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Oil and Gas Impacts in the Big Cypress Ecosystem: An Analysis of Impacts Associated with Proposed Activities in the Nobles Grade Area

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An analysis of impacts associated with proposed activities in the Nobles Grade area



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Oil and Gas Impacts in the Big Cypress Ecosystem: *An analysis of impacts associated with proposed activities in the Nobles Grade area*

Final Report

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List of Acronyms

American Water Works Association	AWWA
Area of influence	AOI
Big Cypress Basin	BCB
Big Cypress National Preserve	BCNP
Collier Resources Company	CRC
Everglades Foundation, Inc.	EFI
Everglades National Park	ENP
Florida Fish and Wildlife Conservation Commission	FWC
Floristic Inventory of South Florida	FISF
Florida Natural Areas Inventory	FNAI
Gallons Per Minute	GPM
General Management Plan	GMP
High-Density Polyethylene	HDPE
National Geodetic Vertical Datum	NGVD
National Park Service	NPS
Nobles Grade Area	NGA
Off-Road Vehicle	ORV
Oil and Gas	O&G
Pounds Per Square Inch	PSI
Red-Cockaded Woodpecker	RCW
Society of Petroleum Engineers	SPE
South Florida Water Management District	SFWMD
Species of Special Concern	SSC
Stormwater Pollution Prevention Plan	SWPPP
Systematic Reconnaissance Flight	SRF
The Institute for Regional Conservation	IRC
The Nature Conservancy	TNC
Threatened or Endangered Mammal Species	TEMS
Total Dissolved Solids	TDS
United States Fish and Wildlife Service	USFWS
United States Geological Survey	USGS
University of Georgia	UGA
Water Conservation Area	WCA
3-Dimensional	3-D

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Executive Summary

This report is the outcome of a science panel review sponsored by Collier Resources Company (CRC) and administered by the Everglades Foundation to provide a science-based assessment of impacts from oil and gas (O&G) activities in Big Cypress National Preserve (BCNP). A team of experts, independently selected by the Everglades Foundation, Inc. (EFI) met in 2009 to study, review, discuss, and report on the topic. The EFI opposes mineral exploration on public lands. However, EFI recognizes that O&G exploration and development is a permitted activity in BCNP, that O&G exploration and/or production has been continuous in BCNP both prior to and since its formation in 1974, and that CRC maintains rights to explore and extract O&G resources in portions of BCNP. Given these circumstances, and to protect the Everglades ecosystem, EFI collected as much scientific data and expertise as possible to determine how to best protect BCNP, its Addition Lands, and surrounding ecosystems during mineral exploration and extraction.

This report provides an overview of the different ecosystem components considered and an assessment of impacts that would ensue from 3-D seismic surveying. It also considered a hypothetical plan for long-term development of oil and gas in the Nobles Grade area. The document does not consider best management practices purported by CRC, nor does it consider Federal and state regulations for O&G operations (e.g., BCNP Minerals Management Plan, 36 CFR 9(B), etc.). Instead, the report provides recommendations for avoiding, minimizing, and mitigating impacts relative to specific activities and structures, and it suggests monitoring options, in the case of potential impacts or impacts of unknown severity.

The areas of focus for this project included: (1) a 46,100-acre seismic survey area around Nobles Grade—an old oil and gas road that runs north into the addition lands from I-75 near the Collier County rest area, and (2) Raccoon Point, CRC's current center of oil and gas operations in BCNP, which is just north of Tamiami Trail and the Dade-Collier Training and Transition Airport. The Nobles Grade area, as proposed in the *Nobles Grade 3-D Seismic Survey Plan of Operations* (submitted in 2006 but subsequently withdrawn), is approximately 75 % in the addition lands and 25 % in the original footprint of BCNP. This survey would involve detonating over 5,000 charges set and sealed at approximately 50 feet below ground in order to identify sub-surface areas where oil reserves are likely to be found.

Conclusions Regarding 3-D Seismic Plan of Operations

The science panel recognized that no operations of this sort can occur without some sort of environmental impact, but also that CRC has mineral rights and is proposing to apply for exploration permits. The conclusions of the panel were focused on (a) identifying areas or times when exploration should not be allowed and (b) minimizing impacts of exploration. The panel did not make a recommendation on whether or not to permit exploration, and some mitigation measures are proposed if exploration permits are issued.

- ∞ *The most significant environmental consequence of a seismic survey is that it will likely result in further oil and gas extraction in Big Cypress, which does have significant*

potential consequences. A 3-D seismic survey will help locate O&G reserves, thus leading to permit requests for future extraction. So, the most significant impact of 3-D seismic surveying would be the impacts associated with long-term development of those resources. Impacts from any new development would accumulate through time with impacts from the Raccoon Point area, ORV trails, and other degraded areas around BCNP.

- ∞ *The proposed schedule for 3-D seismic activities is very ambitious and depends on idealized dry season conditions or drought to complete all activities.* Given year-to-year variability in seasonal rainfall, CRC will need flexible activity schedules or they will need to reduce the spatial and temporal scale of activities within a given dry season. It is recommended that CRC work closely with BCNP resource management staff to develop contingency schedules that consider unpredictable weather leading up to and throughout a survey.
- ∞ *Environmental awareness training should be required for all parties involved with a 3-D seismic survey.*
- ∞ *CRC should only be able to conduct 3-D seismic surveying activities when soils are dry.* If motorized vehicles such as ORVs and sonic drill rigs are used when soils are wet, impacts such as soil rutting, turbidity plumes, and damage to vegetation and roots caused by these vehicles could have significant impacts on flow patterns as well as indirect impacts on vegetation and aquatic biota, such as wading birds. Soils should be completely dry, with water levels well below the surface, before exploration commences.
- ∞ *Activity should completely avoid key species, such as the Florida panther, wood stork, and red-cockaded woodpecker.* Several critical biological processes for many of the plants and animals of special concern occur during the height of the dry season, which coincides directly with the proposed timeframe for seismic activities. Despite this, some impacts could be minimized or avoided altogether by maintaining sufficient distance between seismic activities and key species (e.g., Florida panther), colonies/clusters (e.g., feeding or nesting wood storks), or habitats (e.g., pineland areas with red-cockaded woodpecker cavity trees) and limiting all activity to non-crepuscular, daytime hours only.
- ∞ *Use existing roads and clearly defined existing trails.* Vegetation and small animals will be vulnerable to the movement of people and equipment during a 3-D seismic survey. Use of existing roads and trails (as proposed in the *Nobles Grade 3-D Seismic Survey Plan of Operations*), slow speeds, and avoidance of inundated and densely vegetated areas will help to minimize these impacts. CRC and their associates should make every attempt to avoid breeding choruses of frogs, gopher tortoise burrows, rare plants, strands, cypress domes, and pinelands. However, it should also be pointed out that not all “existing roads and trails” should be considered as disturbed areas of BCNP. In fact, some of these areas may be in recovery.

- ∞ *Take precautions to minimize the spread of exotics.* BCNP staff members have mapped stands of exotic plants, but individual plants may be scattered throughout the area serving as a potential source of propagules subject to spread by people and equipment. To avoid the introduction or spread of contaminants, pathogens, or exotic species, equipment and field gear should be thoroughly cleaned before entering the site, fueling and fluid changes should be done in a contained area, and all waste should be hauled out daily.
- ∞ *There are several unknown, but potential, impacts of the 3-D seismic activities.* These include: 1) the potential for seismic detonation to fracture cap rock and affect local topography and surface-groundwater interactions, 2) the potential for downstream transport of seismic detonation end-products through the aquifer, 3) the potential shockwave impacts on groundwater discharge into nearby pools that serve as dry-season refugia for aquatic organisms and a food supply for many larger animals, and 4) the potential shockwave impacts to plant root systems and burrowing organisms. Recommended monitoring will help to understand the significance of these impacts and determine whether further action should be taken.

Conclusions Regarding Long-term Development

Given that there is no specific plan of operations for development activities, we considered impacts as they would pertain to general structures and activities associated with oil and gas extraction. The structures most often associated with oil and gas development are roads, pads, and pipelines, and the severity of impacts caused by these structures primarily depends on their location (relative to sensitive habitat) and area of wetland they occupy.

- ∞ *The construction of new roads and pads in BCNP will result in the direct loss of wetlands under the footprint of these structures.* Important ecosystem services (e.g., habitat, water quality enhancement, etc.) provided by these wetlands will be lost for the duration of oil and gas development (> 20 years) and possibly into perpetuity, as these structures are sometimes incorporated into park infrastructure. We recommend any future structures of this type be mitigated from the outset to compensate for time of lost ecosystem services, in addition to restoration of these original wetlands at the conclusion of surface occupation.
- ∞ *Roads and pads can disrupt water flow.* When oriented perpendicular to flow in wetlands, roads and pads serve as a dam resulting in the piling of water on one side and changes in vegetation community structure. Small culverts are the cost-effective solution to this, but damming still occurs during large precipitation events. We recommend more strategic design of roads to minimize length, to orient them—to the extent possible—parallel to flow patterns, and to elevate or bridge sections that have high potential for through-flow so as to avoid impacts of culverts seen in other south Florida wetlands.
- ∞ *Roads, pads, and easements for pipelines can attract invasive plant species and even*

facilitate the spread of these plants across an area the combined length of these structures. Evidence from Raccoon Point suggests invasive species are eradicated/managed along 11-Mile Road, but more work is needed around some of the pads. Exotics must be regularly monitored and eradicated around all oil and gas structures.

- ∞ *Roads and pads also serve as attractors to fauna ranging from amphibians and snakes to large mammals such as bears and panthers and can result in significant increases in road mortality (i.e., mortality from impact with vehicles).* Reduced speeds and vigilance can reduce the potential for this source of mortality. However, these structures can have an indirect effect on road mortality by funneling individuals from the interior of BCNP to a main thoroughfare such as I-75. Proper fencing and gating can help prevent this.
- ∞ *Spills of oil, drilling fluids, or “produced” water would have immediate negative impacts on adjacent wetlands and natural areas.* Runoff from roads and pads can also have long-term impacts that degrade the quality of adjacent wetlands, increasing the area of influence. Although pads are designed to contain rainfall, accumulated stormwater combined with contaminants (fuel, drilling mud, grease, etc.) from the surface will inevitably end up in the wetlands around these structures. Pad stormwater is not effectively managed at Raccoon Point, and we observed turbid stormwater draining directly into the wetland on one field trip. CRC, in consultation with BCNP staff, will need to review their containment and stormwater management procedures.
- ∞ *The current water quality monitoring program at Raccoon Point is inadequate for detecting impacts of oil and gas activities in space and time.* Monthly sampling of current water quality constituents at a handful of poorly located sites is insufficient. Event-based sample collection with some continuous sampling at more strategically based locations should be added in addition to other, more robust water quality indicators of oil and gas activity. The water quality program at Raccoon Point should be re-evaluated by CRC, BCNP, and members of the scientific community and revamped before any new permit requests are submitted.

Other oil and gas activities and structures generate noise and movements that, at certain times of the year and in certain locations, could produce impacts of varying severity. Without a more detailed plan of operations for long-term development, we are unable to comment on specific impacts related to faunal and floral components of the Nobles Grade area. Therefore, in the event that long-term development activities are permitted in the future, the panel recommended that a similar study of impacts be convened to consider the timing, location, intensity, and spatial scale of activities planned.

Introduction

The Big Cypress National Preserve (BCNP) was established in southern Florida in 1974, protecting 582,000 acres (236,000 ha). It was expanded in 1988 with the addition of 147,000 acres (60,000 ha), known as the Addition Lands (**Figure 1**). Big Cypress is categorized as a preserve due to its multiple uses, which include hunting, off-road vehicle (ORV) activity, private land holdings, and oil and gas exploration and development. Prior to 1974, the Collier family owned much of the land within and surrounding the preserve, and they currently retain mineral rights to nearly 400,000 acres (162,000 ha) of subsurface land below BCNP and its Addition Lands. The Federal government protects the Collier family's right to explore and develop oil and gas resources within these lands. However, they are expected to perform these activities in an environmentally sensitive manner that considers the value and preserves the integrity of the living and non-living resources at the surface.

Compared with the “river of grass” Everglades ecosystem to the east, considerably less research has been conducted in Big Cypress National Preserve on the interactions between water depth/water quality and wetland structure and function. In fact, much of what we know about Big Cypress today goes back to the early 1970s work of Drs. H.T. Odum and K.C. Ewel that led to the development of the Center for Wetlands at the University of Florida (cited throughout Ewel and Odum 1984). Other landmark ecosystem studies of Big Cypress include the National Audubon Society's resource inventory and analysis (Duever et al. 1979 and re-printed in 1986), an EPA-sponsored ecosystem analysis of the Big Cypress and its estuaries (Carter et al. 1973), and a U.S. Department of Interior analysis of impacts associated with the proposed jetport construction (USDOI 1969) that is currently named the Dade-Collier Training and Transition Airport and is operated by the Miami-Dade Airport Authority.

This report is the outcome of a study that was commissioned by Collier Resources Company (CRC) to provide a science-based assessment of impacts associated with oil and gas (O&G) activities. The panel that was convened to conduct the study and develop the report were overseen by the Everglades Foundation, Inc. (EFI), a 501(c)(3) not-for-profit, charitable organization dedicated to advancing an understanding of the Greater Everglades Ecosystem and its irreplaceable environmental and economic value. The EFI opposes mineral exploration on public lands. However, EFI recognizes that O&G exploration and development is a permitted activity in BCNP, that O&G exploration and/or production has been continuous in BCNP both prior to and since its formation in 1974, and that CRC maintains rights to explore for and extract O&G in portions of BCNP. Given these circumstances, and to protect the Everglades ecosystem, EFI collected as much scientific data and expertise as possible to determine how to best protect BCNP, its Addition Lands, and surrounding ecosystems during mineral exploration and

extraction.

As the lead organization on this project, EFI was charged with selecting a panel of experts to consider all possible impacts of O&G activity on Big Cypress ecosystem components ranging from water flows and water quality to large fauna. Panelists were selected based on individual expertise—ranging from forested wetland ecology to wildlife biology/ecology—and affiliation so as to avoid political, professional, and personal conflicts of interest (**Appendix A**). EFI staff also developed agendas and schedules for each of the panel meetings (**Appendix B**). The full panel met in Miami from July 29-31 and again from August 29-31. There was also a partial panel meeting in late June (29 and 30) 2009 to accommodate summer travel schedules of several panelists.

The panel and staff were charged with ensuring that findings and anticipated impacts associated with O&G activities were based on the best available science. This was to include reports, data, publications, and presentations from BCNP as well as information from other states and regions that also support substantial O&G activity and have had similar studies conducted. Panelists were also expected to use information and knowledge gained from personal experience and research programs when possible and appropriate. In situations where data on a particular topic did not exist, panelists were encouraged to use their best scientific judgment to determine the potential for and significance of impact. Given the undeveloped state of the BCNP ecosystem and the location of this landscape relative to adjacent critical ecosystems (e.g., Everglades, Florida Bay, 10,000 Islands, etc.), panelists were given broad bounds for consideration of impacts related to O&G activities. Presentations by CRC and invited guests were open, but panel deliberations were always closed, panel-driven and independent of CRC. In these closed sessions, our goal was to aim for consensus when possible, but also to recognize disagreements. Finally, products were subjected to external peer-review. Throughout, panel staff stressed the importance of confidentiality of report findings until the report was vetted through the panel and peer reviewers.

The areas of focus for this project included: 1) a 72 mile² (186.5 km²) area around Nobles Grade—an old O&G road that runs north into the Addition Lands from I-75 near the rest area (**Figure 2**), and 2) Raccoon Point, which is just north of Tamiami Trail and the Dade-Collier Training and Transition Airport (**Figure 3**). The Nobles Grade area (NGA) is the present area of interest for future exploration (and possibly development) by CRC. The footprint of the NGA, as proposed in the *3-D Seismic Plan of Operations* (CRC 2006), is approximately 75% within the Addition Lands and 25% within bounds of the original BCNP lands. This is noteworthy because public ORV access has been closed in the Addition Lands since 1996 and even before that time, as the land was privately held. CRC's *Plan of Operations* calls for using (to the extent possible) existing roads and trails to conduct much of the seismic survey. However, it is not clear to what extent these existing roads and trails have been disturbed or recovered since previous disturbance.

Raccoon Point is the current center of CRC O&G activities in BCNP, including the 11-Mile Road connecting this area to Tamiami Trail, and 5 pads with a variety of equipment, well heads, storage tanks, etc. (see photos in Figure 4). Raccoon Point served as a point of reference for the panel as it represented the kinds of structures, activities, and impacts that would be associated with the long-term development of O&G resources in the NGA. Raccoon Point was also the site of a smaller 3-Dimensional (3-D) seismic survey conducted in 1999.

The late June (partial meeting) and late July 2009 meetings focused on CRC's draft proposal to conduct a comprehensive 3-D seismic survey across the Nobles Grade footprint (see Figures 1 and 2). See Appendix C for a list of attendees and affiliations for both meetings. Mr. Bob Duncan, president of CRC, gave a half-day presentation on the plan for this 3-D seismic survey—including the state and federal regulations, details on all major activities and methods (including modern technologies and lower-impact approaches), other steps taken to minimize impacts, and the anticipated timeline of events. The panel received presentations from numerous agency experts on the ecology and biota of Big Cypress, as well as the permitting process. See Appendix D for a list of presenters, affiliations, and presentation titles. Given the relative lack of information on Big Cypress in the peer-reviewed literature, these experts and their presentations were invaluable to the panel as a way to understand the intricacies of the greater ecosystem. The panel also visited the Raccoon Point site during this first panel meeting to observe structures and activities associated with current O&G extraction and processing.

The late August 2009 panel meeting focused on a projection of activities that would be associated with long-term development of O&G resources based on a 3-D seismic model created for the NGA. Mr. Duncan presented an overview of the technology and strategy, as well as activities, structures, impacts, permitting, and timeline associated with O&G development, production and reclamation. While this presentation provided important insights into the process, it is important to note that specific details, such as actual location for O&G development, were hypothetical since actual plans require 3-D seismic data, which are not yet available. Agency experts also presented information to the panel on the wildlife of Big Cypress, including Florida panthers (*Puma concolor coryi*) and red-cockaded woodpeckers (*Picoides borealis*). See Appendix D for a list of presenters, affiliations, and presentation titles for the August 29 panel meeting.

In their deliberation of impacts associated with O&G activities, the panelists considered the ecology of the BCNP and its Addition Lands. This included the variability in and interactions among ecosystem components, as well as the role of BCNP within the greater Everglades ecosystem (i.e., points and modes of connection with adjacent ecosystems). The panel then considered the proposed activities with respect to living and non-living natural resources including geology and soils, water resources (hydroperiod, flows, quality, etc.), vegetation, and wildlife (especially threatened and endangered species). The panel evaluated the sensitivity of these resources relative to the severity of impact, positive and negative outcomes, and the

spatial and temporal scales of impact and response. Impacts considered included direct and indirect effects of O&G activities, immediate and delayed effects, as well as potential cumulative, interactive, synergistic, and antagonistic effects. The panel attempted to assess the overall impacts of O&G activities proposed by CRC, taking into consideration existing and permitted uses (ORV, hunting, etc.) of the preserve, as well as the frequency and intensity of natural disturbances such as lightning/thunder claps, fire, and hurricanes. The panel also considered possible recommendations to improve avoidance, minimization, and mitigation of impacts. Additionally, the panel identified potential monitoring programs, where needed, as a way to avoid or minimize impacts.

The final product of this effort is summarized in this document, which contains three major sections. **Section 1** provides background on the ecology and scientific understanding of the NGA of BCNP and its ecosystem components. **Section 2** contains an exhaustive consideration and analysis of impacts associated with the proposed *Nobles Grade 3-D Seismic Plan of Operations* (CRC 2006). This Plan of Operations served as the basis for our analysis in terms of the area considered and methods to be used. It was also the source for many of the maps and some of the data sources used in this document and should be considered as a companion to this document. It is our understanding that this Plan of Operations will be re-submitted in the near future for 3-D seismic survey permits for the Nobles Grade area. **Section 3** focuses on a hypothetical, long-term development plan for an area like Nobles Grade and is referenced to O&G activities currently underway at Raccoon Point. Following peer review, this report will be presented to the CRC and will be made public on the EFI's website (<http://www.evergladesfoundation.org>).

The panel deliberations and impacts presented herein, particularly for the 3-D seismic survey (**Section 2**), are specific to the Nobles Grade footprint (**Figures 1 and 2**). This assessment does not necessarily apply to other areas of BCNP and its Addition Lands. Further, the impacts presented for long-term development (**Section 3**) are based on a hypothetical plan pertaining to artificial 3-D seismic results. More detailed information would be needed, and a similar panel convened, to consider the actual impacts of a more precise plan for O&G development in this area.

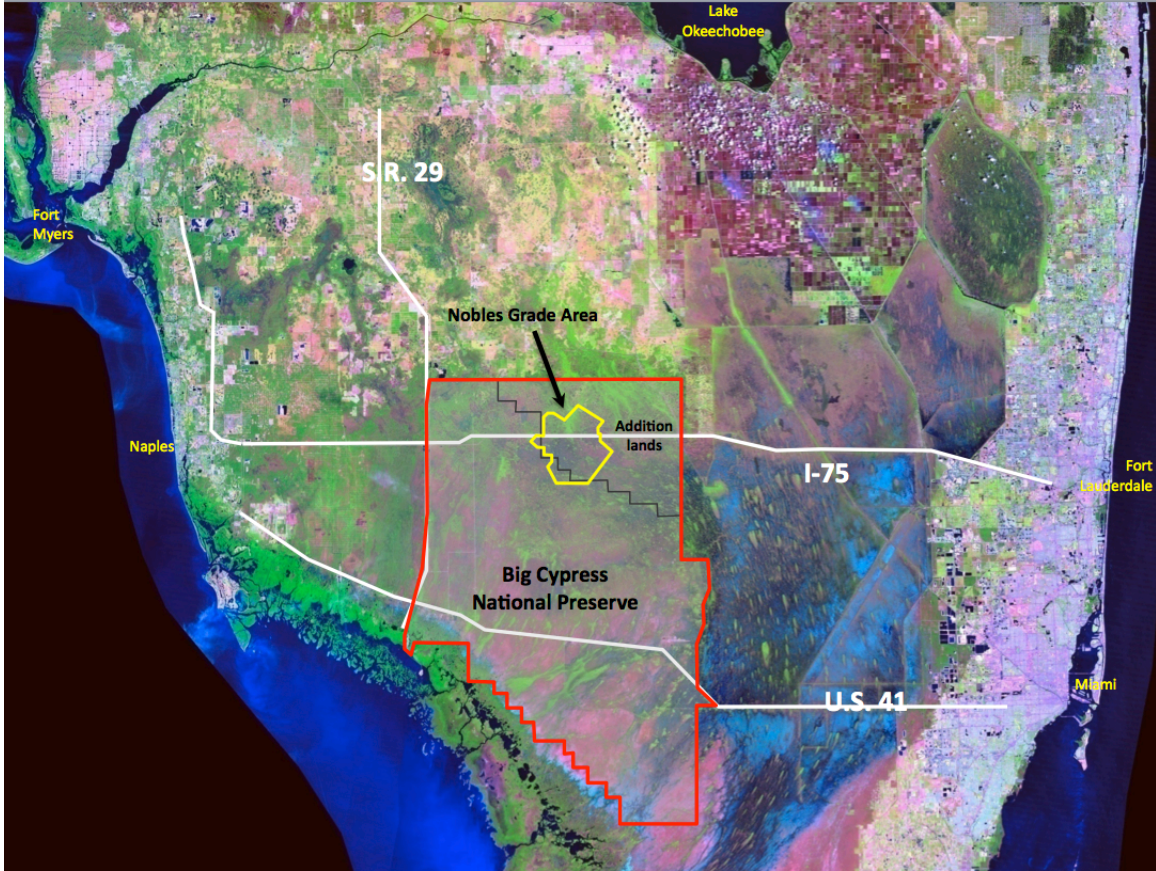


Figure 1: Landsat image of south Florida showing locations of Big Cypress National Preserve, Addition Lands (above stair step border of BCNP), and the Nobles Grade 3-D seismic project area.

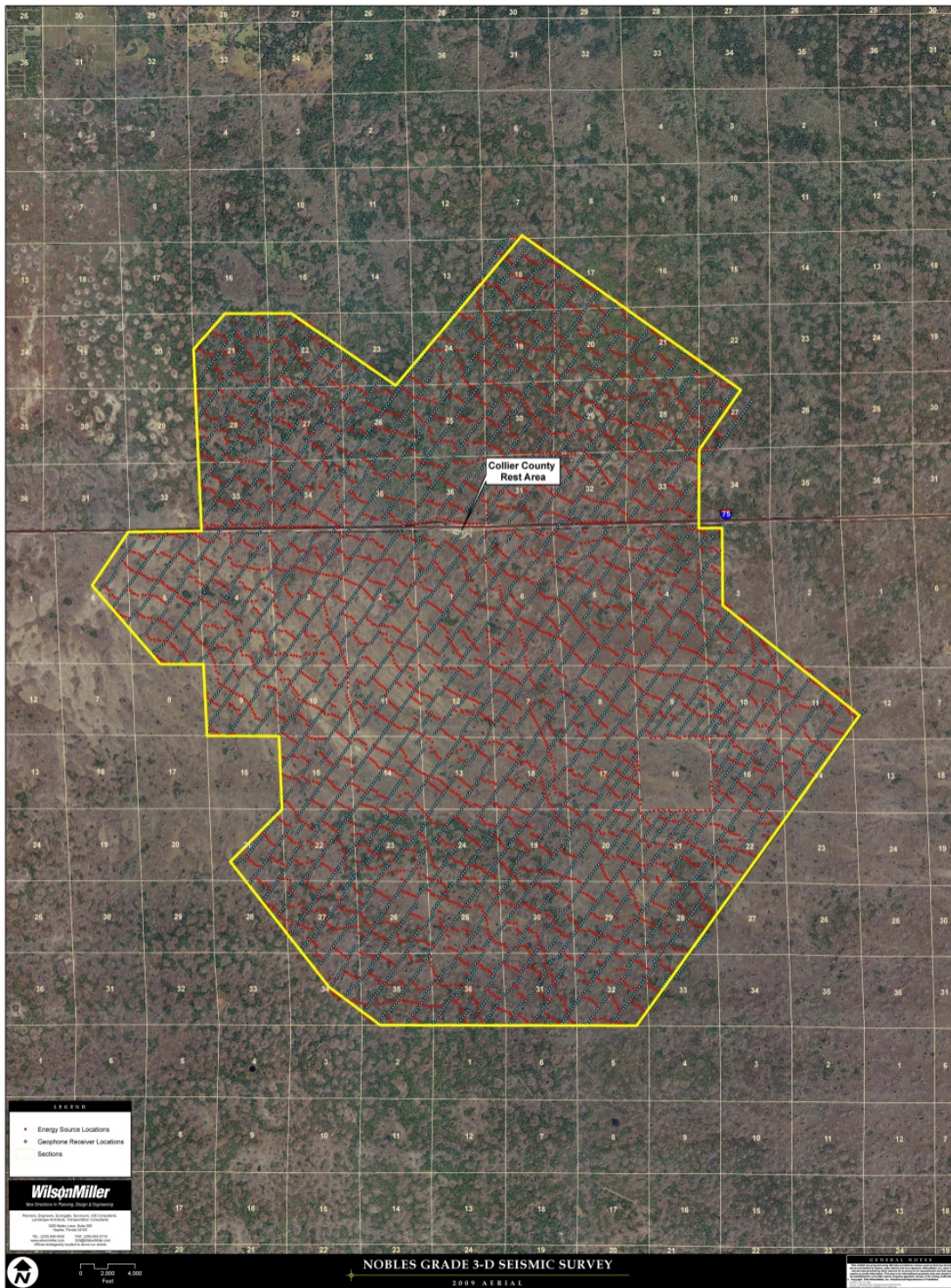


Figure 2: Map of Nobles Grade area relative to I-75 showing the location of the rest area. This map also shows the re-positioned, proposed energy source locations along inferred existing roads and trails. Map was made available courtesy of Wilson Miller Consulting and was included in the 2006 *3-D Seismic Plan of Operations* (CRC 2006).

