *Ziziphus celata* may never reach a level at which reclassification could be possible. The objective of this recovery plan should be to increase existing populations and prevent extinction. Extinction is likely for this species due to low numbers of individuals and no known reproduction in the wild. *Ziziphus celata* may be considered stabilized when: existing populations, within the historic range, are adequately protected from further habitat loss,

degradation, exotic plant invasion, and fire suppression and when this plant is successfully reproducing in the wild. These sites must also be managed to maintain the seral stage of high pine to support *Z. celata*.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

S1. Determine current distribution of *Z. celata*. It is possible that populations of this species have yet to be discovered. Currently, three of the sites for *Z. celata* are in pastures and the other two are in restricted remnant areas. A complete survey has not been made of the Lake Wales Ridge for this species, making defining a distribution difficult.

S1.1. Conduct surveys for additional populations of *Z. celata*.

S1.1.1. Conduct surveys in Polk and Highlands counties. The southern portion of this species' range has been well surveyed; the northern section needs further attention.

S1.1.2. Continue surveys for *Z. celata* on protected lands. New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.

S1.2. Maintain distribution of known populations and suitable habitat in GIS database. Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the FNAI database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.

S2. Protect and enhance existing populations. Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases is isolated. Within the islands of xeric habitat, this species is found in only two remnant natural sites and three pastures sites, indicating how little habitat is left for *Z. celata*. For this reason, existing populations are in need of protection.

S2.1. Protect privately owned habitat through acquisition, conservation easements, or agreements with landowners.

- S2.2. Protect populations of *Z. celata* on public lands. The only publicly-owned site for *Z. celata* is on the Lake Wales Ridge SF, where managers are developing a strategy for the benefit of *Z. celata*. Guidelines allow for a mosaic of successful habitat stages.
- S2.3. Use local or regional planning to protect habitat. Utilize available regional and county planning processes to encourage protection of suitable unoccupied and occupied habitat of *Z. celata*.
- S2.4. Continue *ex situ* conservation. *Ex situ* collections are important for preserving genetic diversity, preventing extirpation, and determining ecological characteristics and habitat management needs of species. These collections will be instrumental in the recovery of *Z. celata*.
- S2.4.1. Conserve germ plasm. The seed for this species is not presently in long-term storage.
- S2.4.2. Maintain *ex situ* collection. Currently, the Center for Plant Conservation coordinates conservation activities and maintains a database for the National Collection. Bok Tower Gardens, as a participating institution, maintains and propagates *Z. celata* as part of the National Collection.
- S2.5. Augment natural populations of *Z. celata*. Augmentation of known populations may be necessary to induce reproduction.
- S2.5.1. Establish a protocol for reintroduction. Records for source plants, techniques for establishing new populations, and protocols for monitoring are needed.
- S2.5.2. Locate potential (re)introduction sites. Survey habitat within the historic range of *Z. celata* and identify protected lands, both public and private, that would be suitable habitat.
- S2.5.3. (Re)introduce plants to protected sites. Use plants under cultivation to (re)establish plants in suitable habitat.
- S2.6. Enforce available protective measures. Use local, State and Federal regulations to protect this species from over collecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *Z. celata* lives.
- S2.6.1. Initiate section 7 consultation when applicable. Initiate section 7

consultations when Federal activities may affect this species.

- S2.6.2. Enforce take and trade prohibitions. This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting, or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida rules regarding removal of plants from state lands.
- S3. Continue research on life history characteristics of *Z. celata*. Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species more specific biological information is needed.
- S3.1. Continue research to determine biology and demographic information, such as numbers of sites and populations, numbers of individuals in a population, morphology, reproduction, recruitment, dispersal, growth, survival, and mortality. Since this plant is not reproducing in the wild, the questions surrounding this issue are crucial to the recovery of *Z. celata*.
- S3.2. Continue research to assess the reproductive potential of *Z. celata* in the wild. No mature fruit has been observed in the wild for this species. All recent growth in *Z. celata* has been vegetative. A pollination study is currently being conducted to ascertain the factors preventing natural reproduction.
- S3.3. Continue research to assess management requirements of *Z. celata*. Determine which natural populations can be increased by habitat management. Surveys, research, and monitoring information will provide factors contributing to any declines at each site. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers. Close coordination among land managers is essential to develop adaptive management techniques.
- S4. Continue monitoring existing populations of *Z. celata*.
- 4.1. Evaluate the effectiveness of the monitoring protocol used to assess population trends for *Z. celata*. As more information is gained about *Z. celata*, monitoring protocols may need to be altered to make use of new information.
- S4.2. Monitor and detect changes in demographic characteristics, such as growth, survival, and mortality. Herbivory, pollinators, disease, and injury should also be monitored. Characteristics such as reproduction, recruitment, and dispersal cannot

be monitored in the wild at this time, but should be included as introductions make reproduction possible.

- S4.3. Monitor the effects of various land management actions on *Z. celata*. Assess any changes in demographic characteristics of *Z. celata* in response to land management activities, such as prescribed fire, exotic plant control, etc.
 - S4.4. Continue to work with private landowners. The successful recovery of this species will be influenced by the participation of private land owners. To date a varying amount of support has been gained among the individual land owners.
 - S4.5. Monitor introduced plants. Monitoring of reintroduced plants will be essential for assessing the status of new plants and their contribution to the population as a whole. Compare adult survival, seedling production, germination rates, seed survival, seedling survival, and growth rates between transplanted and natural plants. Where monitoring indicates that introduction has been unsuccessful, reevaluate protocol and methodology developed.
- S5. Provide public information about *Z. celata*. It is important for the recovery of this species that governmental agencies, conservation organizations such as the Florida Native Plant Society, and private landowners be appropriately informed about this species. Care is needed, though, to avoid revealing specific locality information about *Z. celata*. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species. Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *Z. celata* and other rare species requires a self-sustaining, secure, number of natural populations.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat. Extensive habitat loss has already occurred throughout the range of this species. Both development and fire suppression have decreased the available habitat. There is one protected site for *Z. celata* in Polk County and none in Highlands County.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements. With so little xeric scrub habitat left, any method of securing protected populations should be sought.
 - H1.2. Manage and enhance habitat. Manage habitat to maintain *Z. celata* populations by preventing damage from off-road vehicle use and collection, and by providing proper management of habitat including prescribed fire.

- H1.2.1. Conduct prescribed burns. Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches are necessary to construct a natural fire landscape. The scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible.
- H1.2.2. Control and eliminate exotic and invasive plants and animals. Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established, for example, camphor, wild cherry trees, and blackberry bushes have threatened one *Z. celata* site, but they have been removed and are no longer a threat. Without control, exotic/invasive plants may become a threat to the survival and recovery of *Z. celata*.
- H1.2.3. Control access to areas where listed plants are growing. Collection, trampling, and off-road vehicles can severely threaten individual populations. *Ziziphus celata* is currently threatened at one site by cattle trampling and by the expansion of a county waste facility on another site. Fencing is being installed at the first site, but the potential new facility may need future attention if an entire *Z. celata* site is not to be destroyed.
- H2. Restore areas to suitable habitat. Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime. Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include rare endemic species.
- H3. Conduct habitat-level research projects. Study the response of *Z. celata* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.
- H4. Monitor habitat/ecological processes. Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *Z. celata* occurs.
- H5. Provide public information about scrub and its unique biota. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without

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