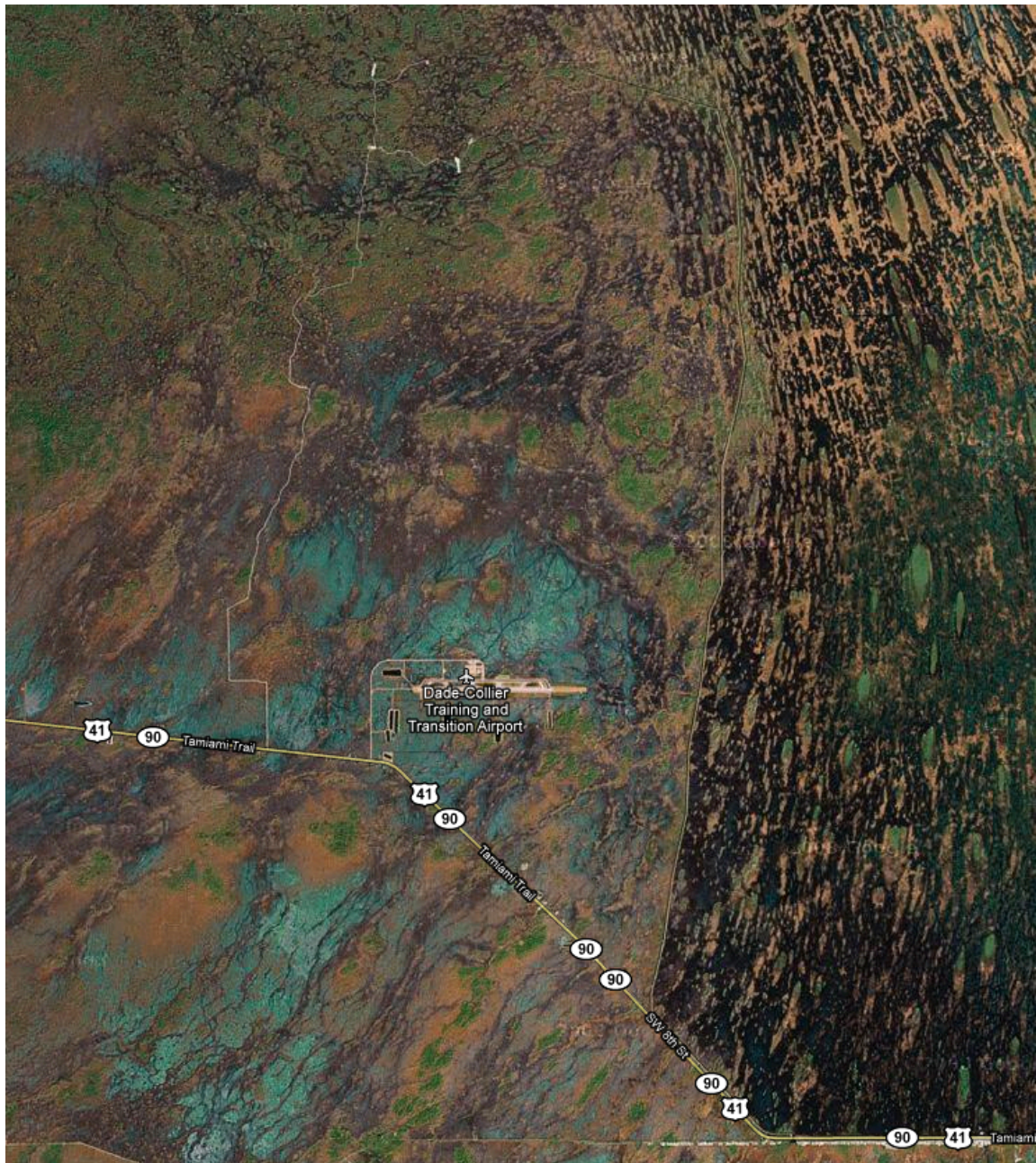


Figure 3: Google map showing 11-mile Road to the west of the Dade-Collier Training and Transition Airport (“jetport”) off Tamiami Trail. The 11-mile Road ends at Collier Resources Company’s Raccoon Point field, which includes 5 pads and 17 wells.



Figure 4: Photos illustrating a few of the different oil and gas structures observed on pads at Raccoon Point (Photos by Stephen Davis).

Section 1: Ecosystem components of the Nobles Grade area of Big Cypress National Preserve and Addition Lands

1.1 Water in Big Cypress

1.1.1 Water Depth and Hydroperiod

Water is the fundamental driver of wetlands, including the Big Cypress ecosystem. The depth, flow, and permanence of water at the surface or just below the soil surface dictate species presence (i.e., which species of plants and animals are able to persist). Flooding or saturation at or near the surface for extended periods typically leads to anoxic and more reduced soil conditions, which are unfavorable for many terrestrial plants. At this point, wetland plants (hydrophytes) proliferate and compete locally for resources such as light and nutrients. Across wetlands, plants are largely organized by their ability to tolerate local hydrologic and physico-chemical conditions (pH, salinity, redox potential, etc.) while competing with one another for resources. Over the long-term, their presence is the result of their ability to persist over time-averaged conditions that integrate across fluctuations in the environment (e.g., wet season to dry season, or dry year to wet year). Given the gentle topography of south Florida, small changes in soil flooding or saturation can elicit significant changes in plant community zonation.

The depth, flow and permanence of water in a wetland also affect rates of ecosystem processes such as primary and secondary productivity, respiration, decomposition, and organic matter export, as well as organismal functions such as nesting, timing of flowering or reproduction, feeding behavior, etc. Ecosystem processes are an indication of the performance of the wetland and determine ecosystem attributes such as the structure of the vegetation (e.g., tall forest vs. dwarf forest, emergent vs. floating aquatic), the accumulation of organic matter in soils, and the transfer of energy through the food web. Organismal functions, on the other hand, are often cue-driven processes that affect the success of an individual or population. An example of this would be water depth affecting seed production in baldcypress (*Taxodium distichum*) or nest initiation in wood storks (*Mycteria americana*). In south Florida, we have witnessed the implications of altering the depth, flow, and permanence of water in wetland ecosystems on native plant and animal communities. As an example, reduced flows of water in the Everglades over the past century have increased fire frequency or extent, changed soil development and topography, and ultimately shifted plant communities (Sklar et al. 2002).

1.1.2 Water Quality

Ecosystem processes also include biochemical and geochemical processes that account for the sources and fate of elements in wetlands. These processes dictate cycling of elements and are collectively referred to as wetland biogeochemistry. Wetlands have long been known to serve as sources, sinks, and transformers of

organic and inorganic materials that pass through surface waters or groundwaters. They are particularly effective at reducing suspended solids or turbidity, nutrients such as nitrogen (N), and phosphorus (P). As a result, wetlands are often used for treatment of wastewater and agricultural runoff. However, even treatment wetlands have thresholds for uptake and often require some sort of remediation to maintain or maximize water-treatment efficiency. These biogeochemical qualities, combined with the importance of precipitation as a hydrologic driver, result in a high water-quality signature for much of BCNP (Miller et al. 2004).

Given the importance of water to wetlands, it should come as no surprise that the quality of that water is also critical to wetland health and the sustenance of the organisms and processes supported by the ecosystem. Water quality is a relative term used to describe the chemical and physical conditions of water used for consumptive and recreational uses, as well as the capacity of water to support life in natural settings such as wetlands. The term is relative in that the minimum standards for quality of water for drinking differ from those for swimming or those required to support native species and typical rates of ecosystem processes in wetlands. Regardless of standards, wetlands are no less responsive to fluctuations in water quality than humans consuming waters of varying quality. Water of “poor” quality can be detrimental for organisms such as plants, fish, and humans as well as wetland ecosystems such as the Everglades or Big Cypress.

It is worth noting that the quality of groundwater—especially the quality of water at depths to which CRC would be drilling—is very different from surface water. Mixing groundwater with surface water through the activities proposed in the 3-D seismic survey (or long-term drilling activities) can have equally detrimental impacts at the surface of the Big Cypress ecosystem.

Natural deviations in water quality often occur temporally as a result of changes in climatic patterns (e.g., shifting from the wet season to dry season, or vice versa) or spatially as a result of subtle changes in topography that affect the depth, flow, or permanence of water at the surface (Miller et al. 2004). Water from rainfall has very different quality compared to groundwater or water that flows over natural landscapes and interacts with vegetation, soils, and fauna. As an example, the surface water concentration of total dissolved solids (TDS) at the height of the wet season will often be much lower than TDS concentrations at the height of the dry season, when precipitation inputs are lowest and evaporative losses are highest. The organisms that are present in wetlands are well adjusted to these types of natural fluctuations, even though they may do better at some times (e.g., the wet season or a wet year) than others (i.e., those that may thrive during the dry season or a dry year). The community of organisms and the rates of processes we could measure through time and across a wetland ecosystem are thus shaped by this natural variability.

Unnatural deviations from normal spatial and temporal patterns in surface water quality often lead to different rates of ecosystem processes and, if sustained over

long periods of time, can result in changes in plant and animal communities. In south Florida wetlands, ecosystem processes and species presence are often sensitive to (or limited by) the availability of P. Nitrogen inputs are also important and may act to enhance rates of soil respiration and subsequent cycling of P and other elements. Collectively, P and N are of great importance in biological systems, as these elements are required for structural (N and P), electrochemical (P), and mechanical functions (P) of biological organisms (Sterner and Elser 2002). Aside from biological uptake, different forms of these two elements can also be effectively removed from a system via abiotic processes such as volatilization and loss to the atmosphere, adsorption onto particles, or binding in mineral forms. As a result of the limited availability of N and P relative to other biologically required elements, primary producers in tropical wetland and coastal ecosystems often display a limitation due to one of these elements (Fourqurean et al. 1992, Lapointe and Clark 1992, Amador and Jones 1993, Agawin et al. 1996, Feller et al. 2003), thus affecting ecosystem processes and species dominance.

Nitrogen and phosphorus may enter wetland ecosystems such as Big Cypress via a number of different pathways. Regardless of their mode of entry, nutrients are transmitted in organic or inorganic forms to wetland ecosystems via surface water flow, groundwater inputs, and atmospheric deposition (both wet and dry). Relative to the water column, the sediment/soil and plant biomass in these ecosystems represent the largest reservoirs of N and P. Once N and P are immobilized within Big Cypress (as has been shown in other wetlands), the different forms of these elements are transformed via an array of biogeochemical pathways—depending on conditions such as sediment type (mineral vs. organic-rich), redox, pH, light, temperature, and availability of labile organic substrate (Nixon 1981, D’Elia and Wiebe 1990, Bianchi 2007).

In south Florida wetlands, municipal runoff and agricultural inputs are among the most significant sources of P and N loading and contributors to water quality degradation. A classic example of the associated impacts is the P loading from the Everglades Agricultural Area that has changed soil respiration, primary production, and plant community structure (i.e., a shift from sawgrass (*Cladium jamaicense*) to cattail (*Typha* spp.) in Water Conservation Area 2 (WCA) and along certain canals throughout south Florida. Additions of other contaminants, such as heavy metals and organic chemicals (pesticides, herbicides, etc.), have negative impacts on wetlands either by altering soil conditions (that affect species presence and rates of ecosystem processes) or accumulating to toxic levels that can be lethal to native flora and fauna. Water quality around the NGA indicates low levels of chloride, sulfate, total P, total N, nitrite/nitrate, and ammonia/ammonium relative to near-canal sites and, surprisingly, even more oligotrophic areas in Shark River Slough of ENP (**Figures 1.1 and 1.2**). Given the BCNP ecosystem’s sensitivity to macronutrients such as N and P and the susceptibility of its assemblage of organisms to toxic substances (e.g., oil spills), we considered the potential impact of different O&G activities on water quality in and around the NGA of Big Cypress.

1.1.3 Climate and Surface Hydrology

Within the proposed 3-D seismic exploration program area in Nobles Grade, surface water generally moves south and southwest through the shallow sloughs as sheet flow controlled by the surface topography and channel flow through ditches and channels associated with I-75 drainage structures and pre-1996 agricultural practices in BCNP. The area is inundated during the wet season by water ranging from a few inches to several feet in depth. Surface water is ponded year-round in the central depressions of cypress dome areas in all but drought years. Existing hydrologic data available for the BCNP area consists of gauged rainfall, surface and groundwater stage (level), and potential evapotranspiration for a number of stations within the BCNP, complemented with rain gauges in areas throughout the Big Cypress Basin (BCB), which includes Collier County and western Monroe County (mainland only).

Seasonal variability in rainfall in this region also accounts for significant temporal variability and averages 52 to 54 inches (133 to 136 cm) per year with as much as 80% of the annual rainfall deposited between the months of May and October (**Figure 1.3**; McPherson 1973, Duever et al. 1986b). Rainfall around the BCB/BCNP area is typically dominated by local weather phenomena. Local thunderstorms account for large amounts of rain and the rainfall distribution is, therefore, highly variable both in time and space. Daily rainfall records have been collected in several rain gauges within the BCNP. In addition, a number of rainfall records for northern Collier, Lee and Hendry counties are available (Christierson 2001). The locations of the rainfall stations within the BCNP are depicted in **Figure 1.4**.

As a point of reference, the average annual rainfall for this region in the last decade (1990-99) is 48 inches (121.9 cm), which is comparable to the 51-inch (129.5 cm) average rainfall computed for the Caloosahatchee watershed located north of the BCNP area (Jacobsen 1999). The annual average rainfall for the Estero Bay area was somewhat greater, approximately 14 inches (35.6 cm) higher due to heavy local thunderstorms that occurred in this area in 1991, 1992 and 1995. The wettest year during this period was 1995 with 70 inches (177.5 cm) and the driest year was 1996 with 37.6 inches (95.5 cm).

Evapotranspiration from the land surface consists of evaporation directly from the soil and the soil-vegetation surface, as well as transpiration through plant leaves. Measured potential evapotranspiration rates are rarely available (Wilson 1990) but in humid regions, evaporation pans provide reasonable estimates of potential field evapotranspiration. A record of actual pan evaporation data for the period from 1990-99 is available for the BCB. The meteorological station "BCB Field" is located south of the Estero Bay Watershed and south of the Cocohatchee Canal. The monthly rainfall and evaporation distributions for BCB during this period are presented in **Figure 1.5** and show that the rainfall exceeds the potential or maximum evapotranspiration during the summer months. The data show some variation

during the period from 1990-99 with the lowest evaporation rates occurring in 1995 (**Figure 1.5**).

The major surface flow ways in the BCB/BCNP area consist of a number of floodplains and an intricate system of human-made channels. The main river branches in the northern part of the area have previously been delineated and set up in the Estero Bay model. It includes the Imperial River, the Corkscrew wetland system, Lake Trafford and the northern part of Camp Keais Strand. The Corkscrew wetland connects to the Imperial River and Cocohatchee Canal to the west and to a large canal network, the Golden Gate and Faka Union system, to the south. The main branches in the Golden Gate and Faka Union system have previously been delineated and set up by Dames and Moore (1998) in a UNET model. Additionally, four major floodplains are located in the southern and eastern area including Henderson Creek, Stumpy Strand, Fakahatchee Strand and Okaloacoochee Slough. The main flow ways in the catchment are delineated in **Figure 1.6**. Existing surface water stage and flow monitoring gauges for the BCNP area are shown in **Figure 1.7** and **Figure 1.8**.

Within the NGA, surface water is generally present in lower elevations of the program area during the late summer and fall periods of the wet season. Through the winter and spring months, water levels recede to cypress dome areas and soils become firm. Sheet flow rates are highest during high water periods, and decrease as the wet season ends. Mullet Slough is the only major flow way in NGA conveying water flow eastward towards WCA 3 (3B) and the Everglades—representing a major point of surface water connectivity between Big Cypress and the “river of grass” Everglades to the east.

The major floodplains in the BCB/BCNP area have been delineated based on several different sources of information including topographic contour maps of the area, existing delineations made by Dames and Moore (1998), road maps including a BCB canal and water control structure index map, and satellite images of the watershed. In general, the terrain in the watershed is extremely flat. Ground elevations range from 40 ft (12.2 m) National Geodetic Vertical Datum (NGVD) at the northeastern BCB boundary and 3-5 ft (0.9-1.5 m) NGVD at the western end near the coastal zone. Due to the very small ground slopes (approximately 0.035%), water moves slowly and minor human-made alterations (e.g., ORV trails and soil ruts) affect water levels and flow ways significantly. Furthermore, the slightest deviation in surface elevation may detour runoff, which means that the resolution of the digital elevation model (DEM) is crucial to quantify water stages and flows on the floodplain.

A combined topographic contour used to develop a hydrologic model for the BCB (DHI 2002) is presented in **Figure 1.9**. It is important to note that this study area does not include the NGA, but is presented here as reference information for topography in the BCNP. For comparative purposes, the topography within the NGA is shown on **Figure 1.10**. The values for this detailed topographic contour map are consistent with those found in the greater BCB. Within the NGA, the topography is

relatively flat with elevations ranging from 12-14 ft (3.7-4.3 m) NGVD north of I-75 to elevations of 8.9-9.8 ft (2.7-3.0 m) NGVD south of I-75.

1.1.4 Soils and Groundwater Hydrology

Big Cypress soils (usually sandy or marl) are typically thinner than Everglades and WCA soils, and elevation in BCNP is generally higher than the Everglades, meaning water levels are generally shallower. Therefore, surface waters are typically in more direct contact with cap rock in BCNP than in the Everglades. The end result is high-grade water quality in BCNP, though the phosphorus levels are slightly higher on average than in ENP (Miller et al. 2004).

In general, soils in the NGA are poorly developed and can be characterized as follows:

- ∞ *Cap rock* is found at or near the surface in many locations in the program area. This unit often has a thin, calcium rich marl or quartz sand over it. Baldcypress sloughs and strands have cap rock at or near the surface.
- ∞ *Marl soil*, usually less than one foot thick (0.3 m), is found over much of the program area in areas covered by the dwarf form of baldcypress. The marl soil has a high pH and is a poor substrate for most vegetation. Marl soils have developed on lower elevations and support small baldcypress in sloughs and strands.
- ∞ *Organic (or peat) soil* is found in wet, baldcypress dome areas where the cap rock is absent and decaying vegetation has accumulated in depressions. These areas have very low pH and support baldcypress and submergent and emergent wetlands vegetation.
- ∞ *Sandy soils* are thin quartz sands and are generally found over higher elevations in the program area. These soils support pines and hardwoods.

1.1.5 Hydrogeology

The hydrogeology in the BCB/BCNP area is typical of southwest Florida. It is characterized by high, permeable soil layers consisting of sand, sandstone and limestone, although horizons of low permeable fine sediments are observed locally, particularly in depression areas. The upper three aquifers consist of shells, sand and limestone, with a relatively high hydraulic conductivity. Finer silt and clay sediments are found lower in the aquifer.

Groundwater resources of the area were examined most recently in the late 1990s by the USGS and reported in a USGS Water-Resources Investigations Report (Reese and Cunningham 2000). The depth to groundwater from seven observation wells in or near the program area confirms that the water table is at or near the surface. These observations were confirmed by CRC (2006) during sonic rig testing. A few groundwater stage wells are located within the BCNP and are shown on **Figure 1.11**.

Shallow water tables are found throughout the Nobles Grade area, as well as across BCNP. During the wet season, this water rises above the ground in the wetland forest and marsh areas. In much of the swamp areas, the water level is above ground level for long periods during the year. A direct coupling between surface water and groundwater may thus be assumed in the watershed. This approach has been adopted in a number of hydrologic studies in adjacent areas: Estero Bay (Christierson 2001) and the Caloosahatchee River basin (Jacobsen 1999).

The surficial and intermediate aquifer system in the BCB/BCNP area is divided into the following aquifers separated by aquitards:

- ∞ Water Table aquifer, with an approximate thickness of 50 ft in the NGA
- ∞ Tamiami/Sandstone/Hawthorn aquifer, with an approximate thickness of 250 ft below the aquitard in the NGA

These listed aquifers are assumed to account for the exchange with the river and canal network and to constitute the major source of groundwater in the model area. The deeper Floridian aquifer system is considered isolated from this overlying aquifer system, not recharging nor adding additional water. However, according to geological surveys in the area, negligible exchange occurs between the Mid Hawthorn and the underlying Floridian aquifer.

Information on the aquifers in the BCB/BCNP area is available from three different studies. The existing Estero Bay model (Christierson 2001) contains bottom elevations and hydro-geological properties for the Water Table, the Lower Tamiami aquifer and the Sandstone/Mid Hawthorn aquifer in the northern part of the BCB area. This information was originally extracted from the existing calibrated regional South Florida Water Management District (SFWMD) MODFLOW model for Lee County. In an additional effort, a MODFLOW model of Collier County covering the entire BCB, including part of Lee County, was made available by BCB staff (Bennett 1992). DHI Consultants (2002) converted and upgraded the MODFLOW model to an integrated surface-groundwater model (MIKE SHE); a profile of the hydrogeological model in MIKE SHE is presented in **Figure 1.12**.

Within the NGA, the terrain is dotted with baldcypress domes formed around water-filled depressions where the cap rock is absent. The water depth is relatively shallow (a few feet) in these depressions. A review of shallow drilling information from the area has documented that this section of sediments is an alternating sequence of saturated shelly sand, shell beds and shelly limestone. The entire 500 foot (152 m) thick sequence examined in boring logs (CRC 2006) is unconsolidated, or at best moderately indurated. Below depths of 500 feet (152 m), the sedimentary unit is comprised of moderate to well-indurated Miocene limestone of the Hawthorne Group.

1.2 Vegetation in Big Cypress

1.2.1 History of Floristic Work in BCNP and the NGA

Major research efforts within the BCNP and similar habitat types in other parts of Florida during the 1970s greatly expanded the information base relevant to BCNP plant communities (Alexander and Crook 1973, 1975, Carter et al. 1973, Duever et al. 1974, 1975, 1976, 1978, Ewel et al. 1976, Gleason 1974b, Hofstetter 1973, 1975, Spackman et al. 1976). Each of the five publications that specifically describe BCNP plant communities (Harshberger 1914, Harper 1927, Davis 1943, Craighead 1971, McPherson 1973) used a different classification system to describe the vegetation types.

Gunderson et al. (1982) and Duever et al. (1986b) reviewed the history of vegetation descriptions and floristics in Big Cypress. Early reports of the vegetation of the Big Cypress Swamp include Harshberger (1914) and Harper (1927), which included the area as part of their descriptions of south Florida vegetation. Davis (1943) provided the first detailed community classifications for the region, including descriptions for Big Cypress. He created an “ecological” classification of communities that used soil, climate and water conditions, as well as species composition, to define a hierarchy of community classes and subclasses and mapped vegetation using aerial photography. Craighead (1971) listed species and gave a classification of Big Cypress communities based on personal observations. The Davis (1943) and Craighead (1971) community classification schemes were drawn on by McPherson (1973) to make the first detailed vegetation map for Big Cypress (available in the back-pocket in Duever et al. (1986b) or through the USGS on-line store). Duever et al. (1986b) included descriptions of the vegetation in their survey of the natural resources and land usage of BCNP.

Gunderson et al. (1982) compared the community classification schemes that had been used prior to 1982 (**Table 1.1**). Their comparison organized communities based on physiognomic characteristics (tree vs. herbaceous) that follow soil and hydrology. Their major communities were upland communities of pines and mixed hardwoods and lowland communities that included swamps and marshes. The swamp categories included trees, especially baldcypress and pondcypress (*Taxodium ascendens*) in various topographic configurations (strands, sloughs, domes), and shrubs (dwarf cypress). We collectively refer to these species throughout the document as “cypress”. The marshes were defined by species types or by hydrology (marshes, sloughs, wet and dry prairies).

More recently, community classification in Big Cypress has followed schemes developed in conjunction with ENP and the SFWMD. Jones et al. (1999) and Rutchey et al. (2006) created vegetation classification systems that drew on prior work but were designed for vegetation mapping using remote sensing. These classification systems, which are similar to The Nature Conservancy (TNC) vegetation classification system (Madden et al. 1999), are hierarchical, and use structural

(physiognomic) categories (e.g., forest, scrub, savanna, prairies and marshes, and shrublands) as well as land-use categories (e.g., exotics) to define the highest levels in the classification. Subclasses are defined based upon various environmental characteristics (e.g., saline vs. freshwater, upland vs. swamp), followed by species composition. An early version of these classification systems was used by the University of Georgia's (UGA) Center for Remote Sensing and Mapping Science to create a vegetation map of both ENP and BCNP based on 1994-1995 aerial photography (Welch and Madden 1999). The Nobles Grade vegetation map presented here (**Figure 1.13, also see vegetation cover classes in Table 1.2**) uses the UGA map. Accuracy assessment of this map in ENP and BCNP, however, documented a number of inaccuracies (Bradley and Woodmansee 2008).

Recent Everglades community classifications have been derived from field sampling of plant species composition analyzed by techniques such as cluster analysis and non-metric multidimensional scaling; these methods group sites into communities or associations based on species similarity (Richards et al. 2008, Sah et al. 2009). The Richards et al. (2008) work was done only in marshes and did not cover BCNP, but Sah et al. (2009) used data from Big Cypress surveys in constructing their classification.

Efforts to classify and map community types are paralleled and supported by floristic work that provides descriptions and often locations of the plant species present in an area. Big Cypress species have been included in regional-level work, which began with Small's (1933) *Manual of the Southeastern Flora* and was continued with Long and Lakela's (1971) *Flora of South Florida*. Black and Black (1980) published a species list specific to BCNP, and Gunderson and colleagues made plant inventories of selected sites in BCNP (Gunderson and Loope 1982a-d, Gunderson et al. 1982). Regional systematic works include Long and Lakela's (1976) *A Flora of Tropical Florida* and, more recently, Wunderlin (1998) and Wunderlin and Hansen's (2003) *Guide to the Vascular Plants of Florida*. Wunderlin and Hansen's (2003) guide is supported by an interactive website, *The Atlas of Florida Vascular Plants* (<http://www.florida.plantatlas.usf.edu/>), which is maintained by the University of South Florida's Institute for Systematic Botany. This website gives species locations by Florida county based on vouchered herbarium specimens, as well as conservation information, wetlands status, and photographs. Searches for information, however, can only be done by plant scientific name, not by locale, thus a species list for BCNP is not available through this site.

The south Florida Institute for Regional Conservation (IRC) began a Floristic Inventory of South Florida (FISF) in 1994, covering Florida's ten southernmost counties. Their goals were to determine the status of the south Florida flora and to establish baseline information for conservation of rare plants and for exotic species control. They began with species lists derived from *The Atlas of Florida Vascular Plants* (see above), then modified these using published and unpublished checklists for conservation areas, data from reports, and inventories made by the IRC and others; details for development of the FISF and their classification systems are given

in Gann et al. (2002). The FISF database (<http://regionalconservation.org/ircs/DBChoice.asp>) is searchable by plant species name (scientific or common) and by conservation area, as well as by county or habitat. Because of IRC's conservation concerns, information on species conservation status and origin (native vs. exotic) can also be obtained. This database provides species-level information specific to BCNP.

1.2.2 Overview of Habitat Types Dominating BCNP and the NGA

Duever et al. (1986b) and Muss et al. (2003) have published community-cover estimates for BCNP (**Table 1.3**). These estimates for the whole Preserve show 43-50% cover by cypress (i.e., pondcypress and baldcypress) as swamps and/or prairies, 24-25% cover by prairies and 15-18% cover by pinelands. Other ecologically important communities, such as mixed hardwoods or hammocks, are much less frequent (**Table 1.3**). An estimate based on the UGA vegetation map provides similar numbers for cypress (47%), wet prairies (23%), and pinelands (17%; **Table 1.3**); the UGA map was made from 1994 and 1995 aerial photography (Welch and Madden 1999) and includes the Addition Lands. An estimate of community cover for the NGA (**Table 1.2**) shows a much higher percent cover of baldcypress communities (76%), slightly less pinelands (11%) and much less prairie and marsh (6%) than estimates for the whole Preserve. This latter difference could result from the inclusion of "cypress prairie" in the cypress estimate rather than the wet prairie estimate. If this class is included with the prairie estimate, then there are similar amounts of cypress (43%) but relatively more prairie (35%) in the NGA than in BCNP as a whole. Two areas of special conservation concern in the Nobles Grade region are Kissimmee Billy Strand and the associated Kissimmee Billy Pineland to the east of the strand, both of which lie north of I-75 (J. Sadle, ENP, personal communication). Similar areas, however, as well as hardwood hammocks, appear to also occur in the southernmost region of the NGA (**Figure 1.13**).

According to the FISF database, BCNP has 1,152 species of vascular plants belonging to 160 plant families and 47% of the taxa found in south Florida. Muss et al. (2003) report somewhat lower numbers for BCNP, with 851 species in 145 families. The 1,152 taxa in the FISF database include 52 taxa that were recorded as present in error or are doubtfully present, and four taxa are considered extinct or extirpated, resulting in 1,096 taxa present. Fifty-nine percent of the BCNP taxa are dicots, 36% are monocots, 5% are ferns, and BCNP has 4 species of gymnosperms, including the baldcypress and pondcypress.

1.2.3 Baldcypress Forests

1.2.3.1 Baldcypress swamps

Freshwater wetland forests or swamps (**Figure 1.14**) are the dominant vegetation type in the BCNP. These communities include mixed swamp forests, cypress domes and strands, shrub thickets (such as willow [*Salix* spp.], pop ash sloughs, or pond

apple [*Annona glabra*] sloughs), and dwarf or scrub cypress. Cypress is the dominant plant in the BCNP with baldcypress and pondcypress being the two dominant species (there is some dispute as to the taxonomic breakdown of these species, but we will consider them two separate species here). Sites where these species grow usually hold water for most of the year. *Taxodium* species typically grow in more or less pure stands and are extremely tolerant of flooding. Long (1974) reported that 188 species of plants are found in swamp forests. The understory of these swamps includes a variety of ferns, aquatic plants, and saplings of overstory species. Burning, or the combination of logging and burning, usually results in monospecific willow heads or pop ash sloughs replacing cypress.

Baldcypress, which dominated the mixed swamp forests prior to logging, grew to heights of 131 ft (40 m) and diameters approaching 10 ft (3 m). A few of these large trees remain in some logged swamps. In the virgin cypress forest at Corkscrew Swamp, trees grew at densities of one tree and a basal area of approximately 0.5 m² / 0.01 ha (or 100 m²) (Duever et al. 1975). Although these large cypress are widely scattered, they have broad canopies and dominate the overstory. The subcanopy hardwoods (maple, swamp bay, pop ash, and pond apple) grow to heights of about 65 ft (20 m) and occur at densities of eight trees and a basal area of approximately 0.1 m² / 0.01 ha.

Pondcypress forests have a much greater density of smaller cypress trees and only a few hardwoods. At Corkscrew Swamp, these relatively young cypress grew at densities of 16 trees and a basal area of 0.7 m² / 0.01 ha. Hardwoods occurred at densities of 4 trees and a basal area of 0.02 m² / 0.01 ha (Duever et al. 1975). The density of smaller cypress resulted in a canopy cover of 70-80 percent, roughly equal to that of baldcypress with a hardwood subcanopy (Duever et al. 1975). Pondcypress trees may reach heights of 131 ft (40 m) (Long and Lakela 1971), but within the BCNP they generally grow to only about 20 m. The mixed herbaceous understory can range from sparse to dense, and grow up to 3.3 ft (1 m) tall.

Dwarf, scrub, toy, or hatrack cypress forests have low densities of stunted pondcypress with generally sparse understories consisting of mixtures of *Rhynchospora*, *Cyperus*, other sedges, and grasses. The trees are generally < 12 ft (3.6 m) tall, with diameters of less than 4 in (10 cm) (Wade et al. 1980). They are widely spaced, often 49-65.6 ft (15-20 m) apart, which results in canopy covers ranging from 30-45% (Flohrschutz 1978). Dwarf cypress are generally found in areas that have a hydroperiod of only about 120 days and a maximum water depth of 6-8 in (15-20 cm) (Duever et al. 1984). Craighead (1971) lists this community type as occupying the greatest area within the Big Cypress.

Mixed baldcypress and swamp forest occur in deep depressions in mineral soil. Organic soil up to 6.6 ft (2 m) thick is found beneath these forests. The largest and fastest growing cypress trees grow on the deepest peat. At Corkscrew Swamp, these sites have an average hydroperiod of about 290 days (Duever et al. 1978), and average maximum water levels of approximately 2.3 ft (0.7 m) (Duever et al. 1975).

Pondcypress grows in shallow depressions with little or no organic soil. These forests may be found on the periphery of mixed swamp or baldcypress forests or in small isolated depressions. Hydroperiods average 250 days in these habitats, and maximum water levels may reach 1 ft (0.3 m) (Duever et al. 1975). Scrub or dwarf cypress grows on sand or marl soils of the Ochopee and Tucker Marl series (Leighty et al. 1954). They are approximately 2.7-6 in (7-15 cm) deep overlying bedrock (Craighead 1971). Water depths reach 6-8 in (15-20 cm) and inundation lasts approximately 120 days (Flohrschutz 1978).

Cypress forests transition to climax hammock community through the slow process of peat accumulation that builds a higher, drier site, and thus permits hardwood colonization (Penfound 1952). Since cypress trees are long-lived and fire-tolerant, and peat is periodically removed by fire and oxidation, cypress forests usually persist for hundreds of years. However, man-induced changes (e.g., logging, prescribed burns and human-caused wild fire, draining, and flooding) and natural forces (e.g., fires and hurricanes) can substantially alter these forest communities (Alexander and Crook 1973, Davis 1943, Duever et al. 1986b).

1.2.3.2 Cypress domes

In relatively flat areas of the BCNP, cypress domes (**Figure 1.14**) are a major feature. Domes have small trees on the periphery and progressively larger trees toward the center, creating a rounded profile (Duever et al. 1984). Many of these occur in bedrock depressions or in sinks created when poor surface drainage encourages downward movement of water resulting in dissolution of the carbonate bedrock by both rainwater and groundwater. The more resistant cap rock remains, but is often overturned by root action. As a sink develops, a lake forms, which may fill with peat or marl. In the BCNP, an occasional sinkhole will extend downward to a depth of nearly 20 ft (6 m) (Duever et al. 1986b). Domes may expand and can grow together to form meandering cypress strands characterized by poor drainage. Cypress domes have a more or less monospecific overstory of pondcypress. The understory herbaceous species include bladderwort (*Utricularia* spp.), swamp fern (*Blechnum serrulatum*), spikerush (*Eleocharis* spp.), and marsh fleabane (*Pluchea foetida*). Among the epiphytes are many species of bromeliads (mainly of the genus *Tillandsia*) and orchids. Woody understory species include buttonbush (*Cephalanthus occidentalis*), cocoplum (*Chrysobalanus icaco*), willow (*Salix caroliniana*), and wax myrtle (*Morella cerifera*).

1.2.3.3 Cypress strands

In cross-section, a strand has the same rounded profile as a cypress dome, but strands are generally large forests situated in elongate depressions that serve as seasonal sites for water flow (Duever et al. 1984). Depositional processes seem to best explain the origin of cypress strands. The rock structures could have been formed as beach-dune deposits, offshore bars, or sand spits that, after sea level dropped, were reduced in relief by winds and dissolution until cap rocks developed.

These structures affected later drainage patterns. Cypress colonized the lower, wetter swales, and pine became established on higher and drier areas. Although the effects are not as noticeable in cypress strands as they are in the hammocks, the bedrock at the bottom of the strands has also been broken by root penetration mechanisms (Duever et al. 1986b).

1.2.3.4 Cypress productivity

Aboveground primary productivity values for cypress forests in the southeastern U.S. are among the highest reported for forest ecosystems, due largely to fluctuating water levels and nutrient inflows (Brinson et al. 1981, Brown 1981, Conner and Day 1982, Brinson 1990, Lugo et al. 1990, Conner 1994). Aboveground biomass production of forests with unaltered seasonal water flow frequently exceeds 1,000 g/m²/yr in these forests, with a maximum of nearly 2,000 g/m²/yr reported for an undisturbed cypress/tupelo (*Nyssa* spp.) forest in South Carolina (**Table 1.4**). Litterfall accounts for an average 39% of the aboveground primary production in wetland forests.

Brinson et al. (1981) suggest that the amount and frequency of water passing into and through a wetland are the most important determinants of potential primary productivity of these forests. Periodic inundation subsidizes the forested wetland with nutrients and sediments that stimulate plant production (Gosselink et al. 1981). Forested wetlands with stagnant or sluggish waters are usually less productive, but not always (Brown and Peterson 1983). Communities with permanently impounded conditions or on sites with poor drainage, which leads to continuously high water tables and the accumulation of acidic peat soils, have lower productivity, primarily because of low nutrient turnover under anoxic conditions, N limitations, and low pH (Brown et al. 1979). This change in productivity with respect to flooding has been discussed by several authors (e.g., Conner and Day 1976, 1982, Odum 1978).

Mature cypress trees prosper under flooded conditions (Dickson et al. 1972), but growth can be affected by changes to the natural hydrologic regime. Cypress has tolerated flood depths of 10 ft (3 m) or more (Wilhite and Toliver 1990). In Florida, Harms et al. (1980) found that 0-16% of the cypress trees died within seven years in water from 8-39 in (20-100 cm) deep. In water over 47 in (120 cm) deep, 50% of the cypress died after four years. A long-term study of cypress survival was conducted near Lake Chicot, Louisiana (Penfound 1949, Egglar and Moore 1961). After four years of flooding with water 24-118 in (60-300 cm) deep, 97% of the cypress survived. Eighteen years after flooding, 50% of the cypress trees were still alive. However, most of the living trees in the deep water had dead tops (Egglar and Moore 1961). Conner and Day (1992) found that growth of baldcypress was greater in a permanently flooded swamp than in an undisturbed cypress forest. Stahle et al. (1992) and Young et al. (1995) reported that in both South Carolina and Tennessee increased flooding resulted in a short-term increase in baldcypress growth rate followed by a long-term decline.

Drainage of swamp forests can affect primary productivity rates. Drainage of a cypress swamp in Florida led to a thinning of the overstory canopy and a reduction in biomass production of the trees, litterfall, and herbaceous plants (Carter et al. 1973). Productivity of a drained cypress stand in Florida was 3,444 lb/acre/yr (387 g/m²/yr) compared to 7,636 lb/acre/yr (858 g/m²/yr) for an undrained stand.

1.2.3.5 Cypress regeneration

Three-year old baldcypress saplings have been reported to produce viable seed (Priester 1979, Brown and Montz 1986). Though vigorous saplings and sprouts are capable of seed production, consistent mast crops do not occur until trees grow appreciably larger. Wilhite and Toliver (1990) noted that baldcypress trees generally produce seed every year, but larger seed crops occur every three to five years. Cones of baldcypress sampled in Louisiana, Mississippi, Texas, Arkansas, and Illinois produced on average 14-17 seeds (Faulkner and Toliver 1983), but in poor cone production years, cones also tend to produce fewer seeds (Faulkner and Toliver 1983). Additionally, Bonner (2008) noted that a large percentage (over 50%) of baldcypress seeds are usually not viable, because the seed lacks an embryo.

Cones of baldcypress complete maturation as early as October. Beginning at this time and continuing for several months, seeds are released as cones break apart on the twig (Brown and Montz 1986). Some cones fall from the tree whole, and these cones also eventually shatter and release seed (Brown and Montz 1986). Seeds are primarily dispersed by water (Wilhite and Toliver 1990) and float for extended periods (Schneider and Sharitz 1988). Schneider and Sharitz (1988) indicated that baldcypress cones or scale clusters floated for an average of 18 days, while individual baldcypress seeds floated an average 42 days. Seeds are dispersed non-randomly (Schneider and Sharitz 1988), and this dispersal is driven by the timing, magnitude and flow direction of floodwater (Schneider and Sharitz 1988, Middleton 2000). Investigations indicate that baldcypress seeds that have been distributed by water tend to accumulate near emergent substrates such as logs and tree bases (Schneider and Sharitz 1988). Seed viability can decline relatively quickly in the soil seed bank if favorable environmental conditions are not present. Middleton (2000) reported that 58 % of baldcypress seed placed on the soil surface in an Illinois swamp were viable after 100 days, and about 6 % remained viable after a year. In contrast, Demaree (1932) demonstrated that some baldcypress seeds can remain viable for as long as 30 months when submerged under water. Baldcypress seed crops that have been in the seed bank for more than a year should probably not be considered reliable for producing a seedling cohort following a harvest or site restoration.

Cypress has exacting environmental requirements for successful establishment of seedlings to perpetuate the forest. Previous investigations of regeneration after harvesting cypress forests have concluded that natural establishment of seedlings is closely tied to hydrology and light conditions (Meadows and Stanturf 1997). Natural

regeneration of cypress forests after harvesting is not likely in hydrologically altered areas (Conner and Toliver 1990) unless stump sprouting (coppice regeneration) is strong. A report prepared for the Florida Forestry Association supports the view that cypress stands can regenerate in part from stump sprouts with coppice growth typically starting to produce seed in the first few years after harvesting (Peacock and Associates, Inc. 2002). This “coppice seeding” augments regeneration from stump sprouts and seeding from residual uncut trees. However, several factors limit the coppicing ability of cypress stumps. In general, it is believed that sprouting is most prolific on young stumps from stems that were harvested during the dormant season. Langdon (1958) and Williston et al. (1980) indicate that baldcypress stumps 10-14 in (25-35 cm) in diameter reliably sprout when boles are harvested in the fall or winter. Mattoon (1915) reported that stumps of vigorous stock up to 60 years old can generally be counted on to send up healthy sprouts. McGarity (1979) found good regeneration by sprouts and re-growth following clearcutting in a Florida baldcypress swamp where average diameter of harvested trees was 12.6 in (32 cm). In addition to age and season of harvest, stump height, felling method, and harvesting level can influence the viability of stumps and vigor of sprouts (Ewel 1996, Gardiner et al. 2000). Overall, Putnam et al. (1960) reported that sprouting of baldcypress was of little significance in regeneration plans.

Where seed sprouting would be limited, planting may be necessary to ensure that cypress seedlings become established. One method of planting that was tested in the southern United States by Clemson University and UGA researchers involves using heavily root pruned seedlings so that they may be planted by grasping the seedling at the root collar and simply inserting them into the soil or sediment without digging a hole (Conner 1988, 1993, Conner and Flynn 1989, Hesse et al. 1996, Reed and McLeod 1994, Brantly and Conner 1997). These pruned cypress seedlings have been successfully planted at a number of sites throughout the south. Also recommended is the use of one-year-old cypress seedlings at least 3.3 ft (1 m) tall and with root collar diameters larger than 0.5 in (1.25 cm) to improve early survival and growth (Faulkner et al. 1985). If herbivory by deer or rabbits is a problem, the use of plastic tree shelters is considered essential. All of these techniques have been demonstrated to increase survival rates for cypress (Conner 1988, 1993, Reed and McLeod 1994, Myers et al. 1995, Schweitzer et al. 1999).

Planting guidelines have also been developed by the University of Florida Cooperative Extension Service (Vince and Duryea 2004). These guidelines suggest the minimum size of cypress seedlings should be at least 12 in (30 cm) in height with the diameter of the root collar at least 0.25 in (0.6 cm). However, the size of the bareroot seedlings to be planted depends upon the site conditions where they are being planted, especially with regard to timing and depth of floodwaters. A larger size seedling ensures that the seedling crown is out of the water and sturdy enough to hold the seedling upright.

1.2.4 Prairies

Vast prairies are some of the most distinctive features of the BCNP (**Figure 1.14**). They are generally found interspersed with pine islands and cypress strands and cover extensive areas of the Coastal Region. The prairie bedrock surface is uneven but not as irregular as that beneath hammock or pine because the post-Tamiami formations have been stripped off and the smooth Tamiami cap rock has not been fragmented by root penetration as it has in forested habitats. The rock is usually covered by a thin veneer of marl or sandy marl.

A variety of plant communities dominated by herbaceous vegetation grow at different levels along a hydroperiod gradient from rarely to almost permanently flooded. Although these occur as a continuum, certain habitat names suggest distinct points along this hydrologic scale. Both dry and wet prairies have a relatively short (up to 3.3 ft [1 m]) mixed grass-sedge flora; tall (3.3-10 ft [1-3 m]) emergent broad-leaved sedges, forbs, and grasses dominate the wetter marsh communities; and aquatic plants, primarily submerged and floating forms, vegetate the ponds, which are inundated for the longest periods. Long (1974) reported a total of 110 species from aquatic marshlands, 172 from wet prairie communities, but only 69 species from dry prairies.

Low, scrubby saw palmettos (*Serenoa repens*) and clumps of wiregrass (*Aristida* spp.), dominate dry-prairie vegetation. Other grasses include broomsedge (*Andropogon* spp.), lopsided Indian grass (*Sorghastrum secundum*), foxtail grass (*Setaria parviflora*), and chalky bluestem (*Andropogon virginicus* var. *glaucus*). Among the more noticeable herbaceous plants are white marsh pink (*Sabatia brevifolia*), milkworts (*Polygala* spp.), button snakeroot (*Eryngium aromaticum*), liatris (*Liatris* spp.), goldenrod (*Solidago* spp.), and rabbit tobacco (*Pterocaulon pycnostachyum*). Aside from an occasional slash pine (*Pinus elliotii*) or cabbage palm (*Sabal palmetto*), the prairies are treeless, but they have many low shrubs. Waxmyrtle, gallberry (*Ilex glabra*), and staggerbush (*Lyonia fruticosa*) are most common.

Maidencane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), beak rush (*Rhynchospora* spp.), muhly grass (*Muhlenbergia capillaris*), love grasses (*Eragrostis* spp.), and other grasses, sedges, and rushes are the most common wet prairie plants. Sawgrass and spikerush, frequently dominate marly or rocky sites. St. John's wort (*Hypericum* spp.) is a characteristic element of the community, which may also include yellow-eyed grass (*Xyris* spp.), marsh pink (*Sabatia stellaris*), gerardia (*Agalinis* spp.), coreopsis (*Coreopsis* spp.), and terrestrial orchids. Bladderworts (*Utricularia* spp.) and floating heart (*Nymphoides aquatica*) are frequent components of the wet season flora. Milkweed vine (*Sarcostemma clausum*), hemp vine (*Mikania* spp.), and primrose willow (*Ludwigia peruviana*), become prominent after a few years without burning, especially on soils with higher organic content.

The term "wet prairie" has been used to describe a variety of marshy habitats including deep marshes and waterlily ponds, so the literature on this habitat must be interpreted cautiously. Duever et al. (1986b) used the term to describe prairie

that occurs on mineral soils that are inundated around 50-150 days per year and burn about every 1-5 years. Maximum wet season water levels rarely exceed 8 in (20 cm) (Duever et al. 1975). Wet prairie is differentiated from marsh on the basis of the prairie's somewhat shorter hydroperiod, which prevents extensive peat accumulation. The wet prairies in the northwestern part of the BCNP grow on sand soils up to 3.3 ft (1 m) deep, as is typical of most Florida wet prairies, but in other parts of the preserve, they are found on thin (1 ft [0.3 m]) marl overlying bedrock.

Prairies are maintained as subclimax associations by fire, and peat fires often create ponds. In the absence of fire, shrubs rapidly invade prairies and marshes, and, within 5-10 years, may form a complete canopy. Wax myrtle is the most common such shrub in wet prairies, and buttonbush and willow most frequently become dominant in marshes. Scrub cypress forests occur on low productivity wet prairie sites incapable of producing enough fuel to carry fires severe enough to kill the young cypress. Wet prairies are maintained by light surface fires every 1-5 years. Prairies vary greatly in productivity. Carter et al. (1973) reported net productivities of 1-3 g/m² per day in a wet prairie community near Fakahatchee Strand, an area to the west of Nobles Grade. Duever et al. (1976) reported an annual production value of 200 g/m² for a Corkscrew Swamp wet prairie, an area to the northwest of the NGA.

1.2.5 Pinelands

Pinelands (**Figure 1.14**) are dry elevated areas (shallowly inundated for <2 months of the year) characterized by extremely irregular, exposed bedrock surfaces (Duever et al. 1984). Pine trees frequently begin in the sediment accumulated in solution holes and push rocks up and over as they grow, disrupting the bedrock surface. Windfalls accelerate the process as they do in hammocks. Pineland soils are generally sandy. Organic soils do not accumulate because of frequent fires and thus do not significantly affect the development of subareal crusts. Because pine habitats are almost always above the water table, little re-precipitation of calcite occurs, and marls are not formed. Along the margins of the pine islands, bedrock drops off abruptly, and in this zone, abundant lichens and algae encrust the rock surface. These algae and those found in solution holes work on a microscale to break up the rock surface, causing a sharp break in slope between pine islands and the prairie. Pine communities are maintained as a subclimax association by fire. If fire is excluded, hardwood invasion leads to a hammock community (Duever et al. 1986b).

Mature pine forests generally have an open, sparse overstory and a low, dense understory. The major overstory species is slash pine. There are two principal types of understory communities, one dominated by saw palmetto and the other dominated by mixed grasses.

Saw palmetto is well adapted to fire, but does not withstand inundation very well. Palmetto often forms a dense understory up to 6.6 ft (2 m) high. In the BCNP, a palmetto understory also may include varnish leaf (*Dodonaea viscosa*), wax myrtle,

gallberry, staggerbush (*Lyonia fruticosa*), winged sumac (*Rhus copallina*), snowberry (*Chiococca alba*), and velvet seed (*Guettarda scabra*) (Craighead 1971). Long (1974) reported 303 species from this plant association.

The vegetation of the pine forests with a mixed-grass understory includes many of the same species found in prairie communities. Common species include grasses in the genera *Muhlenbergia*, *Andropogon*, *Paspalum*, and the showy flowered herbs of the genera *Polygala* and *Asimina*. This wet pineland is the most floristically diverse plant community in south Florida, with some 361 species (Long 1974).

1.2.6 Invasive Exotic Plants

In the FISF database, 71% of the taxa are classified as native. The remaining 268 taxa (23%) are cultivated (5 taxa) or naturalized (263 taxa) non-native species. Muss et al. (2003) report 158 (18.5 %) exotic species. The FISF non-natives include 95 that are considered invasive. Of these, 38 are on the Florida Exotic Pest Plant Council (FLEPPC) Category I list (**Table 1.5**). This list includes “invasive exotics which are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives” (<http://www.fleppc.org/list/07list.htm>). An additional 28 species are FLEPPC Category II, including “invasive exotics that have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species” (<http://www.fleppc.org/list/07list.htm>).

BCNP has control programs in place for three especially aggressive invasive exotic plant species: melaleuca (*Melaleuca quinquenervia*, FLEPPC I), Brazilian pepper (*Schinus terebinthifolius*, FLEPPC I), and Old World climbing fern (*Lygodium microphyllum*, FLEPPC I) (J. Burch, BCNP, personal communication; **Figure 1.15**). *Lygodium japonicum*, another FLEPPC I species, is also present in BCNP (FISF database). The BCNP exotics control program for melaleuca was completed throughout BCNP in 2003, so this program is in a maintenance mode, and the Preserve’s focus is now on completing control of Brazilian pepper throughout the Preserve. Old World climbing fern is recognized as a major threat, and BCNP’s exotic control personnel treat all known locations every two years. All three of these invasive exotics are found within the NGA. Human activity could increase spore dispersal of Old World climbing fern directly through contact with sporulating plants, although 3-D seismic activities are not planned during their peak of spore production (Philippi and Richards 2007).

A potential new major invasive exotic is crested floatingheart (*Nymphoides cristata*, FLEPPC II; **Figure 1.15**) (J. Burch, BCNP, personal communication), but this species invades deeper, open water habitats and is unlikely to become problematic in the NGA. Other potentially aggressive invasive exotics, such as the giant grasses *Pennisetum purpurea* and *Neyraudia reynaudiana*, and shoe-button ardisia (*Ardisia elliptica*) are also found in BCNP (FISF database) and could become problems in the NGA.

1.2.7 Endangered Plant Species

BCNP is a large and unique ecosystem with a diversity of habitats that harbor a rich flora. Muss et al. (2003) found that although BCNP is less than half the size of ENP, it has 90% of ENP's native species richness. This diversity of habitats supports several unique species that are classified as rare, imperiled or endangered. The State of Florida recognizes rare plants as "endangered" or "threatened", the Florida Natural Areas Inventory (FNAI) uses a ranking system derived from TNC, and the IRC uses a similar ranking system. The definitions used by these different groups to classify the conservation status of plant species are provided in **Appendix E**.

Of the 1,096 taxa present in BCNP, 63 (5.7%) are Florida endangered species (**Table 1.6**), while 31 (2.8%) are Florida threatened species. Thus, 8.5% of the flora has conservation status with legal protection. The conservation ranking systems of the IRC and FNAI are more nuanced. Although the ranking systems of these two groups are similar, the lists of endangered or imperiled species they generate are not completely congruent, and the IRC and FNAI species lists differ somewhat from the Florida lists (**Table 1.7**). The most critically imperiled species, however, are probably those that are recognized by all three groups. These species are identified below.

Rare plants known to occur, or to have occurred, in BCNP are described by Gann et al. (2002). BCNP does not have any species that are federally listed as endangered species. Three species in BCNP, however, are candidates for federal listing (**Table 1.8; Figure 1.16**). None of these has been found in the NGA (J. Sadle, ENP, personal communication), but all have been recorded from pine rockland and marl prairie communities, which are found in Nobles Grade (FISF database).

Species recognized as endangered by the State of Florida, IRC and FNAI are at special risk of disturbance by anthropogenic activities. These include 6 species, all terrestrial herbs or shrubs, which are threatened globally, as well as in the state of Florida (**Table 1.9**). Fifteen additional species are critically imperiled in Florida, but are stable within their range outside of Florida (**Table 1.9**). Ten of these are epiphytic, while five are terrestrial. Terrestrial species are probably more at risk from activities associated with seismic exploration than epiphytic species. Six additional Florida endangered plant species are also considered critically imperiled by the IRC (**Table 1.9**). Half of these are epiphytic and half terrestrial.

A number of these critically imperiled species occur in the NGA (**Table 1.10**, J. Sadle, ENP, personal communication). Species that are not on the Florida endangered species list but are of conservation concern also occur, or probably occur, in the area and could potentially be affected by 3-D seismic exploration activities (**Table 1.10**). The species that are terrestrial herbs or shrubs are at greater risk than epiphytes or trees. In addition to the species in **Table 1.10**, Gann et al. (2002) recommend surveying for and/or monitoring Seminole false foxglove (*Agalinis filifolia*), Fakahatchee bluethread (*Burmannia flava*), and giant sedge (*Carex gigantean*) in the

Kissimmee Billy Strand area (**Figure 1.16**). Of these, *B. flava* deserves special attention. *B. flava* is a small, annual, terrestrial herbaceous plant found in mesic or wet flatwoods; it is reported to flower in January (Coile and Garland 2003), although it has been found flowering spring through fall (FISF database species account). *B. flava* is both endangered (State of Florida) and critically imperiled (IRC, FNAI) (**Table 1.9**).

1.3 Herpetofauna of Big Cypress

Amphibians and reptiles play an important role in ecosystem dynamics, particularly from a food web perspective. Despite their generally small size, the combined biomass of amphibians contribute significantly to the base of vertebrate food webs, while various reptiles fill scavenger and predator niches at other levels of the web. In addition, global declines of amphibians have alerted the scientific community to their role as indicators of ecosystem health. The diversity of habitats at BCNP traditionally housed high numbers of reptile and amphibian species with abundances generally higher than those found in ENP (J. Kushlan, personal communication). Despite this, few systematic herpetofaunal surveys have been conducted at BCNP and there is a paucity of published information on the topic.

Duever et al. (1986b) published the first comprehensive species list for BCNP based on interviews, field observations, and various forms of literature. In 1995, George Dalrymple conducted baseline wildlife surveys in the BCNP Addition Lands using transects and drift fences with funnel traps. This study was never completed and only an unpublished progress report remains as a record. Rice et al. (2005) conducted the first systematic study of BCNP's herpetofauna, aimed at creating a baseline for assessing potential amphibian declines. Night visual encounter surveys (VES) and anuran vocalization (i.e., frog call) surveys were the backbone of the study, but were augmented with drift fences and opportunistic sampling to create a more robust species list that included reptiles. The combined results of these studies suggest that there are about 60 native species of amphibians and reptiles in BCNP – 39 reptiles (2 crocodylians, 4-6 lizards, 23-26 snakes, 10 turtles) and 15 amphibians (11-12 frogs, 4 salamanders). In addition, there are ten known introduced species – 7 reptiles and 3 amphibians. The amphibian populations are currently considered stable (Rice et al. 2005), but in view of global declines in amphibian populations associated with a warming climate and a fungal infection (Pounds and Masters 2009), we should be apprehensive about the future of amphibians in BCNP. There are also clear concerns with certain reptiles.

1.3.1 Protected Species

BCNP contains four reptile species that are listed for protection under Federal or Florida State law. The American crocodile (*Crocodylus acutus*) is an occasional visitor to coastal habitats and is therefore not likely to be in the Nobles Grade area. The American alligator (*Alligator mississippiensis*), gopher tortoise (*Gopherus*

polyphemus) and eastern indigo snake (*Drymarchon corais*), however, may occur in areas such as Nobles Grade where oil exploration and development are proposed. In BCNP, snake populations in general seem to be a small fraction of their numbers from the 1970's (J. Kushlan, personal communication), although there are no formal data to confirm this.

1.3.1.1 American alligator

The American alligator (**Figure 1.17**) is Federally listed as threatened due to its resemblance to the more susceptible crocodile and is a State listed species of special concern (SSC). This species is widespread throughout BCNP, using all habitats prone to flooding. Its distribution is seasonally determined by water level. During the wet summer months, this species may be found almost anywhere in BCNP. As water levels drop in the dry season, its range becomes limited to areas with sufficient standing water such as marshes, sloughs and ponds. Alligators are a critical component of the dry-season landscape because their maintenance activities maintain "gator holes", deeper areas where standing water is available even when most of the BCNP is dry. Alligator holes also provide refugia for a wide range of vertebrate and invertebrate species (Kushlan 1972).

1.3.1.2 Gopher tortoise

The gopher tortoise (**Figure 1.17**) is State listed as threatened, recently upgraded from its former status as a SSC. Gopher tortoises have been recorded in the BCNP Addition Lands (Dalrymple 1995), but there is some speculation that these tortoises might have been wandering individuals from a translocation program being conducted by the Seminole Indian tribe to the north as opposed to an established population (D. Jansen, personal communication). This species is generally restricted to pine forests with sandy substrate, although it has been observed using active burrows in prairie habitat outside a pine rockland perimeter elsewhere in south Florida where drainage has left portions of the prairie dry year-round (KNH, personal observation). BCNP is not an optimal environment for gopher tortoises because of their requirements for dry uplands and sandy soils. The pine forests in BCNP are generally based on a limestone substrate and spend part of the year flooded. Nonetheless, there is a chance that gopher tortoise might be encountered in the NGA, particularly in the northern Addition Lands component of the NGA where sandy substrate is more abundant (Dalrymple 1995).

1.3.1.3 Eastern indigo snake

Eastern indigo snakes (**Figure 1.17**) were once relatively common in BCNP, with the Old Loop Road area touted as one of the best places to see them (Thornton 1977). The area's notoriety lured snake collectors throughout the 1950s, and the resulting over-collection undoubtedly contributed to this species' population decline in BCNP (Steiner et al. 1983), as it has across the snake's range. The eastern indigo snake is now listed threatened under both Federal and Florida State

regulation. Indigo snakes are the largest native non-venomous snake in North America with home-range size averaging approximately 1,235 acres (500 ha) for males and approximately 247 acres (100 ha) for females (Hyslop 2007). Indigo snakes have suffered from habitat loss and fragmentation, over-collection for the pet trade, as victims of road traffic, and as inadvertent victims of rattlesnake round-ups wherein gas is poured down co-inhabited burrows. This species overlaps with gopher tortoises across much of its range and frequently uses gopher tortoise burrows to escape from temperature extremes, although in south Florida solution holes often serve this purpose (Steiner et al. 1983).

The current status of indigo snakes in BCNP is uncertain. Rice et al. (2005) were unable to detect this species but reported that someone had seen an indigo snake at BCNP the previous year. Kevin Enge of the Florida Fish and Wildlife Conservation Commission (FWC) has compiled eastern indigo snake records for the state, including two recorded for the Addition Lands in 1995 and 2005 respectively (personal communication). This species apparently uses the property from time to time, but it is clear that the population numbers are low. If present, this species will be at risk from oil exploration and development because of overlapping activity patterns. Indigo snakes are diurnal and were most frequently observed during the dry season by Steiner et al. (1983). This pattern in observations may correlate with increased activity levels during that season, which would put them at a greater risk of mortality due to vehicular collision as this is the optimal time period for O&G activities.

1.3.2 General Habitat Usage Patterns

Duever et al. (1986b) did a general assessment of herpetofaunal habitat use as part of a report on BCNP. Habitats were ranked based on frequency of use for individual species with the high-use categories being indicative of habitats that would cause population declines if they were eliminated. An overall ranking of habitat criticalness was established for habitats that might occur in oil prospecting areas by compiling these high use categories across species (**Figure 1.18**). Based on this compilation, the “pine forest” and “inland marshes, ponds and sloughs” categories appear most crucial for long-term herpetofaunal survival in BCNP. Other patterns of habitat use include both behavioral and seasonal variations in distribution. Amphibians, for example, generally feed in upland areas such as “pine forest” or “hammock forest”, but require wetter habitats like “cypress forest”, “inland marshes, ponds and sloughs”, and “prairies” for breeding. Amphibian breeding is generally concentrated in the warm, wet summer months from March – September. This season, in general, encompasses a peak in herpetofaunal activity, which likely translates to heavier use of critical habitats during this time period.

1.4 Wading Birds in Big Cypress and the Nobles Grade Area

South Florida supports the most diverse community of breeding wading birds in North America. The area's vast wetlands overlay limestone bedrock that has both a regional elevation gradient and localized topographic variations. This complex but subtle topographic variation, combined with high variability in rainfall both within the seasonal wet and dry cycle and among years, produces a dynamic wetland system with greatly fluctuating water levels to which wading birds are well adapted. Some species, such as the great blue heron (*Ardea herodias*) and great egret (*Ardea alba*), are exploiters or "crumb-pickers". These birds forage daily over smaller areas than other species (Beerens 2008), but within those areas they can forage over a wider range of water depths (Gawlik 2002). Other species, such as the wood stork (*Mycteria americana*) and white ibis (*Eudocimus albus*), are searchers or "cream skimmers". These birds forage over large areas and find ephemeral food patches quickly, but they are restricted to a narrower range of habitat conditions and quickly abandon foraging sites soon after prey density declines (Gawlik 2002). These species are highly social and have adaptations for long distance foraging flights. Wood storks, for example, make daily foraging flights up to 58 mi (94 km) away from a nesting colony (Browder 1984), although maximum flight distance from Everglades' colonies in 2006 was only 46 mi (74 km) (Herring 2007).

1.4.1 Wood Storks as Indicators

Searcher species of wading birds select a narrower range of hydrologic conditions and prey densities than do exploiter species (Gawlik 2002). The wood stork (**Figure 1.19**), a federally listed Endangered species, is one of the most sensitive searcher species and has experienced dramatic population declines in South Florida (**Figure 1.20**; Kushlan and Frohring 1986, Ogden 1994, Crozier and Gawlik 2003). In the 1930s and 1940s there were 10,000-20,000 nesting pairs of wood storks, mostly in south Florida in the Big Cypress and coastal mangrove regions. Currently the U.S. population of wood storks is about 8,000 nesting pairs, mostly in north Florida and Georgia (USFWS 2007). Habitat loss and degradation have caused the shift of birds northward out of Florida (Kushlan and Frohring 1986, Ogden 1994). These impacts are also listed as the leading causes of endangerment in the wood stork recovery plan (USFWS 1997).

The wood stork is a sensitive indicator of habitat conditions and because it is large and easily surveyed, it has been chosen as a leading indicator of wetland restoration in south Florida (Frederick and Ogden 2001, Frederick et al. 2009). This is not to imply that storks are indicators of habitat quality for all wading birds and that other species should be ignored. Rather, because, like other searcher species, storks have a narrow tolerance to habitat conditions, it is likely that if habitat conditions are adequate for the stork then they will be adequate for other sensitive species whose populations are of concern. Potential impacts to other wading bird species are considered here but given less priority.

1.4.2 Wading Bird Foraging Ecology in South Florida

Successful wading bird nesting in south Florida depends on the occurrence of foraging conditions that make aquatic prey highly available during the dry season (Kahl 1964, Gawlik 2002). High prey availability comes from a combination of prey production during the wet season and a concentration of those animals later in the dry season. Because the wetlands of the greater Everglades ecosystem are oligotrophic, the production of prey is not high enough to support large nesting events without the concentration caused by the seasonal drying of the wetlands. The topographic variation both at large and small scales, as well as the drying patterns of the water are important for producing concentrations of prey (Gawlik and Botson 2009).

A simulation study that examined the magnitude of prey concentration solely from the physical effect of drying a marsh from 60 cm to 5 cm of water depth, showed a 20-fold increase in prey density (**Figure 1.21**; Garrett 2007). This pattern mimics the seasonal pattern of prey density observed at an alligator hole in BCNP (Kushlan 1976). When water is deep and water levels are falling, fish density increases slowly. Eventually the receding water becomes shallow and small differences in microtopography create important differences in depth. Fish move locally to the deeper refuges, leading to a rapid increase in density with a peak just before the pools dry. Soon after the peak, prey density drops to zero, with or without wading bird predation.

Bird density at a given patch of marsh matches the temporal pattern of fish density (**Figure 1.22**). Density is low when water depth is high, then it increases just as the marsh is drying and fish are being concentrated into pools of remaining water. When the marsh dries, bird density drops to zero as the birds move on to the next foraging pool, which is probably just down the elevation gradient. Thus, even the highest quality foraging habitat will only have birds present for perhaps a few weeks of the year. The relevance to mineral exploration and extraction is that impacts can be minimized if activities occur at a site after it has dried. Conversely, they will be maximized if activities occur just before a site has dried.

When the pattern of foraging patch use is viewed from a landscape perspective, it is apparent that birds follow a fairly narrow band of the high-quality foraging habitat as it dries to the proper depth for foraging. This narrow band of habitat or the foraging “sweet spot” moves down the elevation gradient until the rainy season begins. Thus, birds will typically be in higher elevation marshes early in the dry season, moving to lower elevation marshes as the season progresses. Although this relative pattern is consistent from year to year, the high variability in rainfall patterns among years means that the absolute location of the high quality foraging habitat is not predictable from year to year. Thus, wading birds, particularly searcher species dependent on high quality foraging sites over the entire dry season, require a large area of drying wetlands. The relevance to mineral exploration is that the mobility of wading birds allows them to skirt temporary disruptions to a high-quality foraging patch, but their dependence on a large number of foraging sites

means that the loss of a deceptively small number of foraging sites may have a high cumulative impact.

1.4.3 Wood Stork Occurrence in BCNP and NGA

Wood storks have historically nested in the area that is now BCNP but inferences are limited because formal surveys were done sporadically. The first record of which we are aware is for a colony of 30 pairs of wood storks north of Loop Road in 1931 (Audubon Society, unpublished warden reports). Duever et al. (1986b) reported that storks nested in the area until 1958, which infers that no nesting occurred 1958-1986—a questionable inference given the lack of formal surveys in most years. In 1996, a year after increased numbers of storks were casually noticed by BCNP staff, a systematic aerial survey showed at least 23 sites with nesting wood storks, out of a total of 45 sites containing 1,250 storks for pooled years 1996-2001 (**Figure 1.23**; Jansen and Brooks 1996).

In contrast to the spotty record of stork nesting in BCNP, there is considerable evidence that BCNP provides important foraging habitat for the birds. Because wading birds follow the receding “sweet spot” across the landscape, starting with the high elevation marshes, and because storks begin nesting earlier than most wading bird species, these habitats are particularly important to storks. Indeed, the rate of water recession, which affects the concentration of prey, has been linked to successful nesting by storks (Kushlan et al. 1975, Ogden 1994). Storks that nest around BCNP are dependent on its wetlands as foraging habitat prior to, or early in, the nesting season when adequate water is present. In very dry years the marshes may never get wet enough to provide foraging habitat for storks.

Storks prefer to forage near nesting colonies when habitat conditions are good (Herring 2007), but they will switch to habitats that are up to 56 mi (90 km) away (Browder 1984) when conditions deteriorate quickly because of rain, or when there is no suitable habitat closer to the colony. Two of the largest wood stork colonies in Florida, Tamiami West and Corkscrew Swamp, are within foraging range of Nobles Grade (**Figure 1.24**) and almost all of BCNP is within the U.S. Fish and Wildlife Service’s (USFWS) designation of critical foraging habitat for storks (**Figure 1.25**; USFWS 1997). In some years several large stork colonies form just east of BCNP in WCA 3. These birds often leave the colony on foraging flights heading west into BCNP (DEG, personal observation). Systematic aerial surveys showed that the Bear Island region of BCNP, near Nobles Grade, was an area in which large numbers of foraging wood storks concentrated under certain hydrologic conditions (Browder 1984). Preliminary nesting reports by researchers in 2009 suggest that 3,500 pairs of storks nested in 5 colonies within foraging distance (43.5 mi [70 km]) of the center of Nobles Grade (**Figure 1.24**). This aggregation of birds, many of which almost certainly foraged in BCNP early in the dry season, represents approximately 40% of the current Tamiami and Corkscrew colonies, which represent at least 80% of all wood storks in the U.S. The relevance to O&G exploration is that there is a high

likelihood that flocks of foraging wood storks will occur in the NGA, and that the area is important to storks on a population level.

1.4.4 Temporal Pattern of Wood Stork Relative Abundance in Nobles Grade

The temporal pattern of wood stork abundance in the NGA was obtained by analyzing systematic reconnaissance flights (SRF) of foraging wading birds that have been conducted in BCNP in most years since 1985 (Conroy et al. 2006). The surveys in BCNP were done in various years by staff from the FWC, National Audubon Society, U.S. Army Corp of Engineers, and a consultant. The surveys were part of a larger collaborative study to quantify the distributions of foraging wading birds throughout the WCAs and ENP. The monthly surveys were usually conducted during the dry season with a few surveys extending into the wet season. East-west aerial transects spaced 1.2 mi (2 km) apart were flown from a plane at an altitude of 200 ft (61 m) and a ground speed of 80 mi h⁻¹ (129 km h⁻¹). All wading birds detected in strips 492 ft (150 m) wide along both sides of the transects were recorded to the nearest 1.2-mi (2-km) segment. There were 48 segments, or grid cells, in the NGA (**Figure 1.26**). Only data in these cells were used in the following analysis. Eighty-one monthly surveys were conducted in BCNP since 1985.

The number of storks seen on a survey in Nobles Grade ranged from 0 to 50 (**Figure 1.27**). The relative abundance pattern differed markedly among years (**Figure 1.28**), likely reflecting the range of hydrologic conditions. This underscores the difficulty of using past abundance patterns to predict abundance in a future year.

The seasonal pattern of relative abundance is more consistent, with a peak early in the year then lower abundances throughout the remainder of the dry season, with almost no birds occurring in the area during the wet season (**Figure 1.29**). The Operator's Handbook (NPS 2006) calls for work to be done during a time that results in the minimum impact to listed species, which would be the wet season for the wood stork. Unfortunately, this time period conflicts with the time of lowest impacts for other components of the ecosystem, as identified in the operations plan (CRC 2006). One way around this apparent conflict is to think about the time of greatest impact at a finer scale than a season. Once a wetland area has dried, impacts of O&G exploration on wood storks would be minimized because storks feeding in a drying habitat patch build in numbers until just before the patch dries and then abandon the patch. Thus, by conducting work around foraging patches that have already dried (but not just before they dry), it is possible to conduct work during the dry season and still meet the requirement of working during a time that minimizes impacts to this listed species.

1.5 Red-Cockaded Woodpeckers in Big Cypress

The red-cockaded woodpecker (*Picoides borealis*; RCW; **Figure 1.19**) is listed Endangered by the USFWS and is a SSC listed under Florida State law. Our scientific

history of red-cockaded woodpeckers in BCNP is recent, although the species has perhaps been present there for hundreds of years. Currently, there are no recorded sightings (**Figure 1.30**), cavity trees or active nests in the NGA. However, there have been no extensive surveys in this area to locate RCWs. So, we do not have reliable information on the status of RCWs in this area. The closest areas of confirmed RCW activity are to the south of the NGA and near the Raccoon Point operations.

Red-cockaded woodpeckers occupy mature, open, pine forest habitat that includes one or more mature (usually 80-120 year-old) living pine trees in which they have excavated nest and roost cavities. On average it takes the birds over four years to complete a cavity, but once it is completed it may be used by the birds and their descendants for decades because it is in a living tree.

Jackson (1994) reviewed basic information on the behavioral ecology of RCWs. The RCW is a cooperatively breeding social species that lives as pairs or in extended family groups. Each breeding group includes a breeding male and female, their offspring of the current year, and often one or more “helpers” that are generally male offspring from previous years. The helpers assist the breeding pair in excavating cavities and in care of nestlings. Each adult bird requires its own cavity in a living pine tree in which to roost each night. The roost cavity of the breeding male generally becomes the nest each year. If there are too few cavities for all adults in the group, it is usually the female that is left without a cavity. If insufficient cavities are available, those left without a cavity are especially vulnerable to predation. The unusual report of two RCWs occupying a single cavity in BCNP (Jansen 1983) suggests a scarcity of suitable trees for cavity excavation, which was evident during visits to BCNP (JAJ, personal observation).

Prior to our understanding of the cooperative breeding system of the birds, the cavity trees were referred to as a “colony,” but this name implied more than one breeding pair. Today the term used to describe the group of cavity trees is “cluster.” A cluster occupied by one or more RCWs is referred to as an active cluster. Cavity clusters are traditional sites and are usually passed down from generation to generation via the males. Young female RCWs disperse from their natal colony, thus minimizing the potential for inbreeding. If a breeding female dies, the males present at a cavity cluster will remain with the cluster and depend on attracting a new female as a breeder. Red-cockaded woodpeckers feed on a diversity of pine trunk surface and subsurface arthropods and on some seasonally available fruit. Group members forage together and during the course of a day their home range can be as little as about 100 acres (40 ha) to more than 1,000 acres (400 ha), depending in part on habitat quality. In the BCNP, home ranges are among the largest known (Patterson and Robertson 1981), suggesting poor habitat quality.

The endangered status of the RCW has been attributed to: (1) loss of old-growth pine forest, (2) elimination or reduction in the frequency of fire that maintains the open nature of the birds’ preferred habitat, and (3) fragmentation and isolation of populations. Conner et al. (2001) provide a more in-depth view, and Patterson and

Robertson (1981) provide a forest history and basic descriptions of RCW habitat in the BCNP.

In a summary of the distribution and status of RCWs in Florida, Baker et al. (1980) noted only five “colonies” in Collier County. A year later Patterson and Robertson (1981) in the first detailed study of the bird in BCNP, located 18 active RCW cavity clusters, 12 in Collier County and 6 in Monroe County. Cox et al. (1995) further updated our knowledge of the status of RCWs in BCNP. The South Florida Multi-Species Recovery Plan (USFWS 1999) updated the number of active groups in BCNP to 33 active clusters in BCNP prior to the passage of Hurricane Andrew in 1992. The most recent published update on the BCNP RCW population (Jansen and Schulze 2004) indicated that as of 2002, there were 51 active clusters. During a presentation before our panel, Ross Scott of the FWC, who has been working with RCWs in BCNP, indicated that he located 57 active clusters in 2007, including 42 potential breeding groups. He also indicated that he had located 69 active clusters and 52 potential breeding groups in 2009 and felt that there were more. None of his search efforts had been in the NGA.

An understanding of the extreme difficulty of traveling in the region is essential to understanding reported numbers of RCW clusters in BCNP. As Jansen and Schulze (2004:295) noted:

“No systematic searches for clusters have been done. The magnitude and lack of roads in BCNP (285 km of roads in 294,700 ha) necessitates the use of swamp buggies, all terrain cycles, and airboats to access clusters from the ground.”

In short the suggested “growth” in the numbers of active clusters may not be growth at all, but rather the chance discovery of already existing groups. The larger numbers of active clusters are, of course, a positive sign. But the possibility exists that they represent a declining population instead of a growing population. The fact that Jansen and Schulze (2004) found that 11 known active clusters had been abandoned by the birds during the previous 22 years is not a good sign. Similarly, the number of active clusters can be deceiving – some have only males present, thus no breeding activity. Male-only clusters occur when the breeding female dies or disperses and the group is not able to recruit a new breeding female. This problem is symptomatic of isolation of clusters by fragmentation or loss of forest, or by poor quality habitat. The mosaic of habitats in the BCNP, and especially the dominance of wetlands and cypress with pine forest occurring in isolated islands, create great potential for the existence of active clusters with males-only groups that ultimately become abandoned as the males die. The information provided by Jansen and Schulze (2004) and Ross Scott (personal communication) suggests that approximately 25% of the active clusters on BCNP may be occupied by male-only groups. Clearly, systematic surveys for RCWs and more definitive data on their status are needed for BCNP and the NGA, in particular.

The USFWS has acknowledged in the South Florida Ecosystems Recovery Plan (1999) that our state of understanding of RCW populations in south Florida is inadequate. They state that the USFWS needs to:

“... work toward revising the Federal guidelines...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...”

Although ten years have passed since this statement was made, it is still true.

With regard to O&G impacts on RCWs, the novelty of a disturbance (relative to experience of the birds) is an important factor that plays a role in the magnitude of the impact of most of the disturbances mentioned thus far. As an example to explain what we mean by “novelty,” consider noises. All animals habituate to noises that are frequent and irrelevant to them. They are bothered by noises that are novel (i.e., ones that they are not familiar with). Red-cockaded woodpeckers have nested successfully in the median of interstate highways with loud traffic noise all around them. They have also nested successfully within about 328 ft (100 m) of the target on a U.S. Navy bombing range. Because the Navy jets used the range frequently and had begun long before the nesting season, the birds learned that the very loud noise of the jets and the practice bombs they dropped were of no consequence to them, and they continued to feed their young without interruption. On the other hand, when workers put a new roof on a building near an active RCW nest and had a radio playing loud music all day for the time it took to complete the roof, the birds abandoned their nest effort. The music and activity near the nest were both novel and initiated at a time when the birds were particularly sensitive to disturbance. The jets and bombs were not novel. The birds had habituated to them and they had no impact on nesting activities (Jackson 1983).

Individual quirkiness of specific birds can make their response to a stimulus unpredictable. RCWs vary as individuals as a result of genetics and as a result of their past experiences. As a result, we must consider average responses and the various factors that might influence a response.

1.6 Threatened and Endangered Mammal Species (TEMS) of Big Cypress

Mammals are valued by humans for their utilitarian and intrinsic value. Perhaps no other group of organisms has had as much influence on human evolution, culture, and our spread and growth across the planet. Likewise, our success has led to range and population reductions of many mammal species; some have become extinct from our activities, others have become threatened and endangered and have been granted various legal protections. Mammals not only supply us food and fur, they provide additional ecological services that include: control of prey species, soil aeration, seed dispersal, nutrient deposition, ecological competition, habitat

modification, hosting disease organisms and parasites, and exertion of evolutionary tension on other species. Although hunting and trapping remain important economic and cultural activities, an increasingly urbanized populace today often appreciates wild mammals more for their aesthetic and intrinsic value despite the fact that most people will never observe most species in the wild.

The subtropical climate, mixture of wet and dry habitats, and relatively frequent inundation of the peninsula by sea level rise, have strongly shaped the distribution of many species in south Florida, including mammals. BCNP has a diverse number of vegetation cover types that are important habitat for more than 30 mammal species. Although most mammals in BCNP can be found in hardwood hammocks, pinelands, prairies and other uplands, several species depend on wetlands. Currently four species in BCNP are listed as threatened or endangered as a result of human activities and/or because they historically occurred in small numbers. As such, these species are particularly vulnerable to habitat loss and fragmentation, and environmental and demographic stochasticity. Threatened and endangered mammals (TEMS) of BCNP include the federally endangered Florida panther (*Puma concolor coryi*), and the state threatened Florida black bear (*Ursus americanus floridanus*), Everglades mink (*Mustela vison evergladensis*), and Big Cypress fox squirrel (*Sciurus niger avicennia*).

1.6.1 Florida Panther

Although the Florida panther (**Figure 1.31**) has increased in number during the past 15 years, it continues to be one of the world's most endangered mammals with only 100-120 individuals estimated to occur in the wild (FWC 2009, USFWS 2008). Once distributed throughout the southeastern U.S., this federally endangered subspecies is currently restricted to one population located at the extreme southwestern end of the Florida peninsula where it occurs in close association with forests, primarily on large tracts of public land, but also among a scattering of private lands embedded within a matrix of urban, low-density residential, and agricultural areas (Maehr 1997a, Kautz et al. 2006).

The panther's primary breeding range occurs south of the Caloosahatchee River, and west of Miami (Kautz et al. 2006), with the habitat core centered around the public lands triumvirate of Florida Panther National Wildlife Refuge, Fakahatchee Strand Preserve State Park, and the northern portion of BCNP (Maehr 1997a). Approximately 52% of nearly 88,000 panther telemetry locations from 1981-2009 occurred in these three areas, and BCNP alone has supported as many as 60 panthers in a single year (McBride 2007). This should be no surprise considering these areas contain the region's largest tracts of forest and have relatively high landscape-scale connectivity compared to surrounding land.

Despite public refugia, habitat fragmentation and loss caused by Florida's burgeoning human population and associated land uses (Zwick and Carr 2006) pose immediate threats to the survival of the panther and many other species. The small

population size and limited distribution of the panther render it highly susceptible to demographic and environmental stochasticity (Maehr and Lacy 2002), and projected sea level rise from global warming has the potential to submerge most of the species current range (A. Whittle, unpublished data).

Recent increases in panther numbers have been attributed to genetic rescue using translocated Texas cougars (Pimm et al. 2006), better management of deer and their habitat, and land acquisition and protection measures (D. Jensen, personal communication). As a result, panthers have colonized areas where only two decades ago they seldom occurred, including the southeastern portion of BCNP, portions of ENP, and private lands east and southeast of Naples. Panthers have been increasingly observed near urban and residential areas in recent years (FWC 2008). Occupation of these areas brings panthers into close contact with humans; 17 panthers were killed on roads and at least one was shot dead during 2009 (<http://www.floridapanther.net/>). Individuals on the edge of this colonization front are likely those that have dispersed due to intra-specific competition or lack of resources. Population expansion of the panther into these marginal lands and higher risk areas suggests that the species may be approaching carrying capacity in core portions of its range that primarily occurs on public lands.

Portions of BCNP and most of ENP can be considered marginal panther habitat relative to other areas within the panther's primary breeding range because these areas are predominately open, flood-prone wetlands that cannot as effectively nor consistently support panther prey populations as upland habitats can (Smith et al. 1996, Maehr and Lacy 2002). These areas also lack extensive tracts of forest cover that are important to the panther for hunting and denning. As such, recent increases in panther numbers and expansion of range on portions of these public lands could be lost during an extensive wet period. Despite the transient ability of these hydrodynamic areas to support permanent panther occupation, they are nonetheless currently important in supporting a viable panther population given the at-risk small population size of the species and limited habitat availability elsewhere in south Florida.

Although panthers have been observed in the NGA (**Figures 1.30 and 1.32**), only 1.5 % of nearly 90,000 panther telemetry locations from 1981-2009 occurred in this area, yet those relatively few locations represented 49 different radio-collared panthers. The majority (~69%) of panther radio-locations in NGA have occurred in relatively more forested lands north of I-75 (**Figure 1.33**). As with all telemetry studies, these data are subject to biases related to capture efforts, sampling intensity, and evolving radio-collar technologies, and do not necessarily reflect true species occupancy at any given time.

Although male panthers have moved north of the Caloosahatchee River (north of BCNP between Lake Okeechobee and Fort Myers) in recent years, females have not been found north of this landscape feature since the 1970s. Potential colonization routes across this river for panthers (and other animals) to suitable habitat in

south-central Florida are closing fast as a result of rapid development east of Fort Myers. However, successful colonization of areas farther north by panthers is no guarantee for survival of the species. Thatcher et al. (2009) identified four areas in south-central Florida that contained suitable habitat, but these areas in total were predicted to only support 36 panthers.

The panther is a wide-ranging, apex predator that strongly influences prey distribution, behavior, and population dynamics (Logan and Sweaner 2001, Maehr et al. 2005). Although the panther occasionally preys on raccoon (*Procyon lotor*), armadillo (*Dasypus novemcinctus*), and other small animals (Dalrymple et al. 1996, Maehr 1997b), its primary prey are the white-tailed deer (*Odocoileus virginianus*) and the introduced European wild hog (*Sus scrofa*) (Maehr et al. 1990a), which is slower and likely easier panther prey than deer (Maehr 1997a). Both deer and hogs are habitat generalists that thrive in a variety of vegetation types in Florida, but can experience local population declines in flooded wetlands such as occurred in BCNP and ENP in the mid-1990s (Smith et al. 1996). After this wet period, hog numbers in BCNP declined precipitously and have remained low, likely because they experienced additive mortality from concomitant increases in panther numbers. Deer numbers recovered and have stabilized (D. Jansen, personal communication). With hog numbers low, panthers will have to rely more on deer and other alternative prey, and both intraspecific and interspecific competition—particularly with bobcats (*Lynx rufus*)—for food will likely increase (Maehr 1997b).

Prey availability, availability of mates and daytime cover, and avoidance of other cats are important influences of panther home range size, activity, and movement patterns (Maehr 1997a). Average male panther home range size (378 mi² [978 km²]) is larger than that of females (117 mi² [304 km²]) (Thatcher et al. 2009). The panther is primarily active in crepuscular and nocturnal time periods (Maehr et al. 1990b), and thus is seldom observed, even by researchers that monitor them. Janis and Clark (2002) did not detect differences in rates of panther activity, movement, or female hunting success in response to deer hunters, and panther numbers have increased in BCNP despite continued hunting and ORV use.

Panther mating and denning occur year-round, but primarily from February through July. Dens are usually found closer to upland hardwoods, pinelands, and mixed wet forests than other habitat types (Benson et al. 2007). Approximately 39% of all dens (n = 153) occur in pine and saw palmetto dominated areas, and nearly two-thirds of all den sites have a saw palmetto component (FWC, unpublished data). Forty-four percent of all located panther dens occurred in BCNP (FWC, unpublished data). Female panthers have not been observed to abandon dens after visits by researchers (D. Jansen and D. Land, personal communication), who often have trouble locating the cryptically colored kittens (Maehr 1997a).

Projected land-use changes, fluctuating prey populations, shrinking colonization corridors, stochastic threats, and a shortage of vacant, suitable habitat will collectively limit population growth of panthers in south Florida. The panther

population recovery objective of 240 individuals for the south Florida population (USFWS 2008) will likely not be achieved without translocation and subsequent establishment of panthers to north Florida or continental areas of the southeastern U.S. Until that action occurs, the fate of Florida panthers in the wild rests on its ability to withstand the increasing pressures of human population growth that pose both direct and indirect threats to this enigmatic feline. As such, the relative importance and potential contribution of each individual panther in maintaining species viability is very high.

1.6.2 Black Bear

The Florida black bear (**Figure 1.31**) is the state's largest land mammal and carnivore. Historically found throughout the state, this habitat generalist is now restricted to approximately 18% of its former range, with an estimated 2,200-3,300 bears inhabiting eight disjunct subpopulations from Eglin Air Force Base in the northern panhandle to BCNP in the southwest portion of the peninsula (Simek et al. 2005). Most of these subpopulations occur on large tracts of public land characterized by a diversity of vegetation cover types.

Bears in Florida are listed as state threatened, and were a candidate for federal threatened listing because of fragmentation among the eight subpopulations. The primary source of mortality for bears is collisions with vehicles, with over 100 per year killed in the past few years (Simek et al. 2005). Habitat loss and fragmentation have influenced and continue to threaten the long-term genetic viability of all bear subpopulations (Dixon et al. 2007), but pose immediate threats to bears in the Big Bend, St. John's, and Highlands-Glades areas.

At the landscape scale, bears occur at low densities. Female home-range size is primarily influenced by availability of food and presence of cubs, and male home ranges are usually established to maximize reproductive access to females. Availability of these resources can cause large fluctuations in home range size (Maehr 1997b, Dobey et al. 2005). Florida bears mate during the late spring and early summer, and den from late December to mid-April (Dobey et al. 2005). Like panthers, bears rarely abandon den sites and cubs when temporarily disturbed by researchers, even when the female is present (JJC, personal observation).

Like the sympatric panther, the Florida black bear relies heavily on forests, particularly those with an understory soft mast component. Black bears are opportunistic omnivores with a diet comprised of approximately 80% plant matter and 20% animal matter (Maehr and Brady 1984). If undisturbed, individual bears readily adapt to human presence and landscapes, particularly when these areas provide needed resources, such as available denning sites or food. In Kentucky and elsewhere, bears have occasionally been observed to den near active coal surface mines and oil wells, under discarded mining machinery, and near active rock quarries (JJC, personal observation; Manville 1983). Black bears near urban interfaces where unsecured human foods and garbage occur can become a nuisance

and have high mortality (M. Orlando, personal communication). Bear nuisance complaints in Florida have paralleled the growth in bear numbers and human population during the past two decades (Simek et al. 2005). Although bears can readily adapt to human infrastructure and activity, reduced fitness, population declines, and local extinction are common outcomes for bears that come into conflict with humans in such areas (Orlando 2003).

BCNP contains a mosaic of habitat types that bears use, including hardwood hammocks, pine flatwoods, and forested wetlands. The greater BCNP bear population was estimated at between 516-878 individuals (Simek et al. 2005), but other important information about this subpopulation is lacking. FWC monitored black bears using radio-telemetry from 1986-1998 (Maehr 1997b), but the study centered around the Fakahatchee Preserve, and only nine bears (~ 14% of total locations) in BCNP were monitored. There have been bears documented within the NGA, particularly in the upper half of the study area (**Figure 1.30**). FWC considers this bear subpopulation stable, but recommends in support of this goal that habitat fragmentation and degradation be limited, additional habitat be managed for bears, and that a landscape corridor be established and maintained with the Highlands-Glade bear subpopulation (B. Scheick, personal communication).

1.6.3 Big Cypress Fox Squirrel

The Big Cypress fox squirrel (hereafter fox squirrel; **Figure 1.31**) is a subspecies endemic to south Florida that has been considered for federal threatened status, but currently remains only state threatened. The fox squirrel occurs south of the Caloosahatchee River and northwest of ENP where it inhabits forest communities, including baldcypress swamps, tropical hardwoods, pine savannas, mangrove forest, live oak, and occasionally urban areas (Humphrey and Jodice 1992). Habitat loss and fragmentation, and fire suppression are thought to have contributed to population declines (Humphrey and Jodice 1992), and it is speculated that only a few hundred individuals exist (D. Jansen, personal communication). However, little is known about its exact distribution or abundance, and in general, the species is poorly studied. It is unknown whether this species occurs in the NGA.

The diet of the this fox squirrel varies, but hard and soft mast are important general components, as well as animal matter such as bird eggs, nestlings, and small amphibians (Humphrey and Jodice 1992). Fox squirrels are diurnal and prefer to forage in relatively open understories where movement is less restricted. Cattle grazing, frequent understory-suppressing fires, and mowing (e.g., golf courses) are management and land-use activities currently considered potentially compatible with the subspecies (Jodice and Humphrey 1992, Ditgen et al. 2007).

1.6.4 Everglades Mink

Despite its name, the state threatened Everglades mink subspecies is perhaps more commonly found in BCNP than in ENP (Smith 1980). This mustelid is poorly studied,

and little is known about its population status. Once thought uncommon to rare (Layne 1974), recent observations suggest the mink may be relatively common (Allen and Neill 1952, Humphrey and Zinn 1982), but its occurrence and population status in the NGA are unknown.

Mink are chiefly crepuscular and nocturnal predators that thrive in shallow wetlands where they can effectively forage for prey such as crustaceans, mollusks, fish, snakes, ground-nesting birds, rabbits, and other small mammals (Smith 1980). As such, mink are strongly influenced by hydroperiod, particularly during the dry season when they retreat from drying marshlands to areas with longer hydroperiods (Cox and Kautz 2000). During the wet season, mink frequent salt marshes among mangrove stands (Cox and Kautz 2000). Like other aquatic mustelids, mink are vulnerable to wetland loss and fragmentation, as well as pollution caused by spills or release of toxic substances (e.g., heavy metals, hydrocarbons, pesticides, fertilizers), particularly through bioaccumulation caused by consumption of contaminated prey (Humphrey 1992).

Mink breeding season is strongly related to photoperiod (Duby and Travis 1972), but the exact breeding period of mink in south Florida is speculative. Humphrey and Zinn (1982) suggested that mink may breed during the late wet season, but other subspecies farther north breed in late January through March (Sealander and Heidt 1990). Mink den on streambanks or other areas close to water including in muskrat burrows, abandoned beaver lodges, downed trees, and brushpiles (Burt and Grossenheider 1980).

Table 1.1: Comparison of plant community classifications for Big Cypress National Preserve recreated from Gunderson and Loope (1982), Turner River Report.

	Davis 1943 (a)	Craighead 1971 (b)	McPherson 1973 (b)	Duever et al. 1979 (c)
PINE HABITATS	Pine-Wiregrass			
	Pine-Palmetto	Pine-Flatwoods		
	Pine-Cabbage Palm	Pine-Islands	Pine-Forests	Pine-Palm-Palmetto
	Palmetto Prairie	Palmetto Savannah		
MIXED HARDWOOD ASSOCIATIONS	Oak-Hammock		Oak-(Laurel, Live)	Temperate Hammock
	Oak-Palm-Hammock			
	Cabbage-Palm		Cabbage-Palm	
	Low Hammock			
	Tropical Hammock	Tropical Hardwood Hammock	Tropical Hardwood Hammock	Tropical Hardwood Hammock
FRESHWATER SWAMPS	Mixed Swamp Forest	Cypress Strand	Mixed Swamp Forest	Mixed Swamp Forest
	Cypress Dome	Cypress Dome	Cypress Dome	Cypress Dome
	Cypress Slough		Cypress Strand	Cypress Strand
	Cypress Scrub	Dwarf Cypress	Cypress Forests	Dwarf Cypress
	Custard-Apple	Custard Apple Swamp		Pond Apple Slough
	Pop-Ash	Pop-Ash Head		Pop-Ash Head
	Willow	Willow		Willow Head
	Marsh	Marsh, Sloughs	Marshes, Sloughs	Marshes
MARSHES AND PRAIRIES	Sawgrass			
	Flag			
	Aquatic			
	Cattail			
	Spikerush			
	Wet Prairie	Wet Prairie	Wet Prairie	Wet Prairie
Dry Prairie	Dry Prairie	Dry Prairie	Dry Prairie	

(a) extrapolated from plant communities of south Florida

(b) plant communities within Big Cypress region

(c) plant communities within Big Cypress National Preserve

Table 1.2: Community class cover in the Nobles Grade area of Big Cypress National Preserve (BCNP; B. Layman, personal communication). Estimates are derived from the Center for Remote Sensing and Mapping Science’s (University of Georgia) GIS vegetation database of Everglades National Park, BCNP, and Biscayne National Park, which used photo-interpretation of NAPP color infrared (CIR) aerial photographs from 1994-1995. The hierarchical Everglades Vegetation Classification System was used to create the vegetation database; this classification scheme, with cross-walks to other Florida vegetation classifications can be found at <http://crocdoc.ifas.ufl.edu/crosswalk/index.php?cw=evcs>.

Habitat	Percent
Cypress Domes	27.25
Cypress Prairies	33.38
Cypress Strands	15.73
Exotic Plant Species	0.44
Hardwood Hammocks	4.12
Marshes	3.88
Mixed Hardwood Swamps	0.81
Pinelands	11.45
Prairies	2.06
Sloughs	0.02
Disturbed Sites	0.86
Total:	100
Cypress Total:	76.36

Table 1.3: Plant community cover in BCNP. A. from Duever et al. (1986b), based on McPherson (1973), personal communication. B. from Muss et al. (2003) description in introduction to an updated checklist of plants of BCNP. C. From UGA map (Welch and Madden, 1999) with communities re-classified by Jim Burch (BICY) and class areas summarized by J.H. Richards and D. Gann (FIU); this estimate, based on 1994-1995 aerial photography, includes the Addition Lands.

A. Habitat	%	B. Habitat	%	C. Habitat	%
Cypress	43	Cypress swamp	25	Cypress Forest	30.2
		Cypress prairie	25	Scrub Cypress	17.0
Prairies	24	Wet prairies and marshes	25	Wet Prairie	23.0
Pine Forest	18	Pine forests	15	Hydric Pine Flatwoods	8.3
				Mesic Pine Flatwoods	8.3
Mixed Swamp Forest	6.4			Swamp Forest	3.1
Inland Marshes	4.2			Marsh	2.7
Hammock Forest	1.5	Upland hardwood forests	4	Hydric Hammock	0.8
				Mesic Hammock	4.9
Coastal Forest	1.4	Mangrove	1	Mangroves	0.4
Coastal Marshes	0.9				
Agricultural or Disturbed	0.7	(other)	5	Disturbed	0.8
				Water	0.5
Total:	100	Total:	100	Total:	100

Table 1.4: Aboveground biomass production of cypress swamps in the southern United States.

Location/type	Flood periodicity	Water	Leaf litterfall (g/m ² /yr)	Stem growth (g/m ² /yr)	Reference
FLORIDA					
blackwater river swamp	seasonal ^a	flowing	597	1086	Brown 1981
whitewater river swamp	seasonal	flowing	578		ibid
tupelo ^b -cypress ^c -ash	semi-permanent	poor drainage	481	---	Elder & Cairns 1982
water tupelo-baldcypress	semi-permanent	poor drainage	476	---	ibid
baldcypress	seasonal	undrained	345	772	Burns 1978
cypress	permanent	stagnant	---	154	Mitsch & Ewel 1979
scrub cypress	stillwater	stagnant	224	44	Flohrschutz 1978
scrub cypress			100		Duever et al. 1975
cypress domes	stillwater	stagnant	387-488	541	Brown 1981
cypress strand	seasonal	flowing	597	772	Burns 1984
GEORGIA					
pondcypress	permanent	stagnant	328	353	Schlesinger 1978
baldcypress-sweetgum- oak-blackgum-tupelo	seasonal, 3-6 mo.	flowing	650-850	---	Cuffney 1988
LOUISIANA					
baldcypress-water tupelo	semi-permanent	slowly flowing	620	500	Conner and Day 1976
baldcypress-water tupelo	semi-permanent	slowly flowing	417	749	Conner et al. 1981
baldcypress-water tupelo	permanent	stagnant	330	560	ibid
baldcypress-water tupelo	semi-permanent	slowly flowing	488	338	Megonigal et al. 1997
baldcypress-water tupelo	seasonal	slowly flowing	725	430	ibid
baldcypress	permanent	slowly flowing	333	330	ibid
SOUTH CAROLINA					
baldcypress-water tupelo	frequent flooding	flowing	466	293	Muzika et al. 1987
baldcypress-red maple	frequent flooding	flowing	544	1343	ibid
water tupelo-baldcypress	permanent	flowing	438	216	Megonigal et al. 1997
baldcypress-water tupelo ^e	tidal	flowing	594	397	Ratard 2004

Table 1.4: Continued.

Location/type	Flood periodicity	Water	Leaf litterfall (g/m ² /yr)	Stem growth (g/m ² /yr)	Reference
VIRGINIA baldcypress-red maple- blackgum	seasonal, 6 mo.	stagnant	568	---	Day 1984

^aprior to dam construction, flooding was year-round

^bincludes water tupelo, swamp tupelo, and Ogeechee tupelo

^cno distinction made as to whether baldcypress or pondcypress

^daverage value over 57 years

^eaverage of 7 sites

Table 1.5: Florida Exotic Pest Plant Council (FLEPPC) Category I plant invasive exotics known to occur in BCNP. Habit derived from the Florisitic Inventory of South Florida (FISF) database and J. Richards (personal communication). A = annual; a = aquatic; f = fern; gr = grass; H = herbaceous; P = perennial; Sh = shrub; Tr = tree; V = vine.

Species	Habit	Species	Habit
<i>Abrus precatorius</i>	V	<i>Melaleuca quinquenervia</i>	Tr
<i>Acacia auriculiformis</i>	Tr	<i>Nephrolepis cordifolia</i>	P,H (f)
<i>Albizia lebbek</i>	Tr	<i>Nephrolepis multiflora</i>	P,H (f)
<i>Ardisia elliptica</i>	Sh	<i>Neyraudia reynaudiana</i>	P,H (gr)
<i>Bauhinia variegata</i>	Tr	<i>Panicum repens</i>	P,H
<i>Bischofia javanica</i>	Tr	<i>Pennisetum purpureum</i>	P,H (gr)
<i>Casuarina equisetifolia</i>	Tr	<i>Pistia stratiotes</i>	P,H (a)
<i>Casuarina glauca</i>	Tr	<i>Psidium cattleianum</i>	Tr
<i>Colocasia esculenta</i>	P,H	<i>Psidium guajava</i>	Tr
<i>Dioscorea bulbifera</i>	V	<i>Rhynchelytrum repens</i>	P,H (gr)
<i>Eichhornia crassipes</i>	P,H (a)	<i>Ruellia tweediana</i>	P,H
<i>Eugenia uniflora</i>	Tr	<i>Schefflera actinophylla</i>	Tr
<i>Ficus microcarpa</i>	Tr	<i>Schinus terebinthifolius</i>	Tr
<i>Hydrilla verticillata</i>	P,H(a)	<i>Senna pendula var. glabrata</i>	Sh
<i>Hymenachne amplexicaulis</i>	P,H (gr)	<i>Solanum viarum</i>	Sh
<i>Imperata cylindrica</i>	P,H (gr)	<i>Syngonium podophyllum</i>	V
<i>Lantana camara</i>	Sh	<i>Syzygium cumini</i>	Tr
<i>Lygodium japonicum</i>	V	<i>Thespesia populnea</i>	Tr
<i>Lygodium microphyllum</i>	V	<i>Urochloa mutica</i>	A,H (gr)

Table 1.6: Florida endangered plant species present or historically present in Big Cypress National Preserve, after the Floristic Inventory of South Florida (FISF) database. The FISF database lists 69 Florida endangered species, 6 of which are “doubtfully present” or “Recorded as present in error”; these species have been removed from this list, leaving 63 species.

Species	Species
1 <i>Adiantum tenerum</i>	33 <i>Lantana depressa</i> var. <i>sanibelensis</i>
2 <i>Aeschynomene pratensis</i>	34 <i>Linum carteri</i> var. <i>smallii</i>
3 <i>Aletris bracteata</i>	35 <i>Liparis nervosa</i>
4 <i>Asplenium erosum</i>	36 <i>Maxillaria crassifolia</i>
5 <i>Asplenium serratum</i>	37 <i>Microgramma heterophylla</i>
6 <i>Burmannia flava</i>	38 <i>Ocimum campechianum</i>
7 <i>Calopogon multiflorus</i>	39 <i>Oncidium ensatum</i>
8 <i>Campylocentrum pachyrrhizum</i>	40 <i>Ophioglossum palmatum</i>
9 <i>Campyloneurum angustifolium</i>	41 <i>Passiflora pallens</i>
10 <i>Campyloneurum costatum</i>	42 <i>Pecluma ptilodon</i> var. <i>caespitosa</i>
11 <i>Catopsis berteroniana</i>	43 <i>Peperomia glabella</i>
12 <i>Catopsis floribunda</i>	44 <i>Peperomia obtusifolia</i>
13 <i>Chamaesyce porteriana</i>	45 <i>Peperomia rotundifolia</i>
14 <i>Colubrina arborescens</i>	46 <i>Phyla stoechadifolia</i>
15 <i>Cordia globosa</i>	47 <i>Polyradicion lindenii</i>
16 <i>Croton humilis</i>	48 <i>Polystachya concreta</i>
17 <i>Ctenitis sloanei</i>	49 <i>Rhynchosia swartzii</i>
18 <i>Cyrtopodium punctatum</i>	50 <i>Roystonea regia</i>
19 <i>Dalea carthagenensis</i> var. <i>floridana</i>	51 <i>Schizaea pennula</i>
20 <i>Digitaria pauciflora</i>	52 <i>Scleria lithosperma</i>
21 <i>Encyclia cochleata</i>	53 <i>Spiranthes brevilabris</i>
22 <i>Epidendrum anceps</i>	54 <i>Spiranthes torta</i>
23 <i>Epidendrum floridense</i>	<i>Tephrosia angustissima</i> var.
24 <i>Epidendrum nocturnum</i>	<i>curtissii</i>
25 <i>Epidendrum rigidum</i>	56 <i>Thelypteris reticulata</i>
26 <i>Eragrostis tracyi</i>	<i>Tillandsia fasciculata</i> var.
27 <i>Glandularia maritima</i>	<i>densispica</i>
28 <i>Gossypium hirsutum</i>	58 <i>Tillandsia pruinosa</i>
29 <i>Guzmania monostachia</i>	59 <i>Tillandsia utriculata</i>
30 <i>Hibiscus poeppigii</i>	60 <i>Tournefortia hirsutissima</i>
31 <i>Ionopsis utricularioides</i>	61 <i>Trichomanes holopterum</i>
32 <i>Jacquemontia pentanthos</i>	62 <i>Trichostigma octandrum</i>
	63 <i>Vanilla phaeantha</i>

Table 1.7: Number of taxa found in Big Cypress National Preserve ranked as Historical, Critically Imperiled (CritImp), Imperiled (Imper), or Rare by the Institute for Regional Conservation (IRC) and the Florida Natural Areas Inventory (FNAI) State and Global rankings. See Appendix E for definitions of rankings.

	Historical	CritImp	Imper	Rare
IRC	4	74	195	252
FNAI, State	2	22	23	8
FNAI, Global	1	2	12	8

Table 1.8: Plant species candidates for Federal Endangered Species Listing. IRC = Institute for Regional Conservation; FNAI St = Florida Natural Areas Inventory, State ranking; FNAI Gl = Florida Natural Areas Inventory, Global ranking. Additional information at:

http://ecos.fws.gov/tess_public/pub/SpeciesReport.do?lead=4&listingType=C

Species	Habit	Habitat	Agency	Status
<i>Dalea carthagenensis</i> (Jacq.) J.F. Macbr. var. <i>floridana</i> (Rydb.) Barneby				
Florida prairieclover	perennial	coastal strand	IRC	CritImp
Listing Priority: 3	shrub	marl prairie	FNAI St	CritImp
Magnitude: High		pine rockland	FNAI Gl	G5T1
Immediacy: Imminent			Florida	Endang
Taxonomy: Subspecies/population				
<i>Digitaria pauciflora</i>				
Florida pineland crabgrass	perennial	marl prairie	IRC	CritImp
Listing Priority: 5	herb	pine rockland	FNAI St	CritImp
Magnitude: High			FNAI Gl	CritImp
Immediacy: Non-imminent			Florida	Endang
Taxonomy: Species				
<i>Sideroxylon reclinatum</i> Michx. subsp. <i>austrofloridense</i> (Whetstone) Kartesz & Gandhi				
Everglades bully	perennial	marl prairie	IRC	Imp
Listing Priority: 12	shrub	pine rockland	FNAI St	
Magnitude: Moderate to Low			FNAI Gl	
Immediacy: Non-imminent			Florida	
Taxonomy: Subspecies/population				

Table 1.9: Plant taxa in Big Cypress National Preserve (BCNP) that are most at risk. Conservation status according to the State of Florida (FL), Institute for Regional Conservation (IRC), and Florida Natural Areas Inventory state (FS) and global (FG) conservation status (abbreviations at bottom of table) (see Appendix E for ranking definitions). Habit and habitat according to the IRC Floristic Inventory of South Florida (FISF) database (abbreviations at bottom of table). All species are on the State of Florida Endangered species list. A. Species threatened globally and critically imperiled in Florida by at least one agency. B. Species not threatened globally but critically imperiled in the state. C. Species not threatened globally but ranked as critically imperiled by the IRC and endangered by the State of Florida. Key to abbreviations provided on next page.

Species	Status:				Habit	Habitat
	FL	IRC	FS	FG		
A. <i>Digitaria pauciflora</i>	E	CI	CI	CI	T,P,H	MP, PR
<i>Eragrostis tracyi</i>	E	CI	H	H	T,A,H	CG, DU, SM
<i>Oncidium ensatum</i>	E	CI	CI	I	T,P,H	CB, PR, RH, SS
<i>Rhynchosia swartzii</i>	E	CI	CI	R	T,P,V	RH
<i>Tephrosia angustissima</i> var. <i>curtissii</i>	E	CI	CI	CI	T,P,H	CS, DU, MF
<i>Lantana depressa</i> var. <i>sanibelensis</i>	E	I	CI	I	T,P,Sh	CG,CS,DU,MP
B. <i>Asplenium serratum</i>	E	I	CI		E,P,H	RH, SS
<i>Burmannia flava</i>	E	CI	CI		T,A,H	MF
<i>Campyloneurum angustifolium</i>	E	CI	CI		E,P,H	RH, SI, SS
<i>Catopsis berteroniana</i>	E	I	CI		E,P,H	BH, PR, RH
<i>Croton humilis</i>	E	CI	CI		T,P,Sh	DU, RH CB, DW, MP, PR,
<i>Cyrtopodium punctatum</i>	E	I	CI		E,P,H	SS, TM
<i>Dalea carthagenensis</i> var. <i>floridana</i>	E	CI	CI		T,P,Sh	CS, MP, PR
<i>Guzmania monostachia</i>	E	I	CI		E,P,H	RH, SI, SS
<i>Ionopsis utricularioides</i>	E	CI	CI		E,P,H	DW, SS
<i>Maxillaria crassifolia</i>	E	CI	CI		E,P,H	SI
<i>Schizaea pennula</i>	E	CI	CI		T,P,H	BH, FF, MF, RH
<i>Spiranthes torta</i>	E	CI	CI		T,P,H	BM, MP, PR
<i>Tillandsia pruinosa</i>	E	CI	CI		E,P,H	SS
<i>Trichomanes holopterum</i>	E	CI	CI		E,P,H	SS
<i>Trichostigma octandrum</i>	E	CI	CI		T,P,H	BH, RH, SM
C. <i>Campylocentrum pachyrrhizum</i>	E	CI			E,P,H	SI, SS
<i>Liparis nervosa</i>	E	CI			T,P,H	SS
<i>Peperomia glabella</i>	E	CI			E,P,H	SS
<i>Peperomia rotundifolia</i>	E	CI			E,P,H	SI
<i>Spiranthes brevilabris</i>	E	H			T,P,H	MF
<i>Thelypteris reticulata</i>	E	CI			T,P,H	DW, DS, FS, RH, SS

Table 1.9: Continued. Key to abbreviations.

Conservation Status Key:			
Critically Imperiled	CI		
Endangered	E		
Historical	H		
Imperiled	I		
Rare	R		

Habit Key:			
Annual	A		
Epiphytic	E		
Herbaceous	H		
Perennial	P		
Shrub	Sh		
Terrestrial	T		
Vine	V		

Habitat Key:			
Basin Marsh	BM	Floodplain Swamp	FS
Bayhead	BH	Marl Prairie	MP
Coastal Berm	CB	Mesic Flatwoods	MF
Coastal Grassland	CG	Pine Rockland	PR
Coastal Strand	CS	Rockland Hammock	RH
Disturbed Upland	DU	Shell Mound	SH
Disturbed Wetland	DW	Slough	SI
Dome Swamp	DS	Strand Swamp	SS
Floodplain Forest	FF	Tidal Marsh	TM

Table 1.10: Threatened and endangered plant species in the Nobles Grade area (J. Sadle, ENP, personal communication; Gann et al. 2002). Conservation status for State of Florida (FL), the Institute for Regional Conservation (IRC), and Florida Natural Areas Inventory (FNAI) state (FS) and global (FG): AS = apparently secure; CI = critically imperiled; E = endangered; I = imperiled; S = secure; T = threatened. See Appendix E for conservation status definitions. Habit, habitat and range taken from the Floristic Inventory of South Florida (FISF) database. A. Species for Kissimmee Billy Strand; B. Species for Kissimmee Billy pineland.

		Conservation Status:			
		FL	IRC	FS	FG
A. Kissimmee Billy Strand: cypress strand with pop ash in the center					
<i>Cyrtopodium punctatum</i> (L) Lindl.: cowhorn orchid, cigar orchid (Orchidaceae)					
Habit	perennial herb, epiphyte in cypress communities	E	I	CI	S
Habitat	coastal berm, dome swamp, marl prairie, pine rockland, strand swamp, tidal marsh				
Range	South Florida, Greater Antilles (not Jamaica), Central America and South America.				
<i>Polyradicion lindenii</i> (Lindl.) Garay: ghost orchid, palmpolly (Orchidaceae)					
Habit	perennial herb, epiphyte in mixed hardwood swamp	E	I	I	I
Habitat	dome swamp, slough, strand swamp				
Range	South Florida and Cuba				
<i>Sacoila lanceolata</i> (Aubl.) Garay var. <i>paludicola</i> (Luer) Sauleta et al.: Leafy beaked lady's-tresses (Orchidaceae)					
Habit	perennial herb, terrestrial	T	I*		
Habitat	disturbed upland, disturbed wetland, mesic flatwoods				
Range	Florida, the West Indies, Mexico, Central America and South America. *This was for <i>S. lanceolata</i> , which ISB has as more widespread				
<i>Ophioglossum palmatum</i> L.: Hand fern (Ophioglossaceae)					
Habit	perennial herb, epiphyte	E	I	I	S
Habitat	Baygall, Floodplain Forest, Mesic Flatwoods, Mesic Hammock, Rockland Hammock, Strand Swamp				
Range	Peninsular Florida, the West Indies, Central America, South America and the Old World.				
<i>Phoradendron leucarpum</i> (Raf.) Reveal & M.C.Johnst.: Mistletoe, Oak mistletoe (Viscaceae)					
Habit	perennial shrub, parasite (epiphyte) on pop ash		CI		
Habitat	Dome Swamp, Strand Swamp				
Range	----				
Species not documented from Kissimmee Billy Strand but probably present:					
<i>Guzmania monostachia</i> (L.) Rusby ex Mez: West Indian tufted airplant (Bromeliaceae)					
Habit	perennial herb, epiphyte	E	I	S1S2	AS
Habitat	Rockland Hammock, Slough, Strand Swamp				
Range	South Florida, the West Indies, Central America and northern South America.				
<i>Campylocentrum pachyrrhizum</i> (Rchb. f.) Rolfe: Leafless bentspur orchid (Orchidaceae)					
Habit	perennial herb, epiphyte	E	CI		
Habitat	Slough, Strand Swamp				
Range	South Florida, Greater Antilles and northern South America.				
<i>Ionopsis utricularioides</i> (Sw.) Lindl.: Delicate violet orchid (Orchidaceae)					
Habit	perennial herb, epiphyte	E	CI	CI	AS
Habitat	Disturbed Wetland, Strand Swamp				
Range	South Florida, the West Indies, Mexico, Central America and South America.				

Table 1.10: Continued.

B. Kissimmee Billy Pineland: mesic pine flatwoods with acidic sandy soil		Conservation Status:			
		FL	IRC	FS	FG
<i>Tephrosia angustissima</i> Shuttlew. Ex Chapm. var. <i>curtissii</i> (Small ex Rydb.) Isley: Curtiss' hoarypea (Fabaceae)					
Habit	perennial herb terrestrial (shrubby)	E	CI	CI	CI
Habitat	Coastal strand, disturbed uplands, mesic flatwoods				
Range	Endemic to peninsular Florida.				
<i>Tephrosia angustissima</i> Shuttlew. ex Chapm. var. <i>corallicola</i> (Small) Isely: Coral Hoarypea (Fabaceae)					
Habit	more restricted distribution in state than above, but not in FISF for BCNP	E	CI	CI	CI
Habitat	Disturbed Upland, Pine Rockland				
Range	Dade, Collier Co. (ISB <i>Atlas of Florida Vascular Plants</i>)				
<i>Gymnopogon brevifolius</i> Trin. :Slim skeleton grass, Shortleaf skeleton grass (Poaceae)					
Habit	perennial herb terrestrial		CI		
Habitat	mesic flatwoods, pine rockland				
Range	Southeastern United States				
<i>Hypericum crux-andreae</i> (L.) Crantz: St. Peter's-wort (Clusiaceae)					
Habit	perennial shrub, terrestrial		CI		
Habitat	Mesic Flatwoods				
Range	Eastern and southeastern United States.				
<i>Schizaea pennula</i> Sw.: Ray fern (Schizaeaceae)					
Habit	perennial herb, terrestrial	E	CI	CI	AS
Habitat	Bayhead, floodplain forest, mesic flatwoods, rockland hammock				
Range	Peninsular Florida, the West Indies (Puerto Rico, Lesser Antilles),				
<i>Calopogon multiflorus</i> (Orchidaceae)					
Habit	perennial herb, terrestrial	E	CI	S2S3	R
Habitat	Mesic Flatwoods				
Range	Southeastern United States				
<i>Clitoria mariana</i> L., Butterfly:pea atlantic pegeiwings (Fabaceae)					
Habit	perennial vine, terrestrial		CI		
Habitat	Disturbed Upland, Mesic Flatwoods, Pine Rockland, Scrubby Flatwoods				
Range					
<i>Burmannia flava</i> Mart., Fakahatchee bluethread (Burmanniaceae)					
Habit	herbaceous annual, terrestria	E	CI	CI	
Habitat	Mesic flatwoods				
Range	South Florida, the West Indies (Cuba), Central America and South America.				

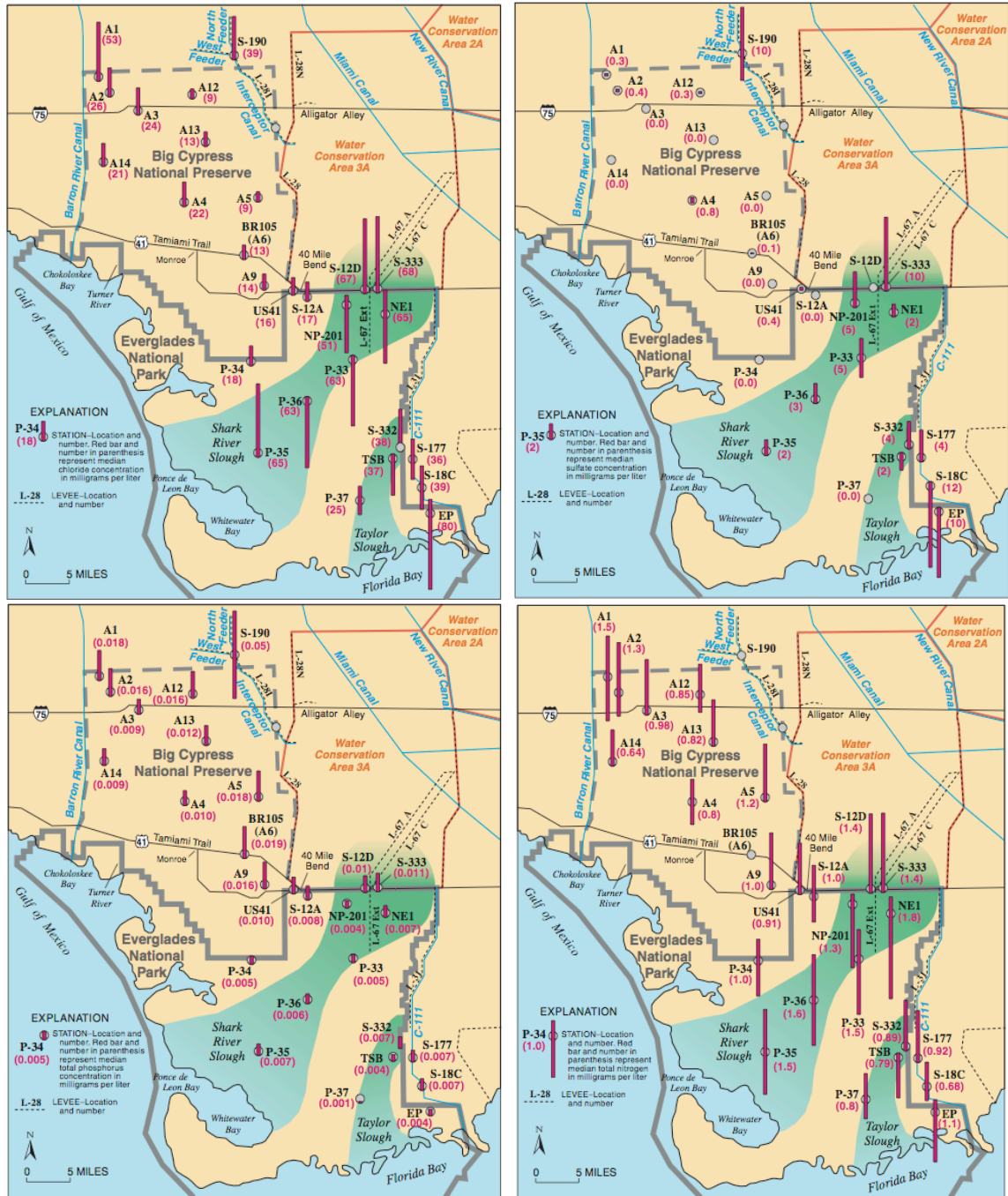


Figure 1.1: Plots showing the median concentrations of chloride (top left), sulfate (top right), total phosphorus (bottom left), and total nitrogen (bottom right) from across Big Cypress National Preserve and Everglades National Park. Sites A 12 and A 13 are nearest and likely within the Nobles Grade area. Figures and data taken from Miller et al. 2004.

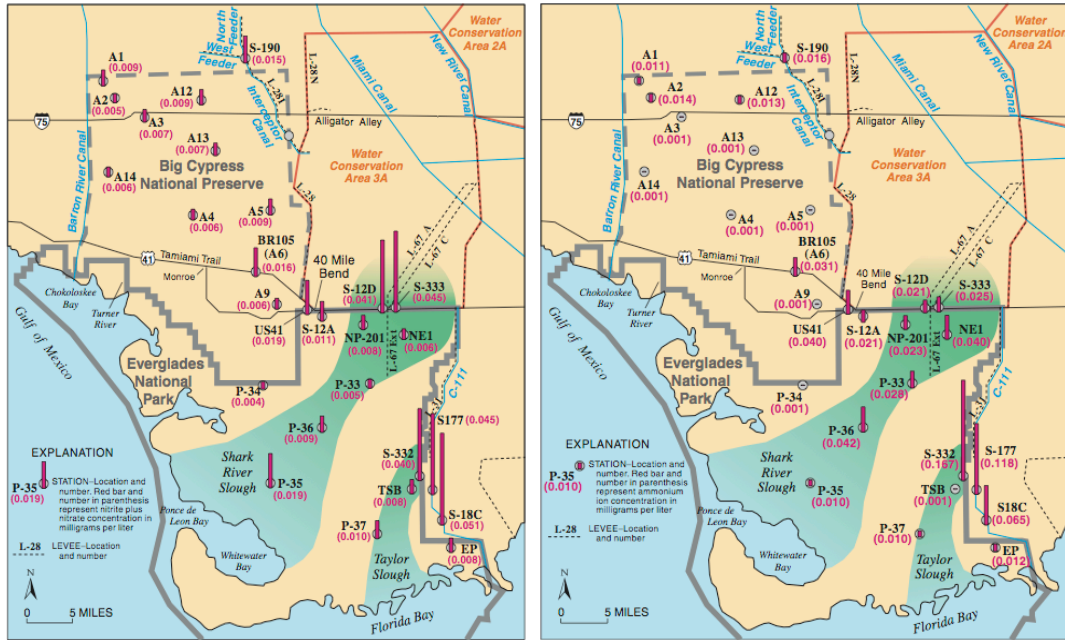


Figure 1.2: Plots showing the median concentrations of nitrate plus nitrite (left) and ammonia plus ammonium (right) from across Big Cypress National Preserve and Everglades National Park. Sites A 12 and A 13 are nearest and likely within the Nobles Grade area. Figures and data taken from Miller et al. 2004.

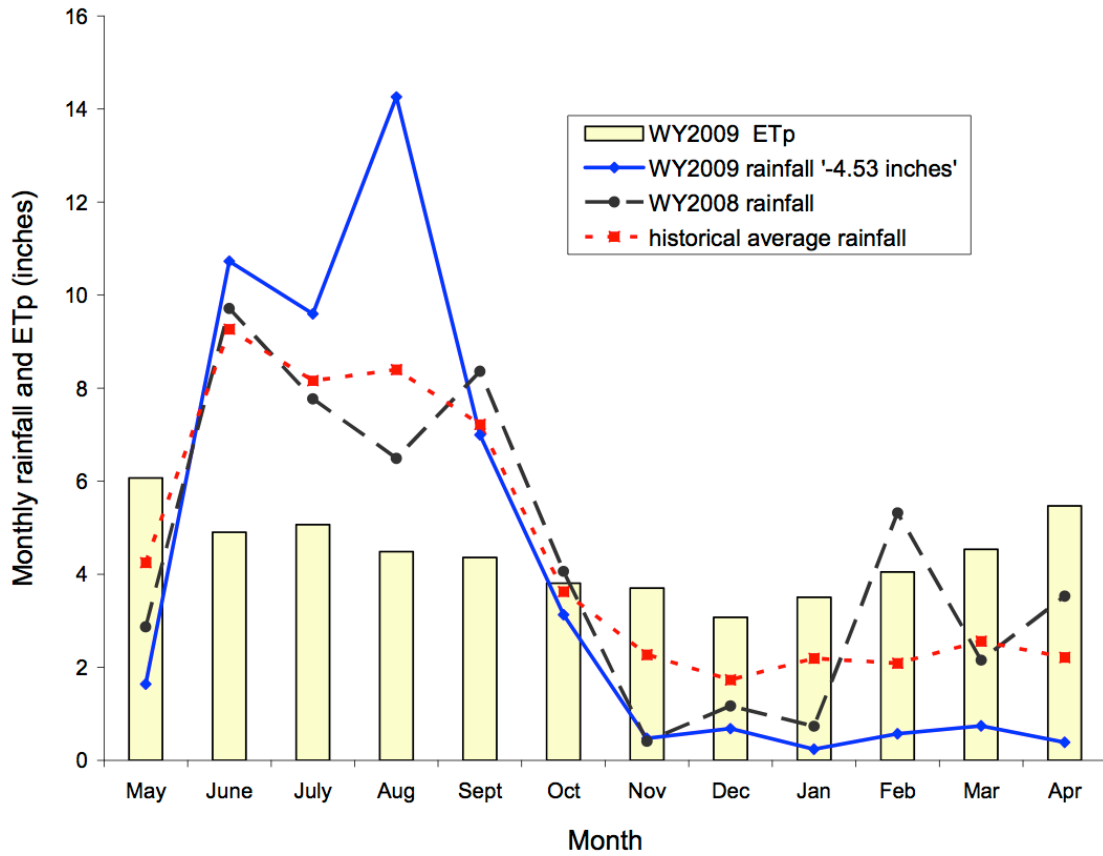


Figure 1.3: Monthly precipitation and evapotranspiration data for Big Cypress National Preserve (Figure 4a of Appendix 2-2 from the 2010 South Florida Environmental Report, SFWMD).

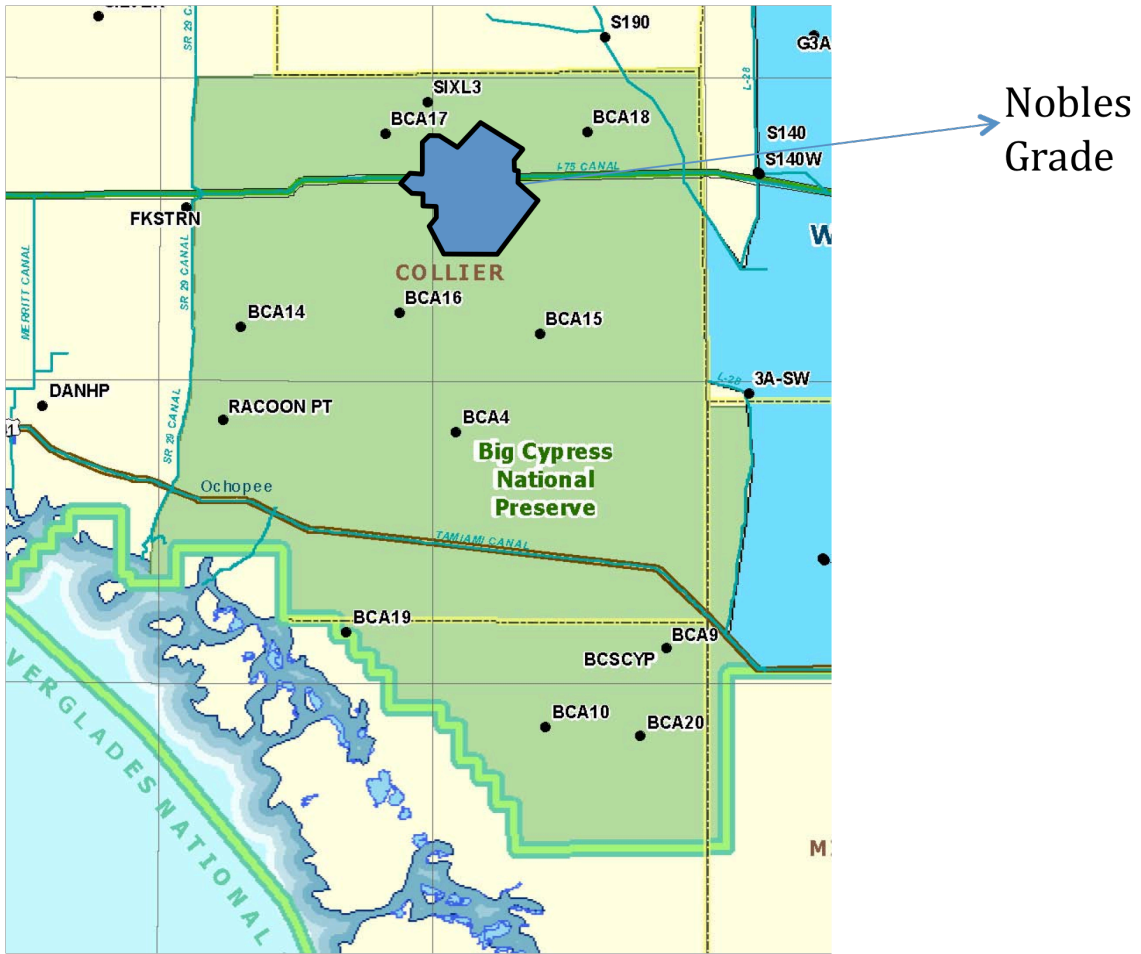


Figure 1.4: Map showing location of rainfall gages within the Big Cypress National Preserve.

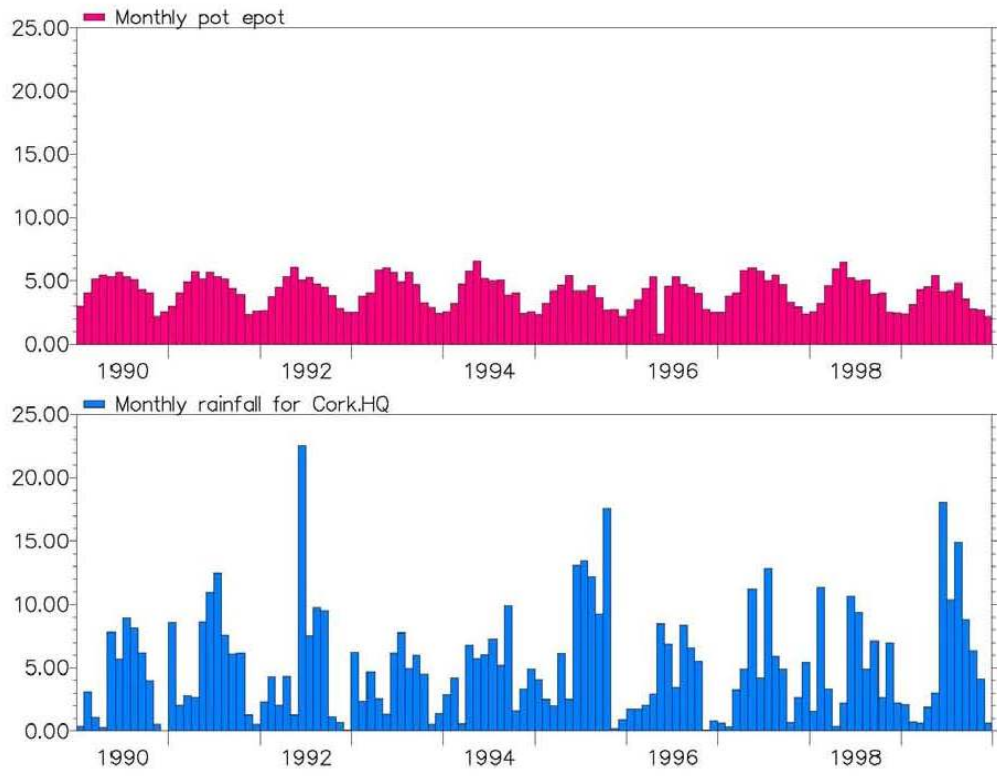


Figure 1.5: Plots of monthly rainfall and evaporation distribution for the Big Cypress Basin from 1990 to 1999.

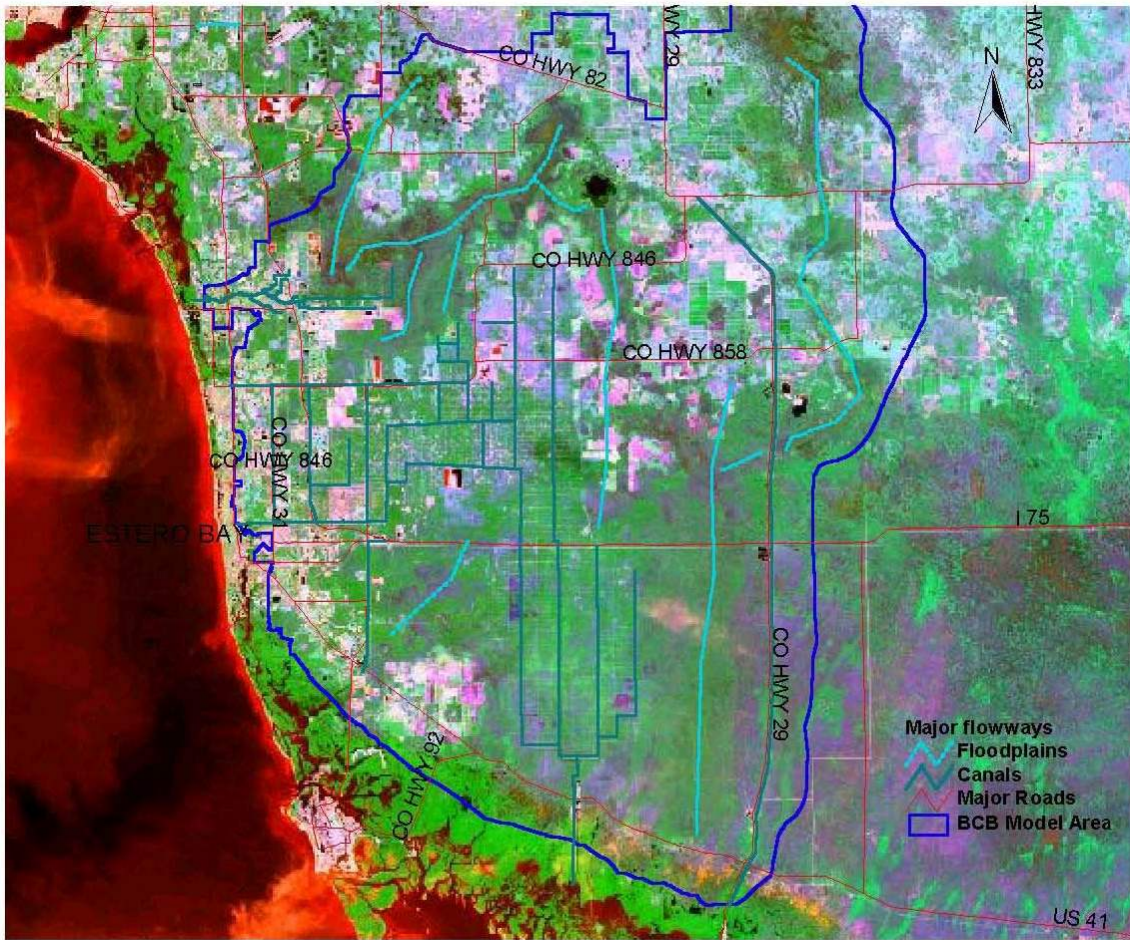


Figure 1.6: Map of Big Cypress Basin illustrating the main flow ways across the watershed. From DHI, 2002.

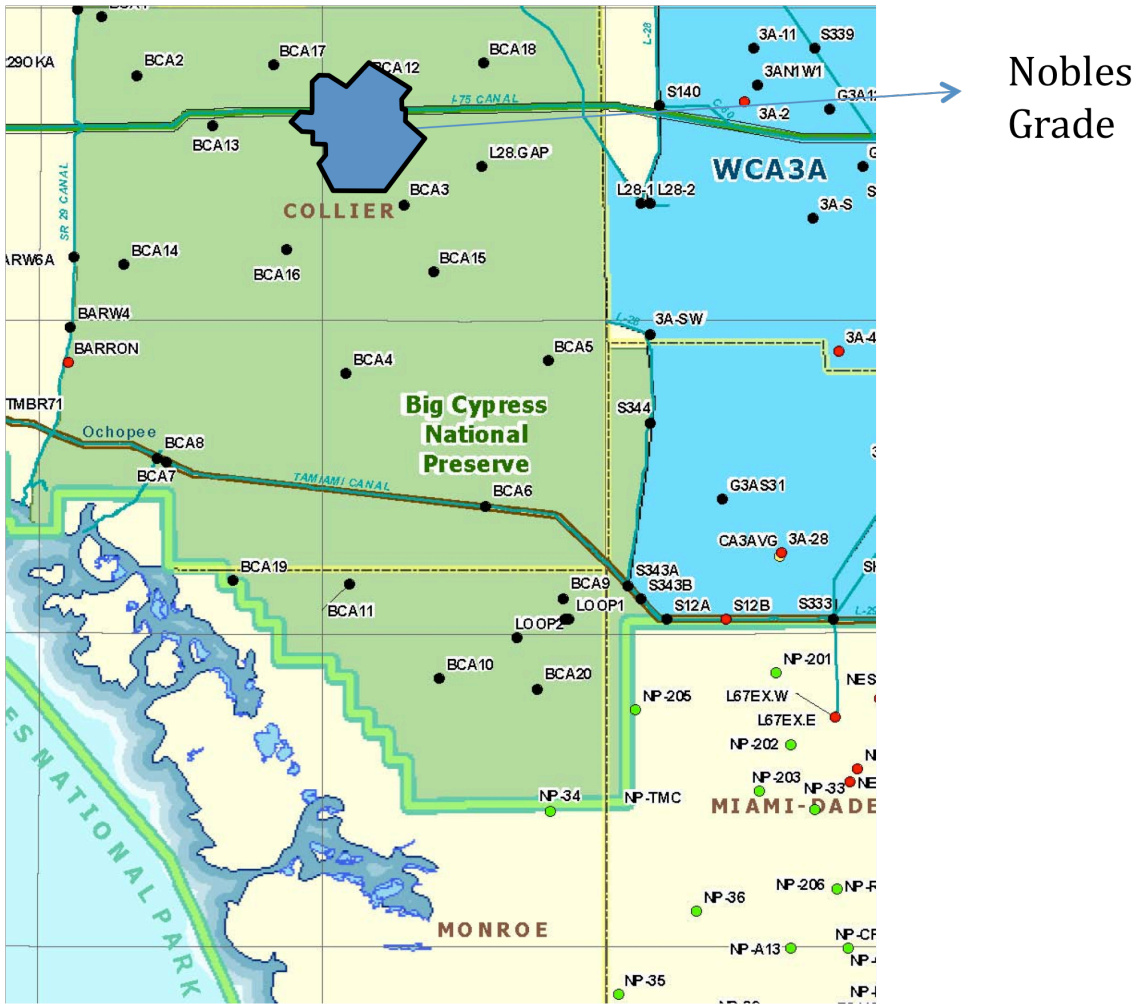


Figure 1.7: Map showing the locations of surface water stage gages within the Big Cypress National Preserve.

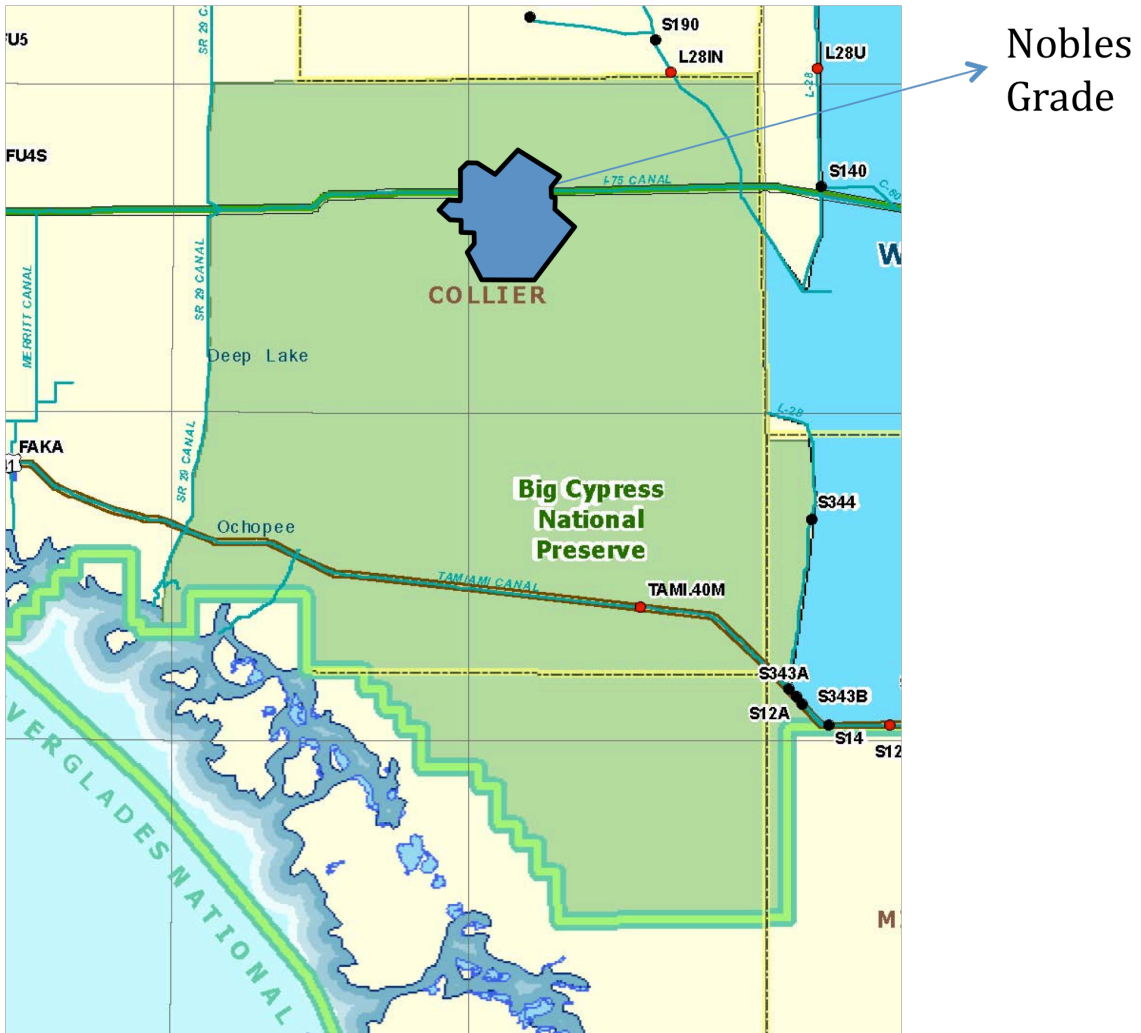


Figure 1.8: Map showing location of flow monitoring gages within the Big Cypress National Preserve.

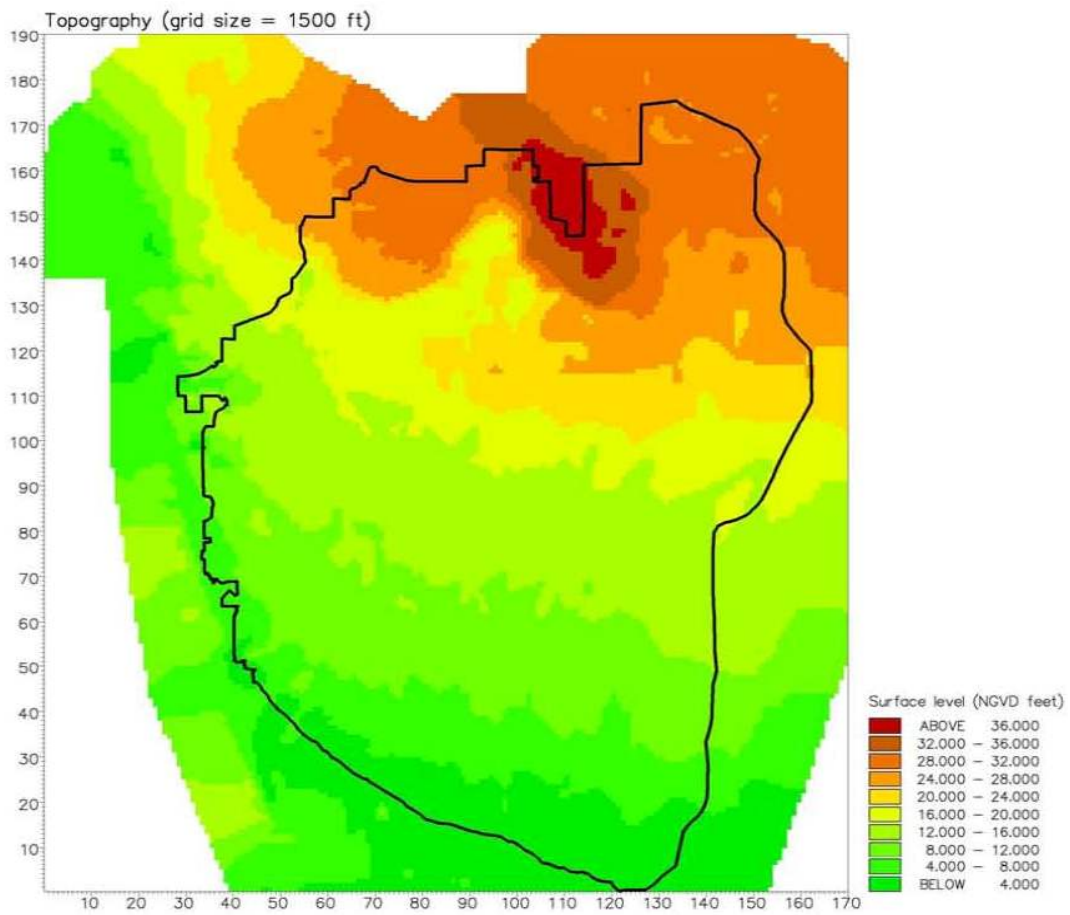


Figure 1.9: Topography contour lines (interpolated) in the Big Cypress Basin watershed. From DHI, 2002.

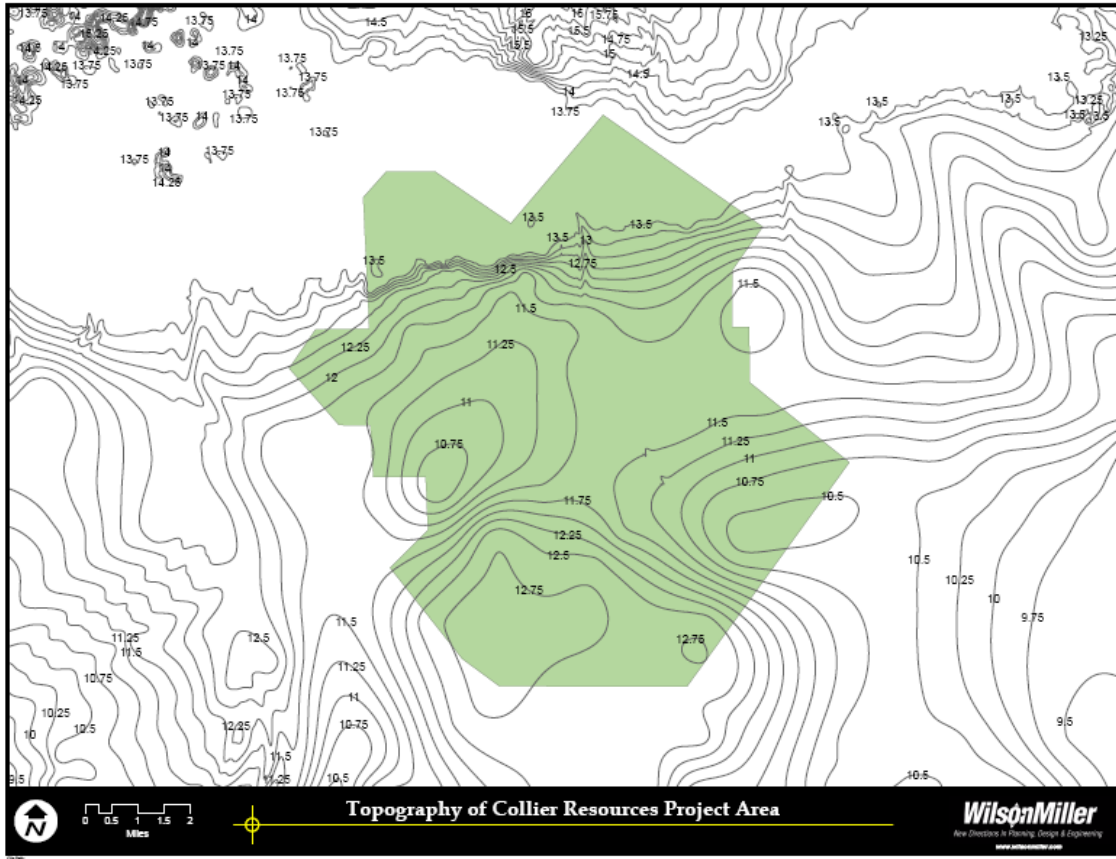


Figure 1.10: Detailed topography contour lines (interpolated) in the Nobles Grade area. Map was made available courtesy of Wilson Miller Consulting.

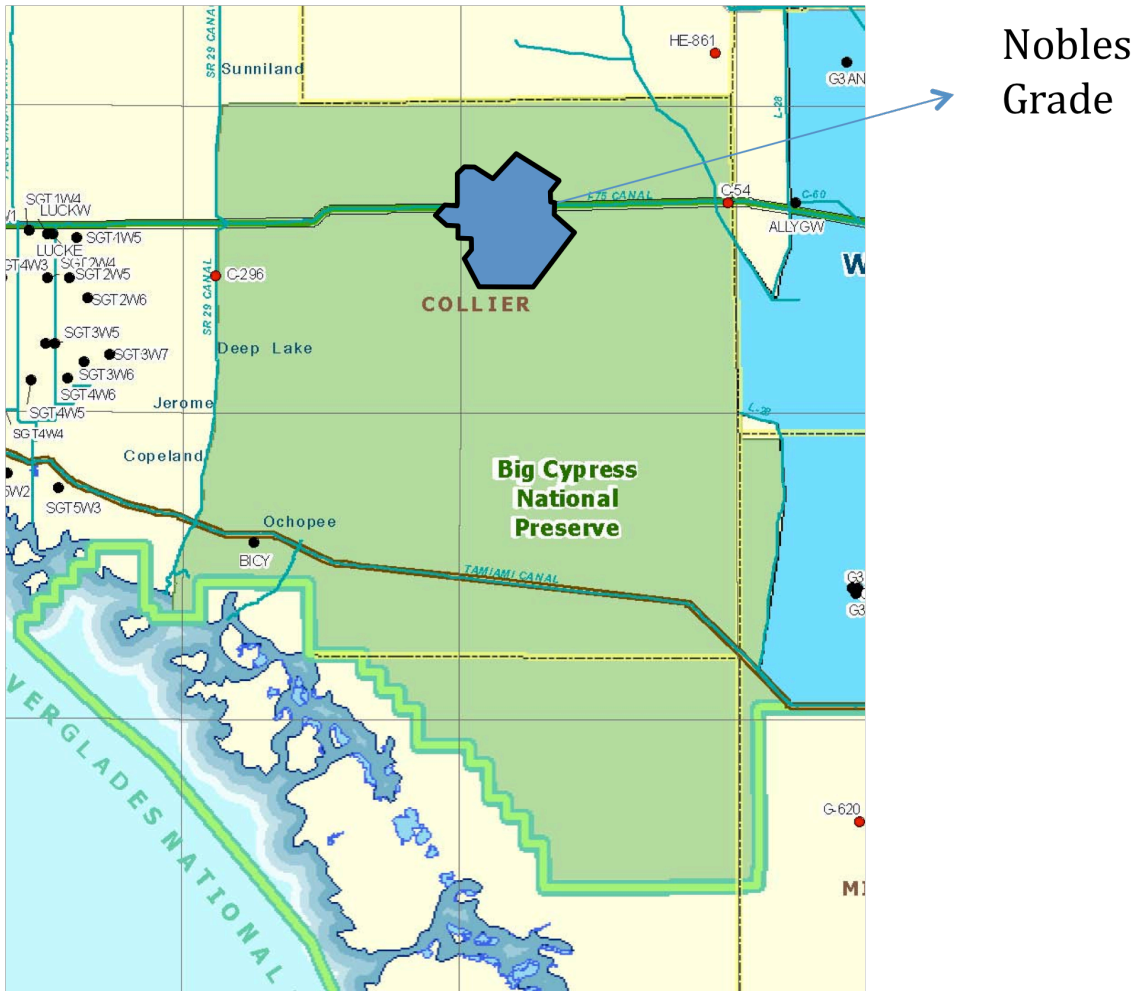


Figure 1.11: Location of groundwater stage monitoring wells within the Big Cypress National Preserve.

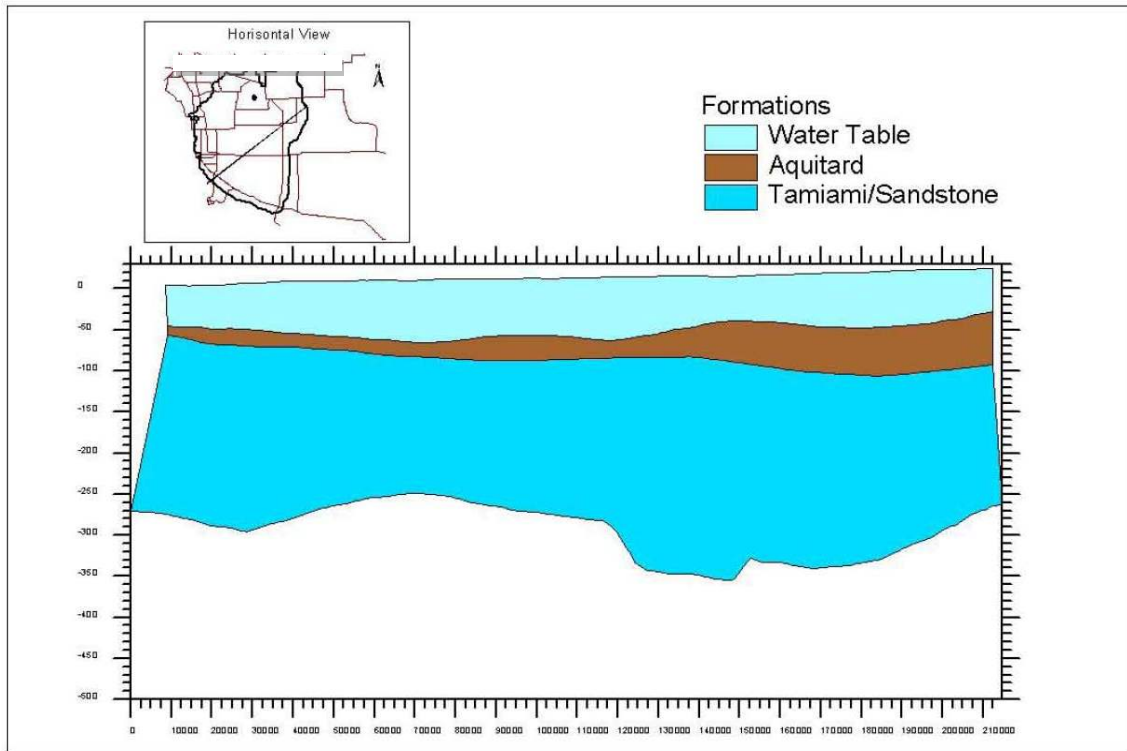


Figure 1.12: Cross section hydrogeologic profile used in MIKE SHE model of the Big Cypress Basin. From DHI, 2002.

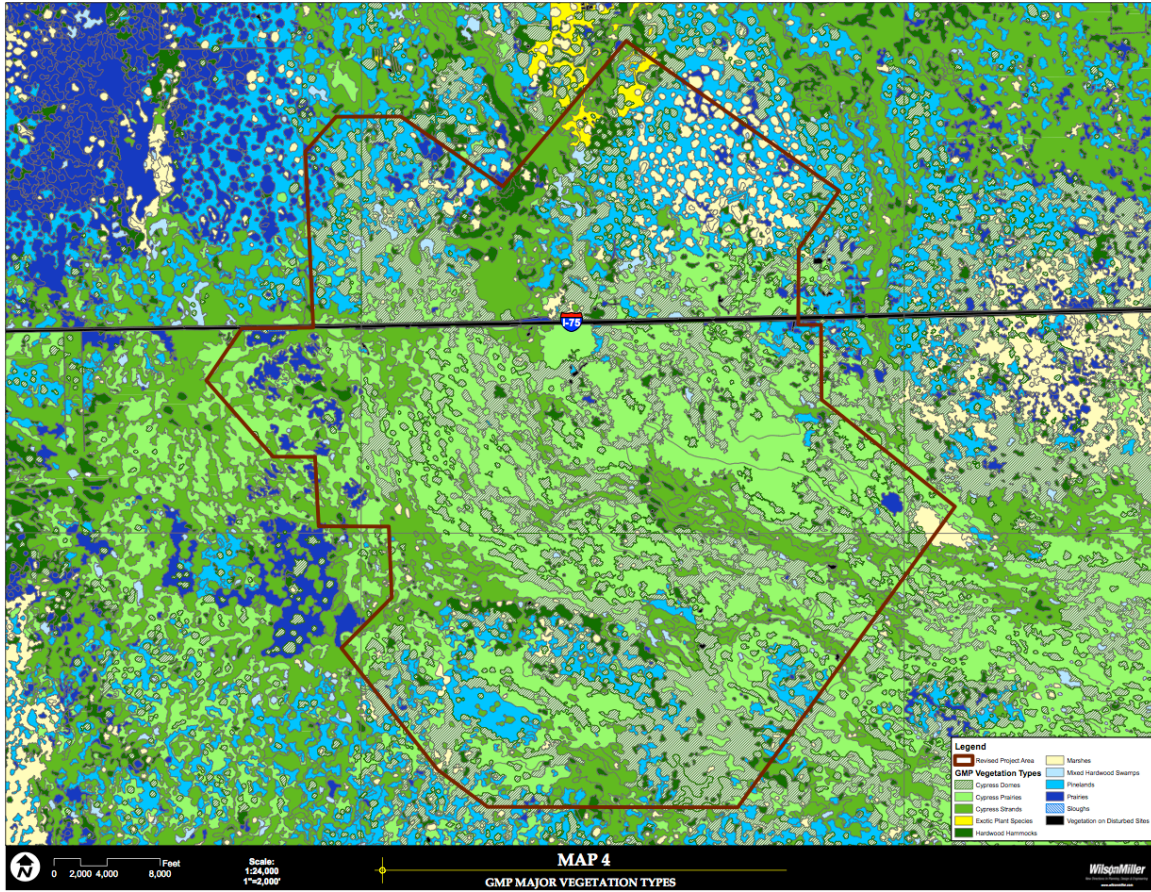


Figure 1.13: Vegetation map with Nobles Grade area indicated. Map courtesy of Wilson Miller Consulting.



Figure 1.14: Habitats within the Nobles Grade area of Big Cypress National Preserve. Photos clockwise from upper left: prairie (by Jennifer Richards), cypress dome (by William Conner), pineland (by Jennifer Richards), cypress swamp (by Andrew Horton).



Figure 1.15: Exotic, invasive plants present in Big Cypress National Preserve. Photos clockwise from upper right: crested floating heart (by Ann Murray, University of Florida/IFAS Center for Aquatic and Invasive Plants. Used with permission.), Brazilian pepper (by Jerome Jackson), old world climbing fern (by Jerome Jackson), melaleuca (by Vic Ramey, University of Florida/IFAS Center for Aquatic and Invasive Plants. Used with permission.)



Figure 1.16: Rare plants of Big Cypress National Preserve. Photos clockwise from top right: ghost orchid (by Jimi Sadle), cowhorn orchid (by Jimi Sadle), hand fern (Jimi Sadle), scarlet ladies tresses (by Jimi Sadle).



Figure 1.17: Protected herpetofauna potentially occurring in the Nobles Grade area of Big Cypress National Preserve. Photos clockwise from the top left: eastern indigo snake (by Deborah Jansen), American alligator (by Kirsten Hines), juvenile gopher tortoise (by Kirsten Hines), adult gopher tortoise (by John Cox).

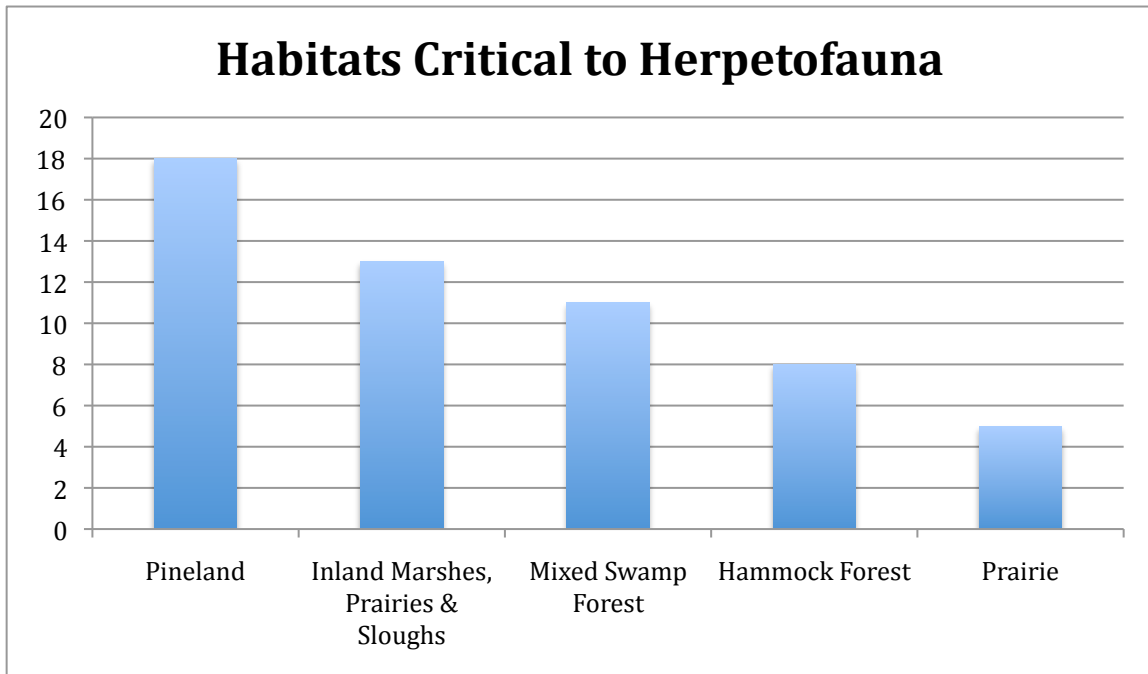


Figure 1.18: Ranking of habitats based on the total numbers of amphibian and reptiles species for which the habitat type is critical to their survival. Bars represent total number of species. Data based on assessments in Duever et al. (1986b).



Figure 1.19: Protected birds potentially in the Nobles Grade area of Big Cypress National Preserve. Photos from left to right: wood storks (by John Cox), red-cockaded woodpecker (by Jerome Jackson).

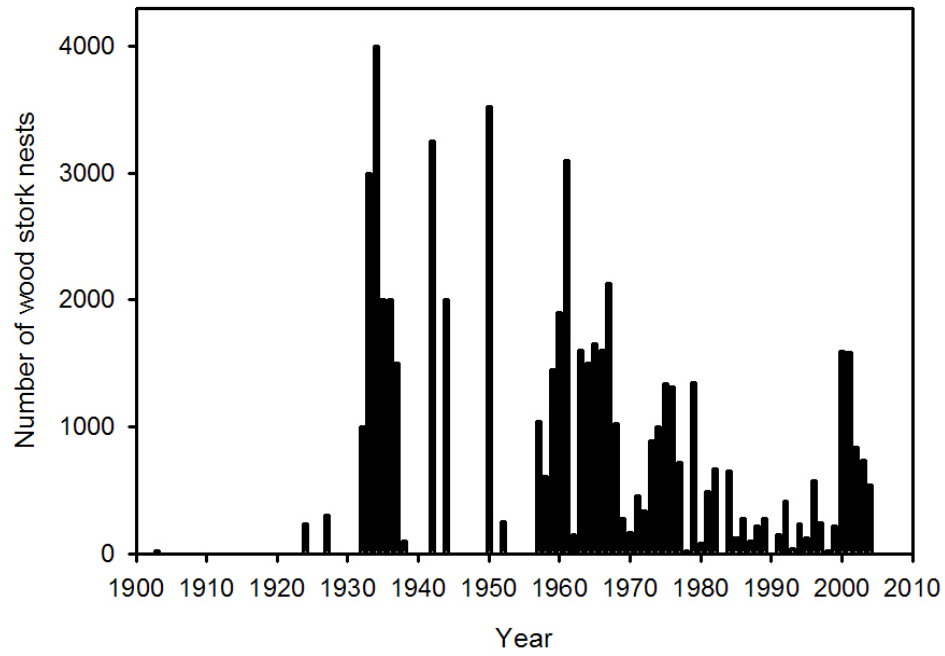


Figure 1.20: Annual counts of wood stork nests in South Florida since 1903. Data source from Crozier and Gawlik (2003) and the South Florida Wading Bird Reports.

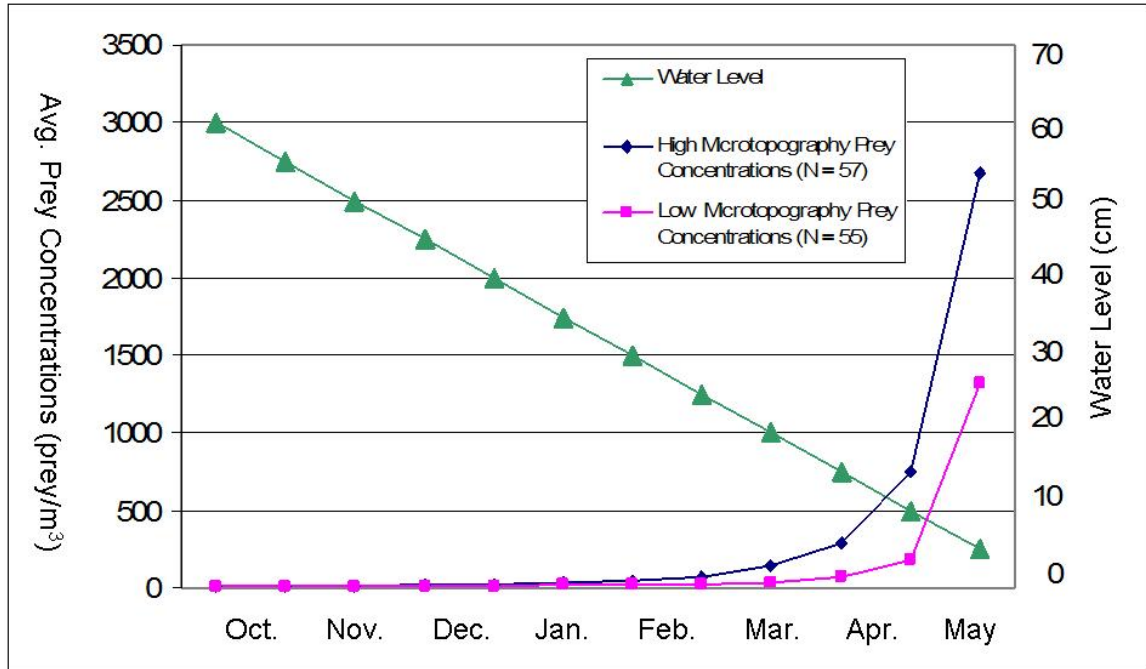


Figure 1.21: Simulated prey concentrations at high and low microtopographic locations in the Everglades as water levels drop from 24 in (60 cm) to 2 in (5 cm) during the dry season. Concentration was solely a function of the physical process of water removal given topographic surfaces measured in the field. Starting prey density was 10 prey/m³. Figure from Garrett (2007).

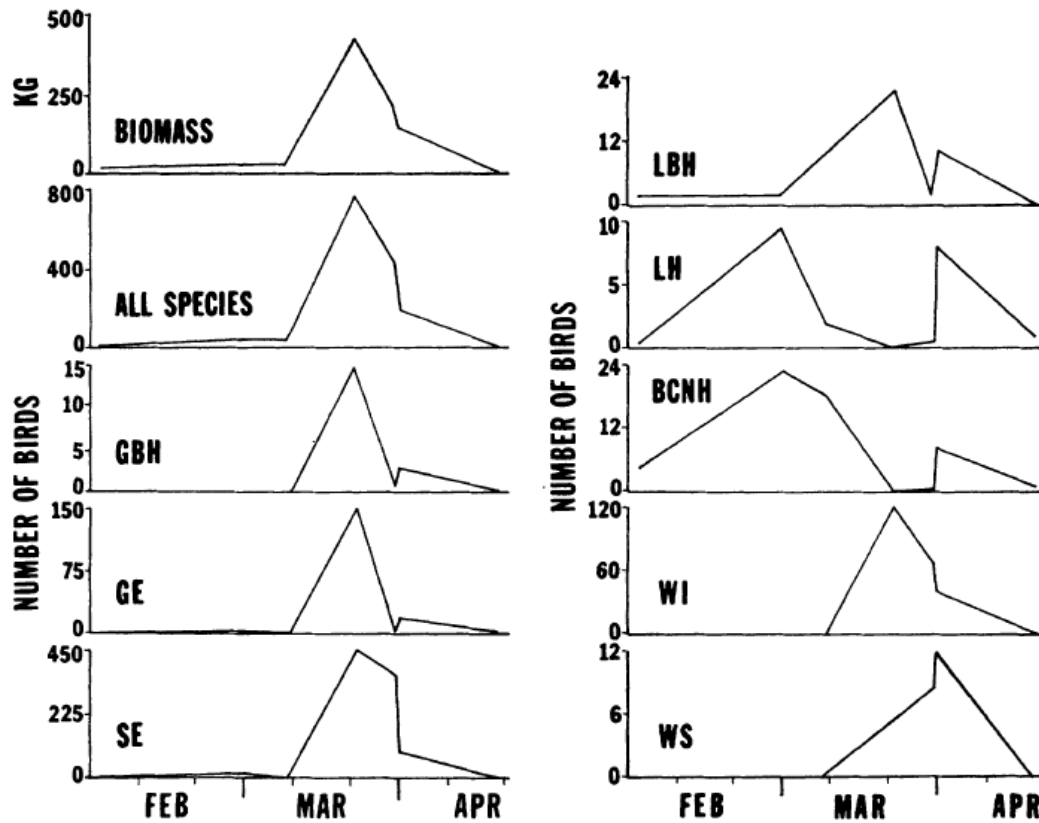


Fig. 4. Changes in number and biomass (live weight) of wading birds feeding in in the pond February–April 1969. Abbreviations are: GBH, Great Blue Heron; GE, Great Egret; SE, Snowy Egret; LBH, Little Blue Heron; LH, Louisiana Heron; BCNH, Black-crowned Night-Heron; WI, White Ibis; WS, Wood Stork.

Figure 1.22: Changes in wading bird abundance and biomass at an alligator pond in Big Cypress National Preserve as the dry season progresses. Reproduced from Kushlan (1976).

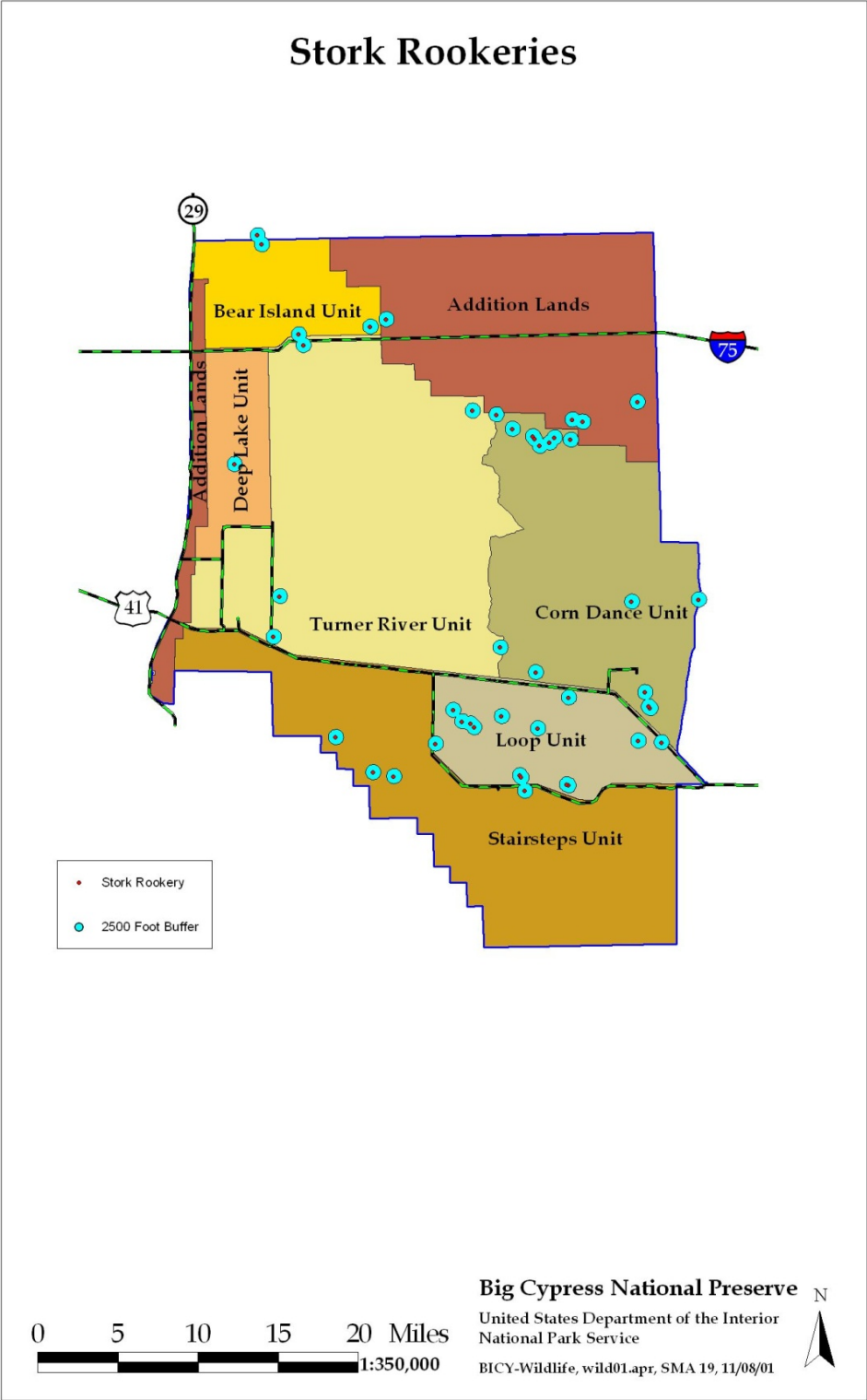


Figure 1.23: The location of wood stork colonies in Big Cypress National Preserve (BCNP) 1996-2001. Map provided by D. Jansen, BCNP.

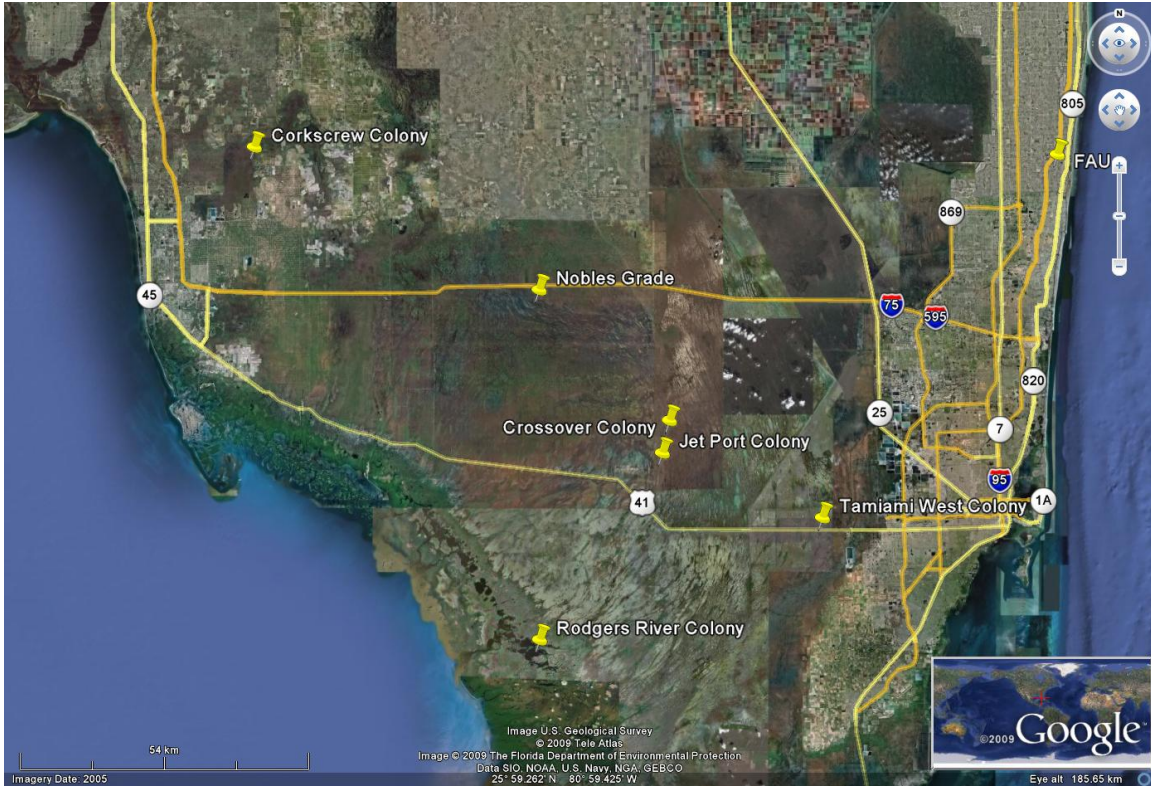


Figure 1.24: The location of major wood stork colonies that are regularly active and within 43.5 mi (70 km) of the center of the Nobles Grade area.

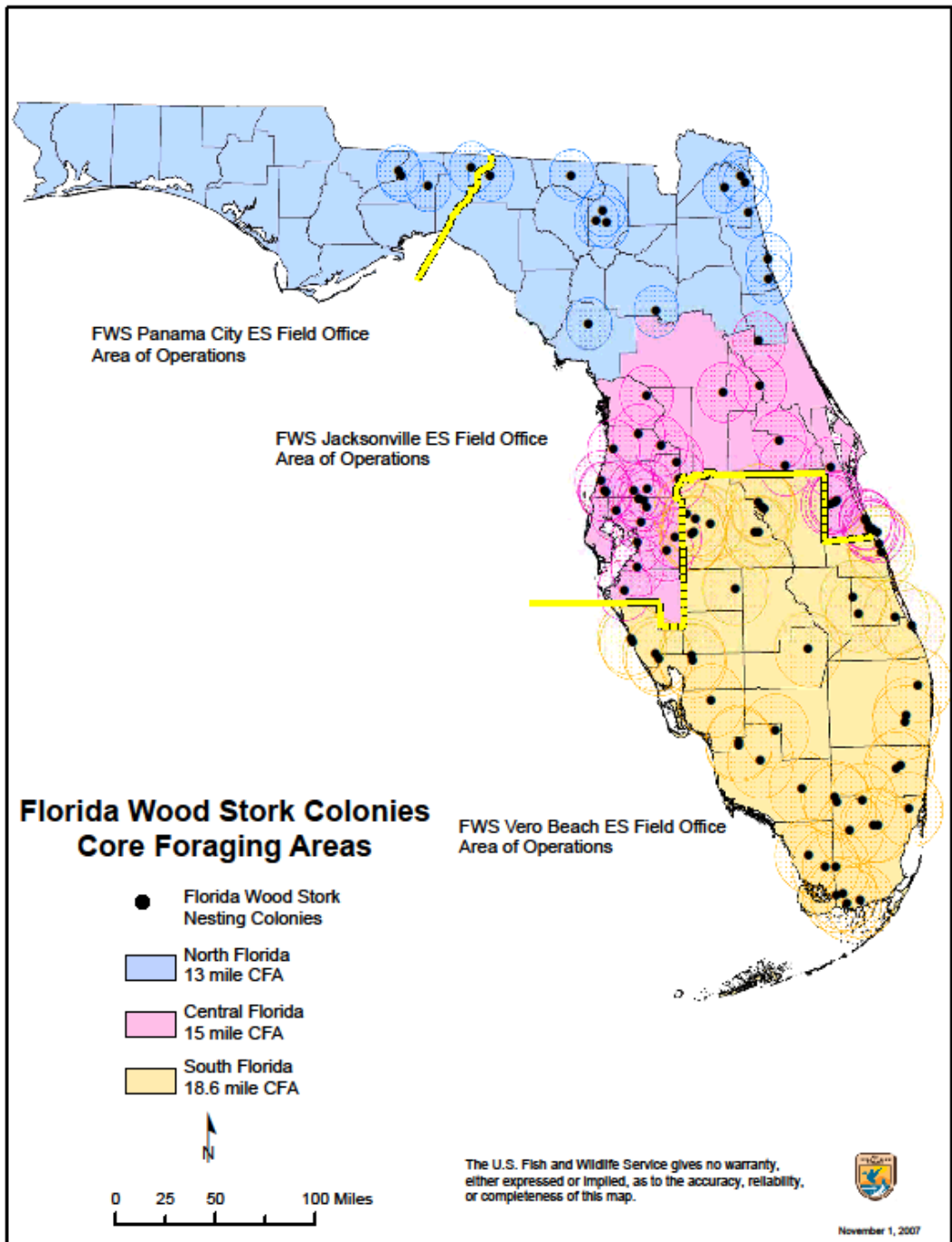


Figure 1.25: Map of Florida showing the location of core wood stork foraging areas as delineated by the U.S. Fish and Wildlife Service (2007).

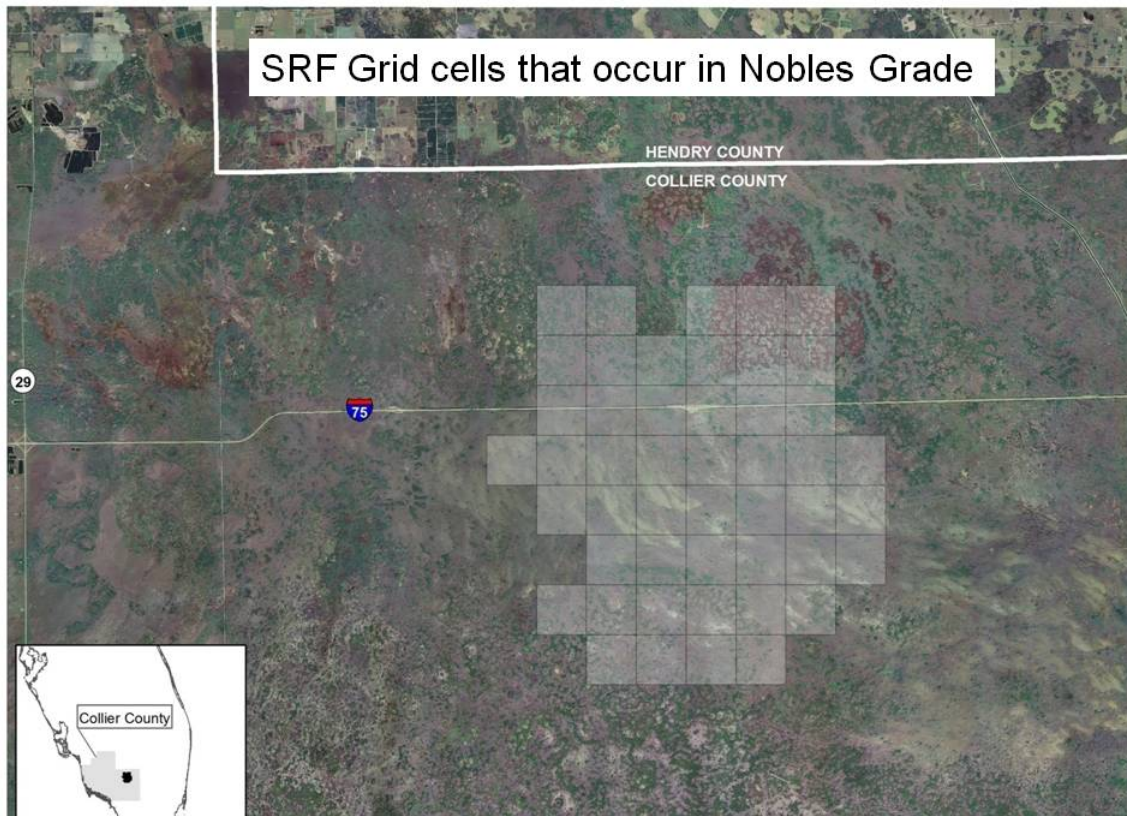


Figure 1.26: Grid cells (1.2 mi x 1.2 mi [2 km x 2 km]) from the aerial Systematic Reconnaissance Flight (SRF) survey that falls within the Nobles Grade Area.

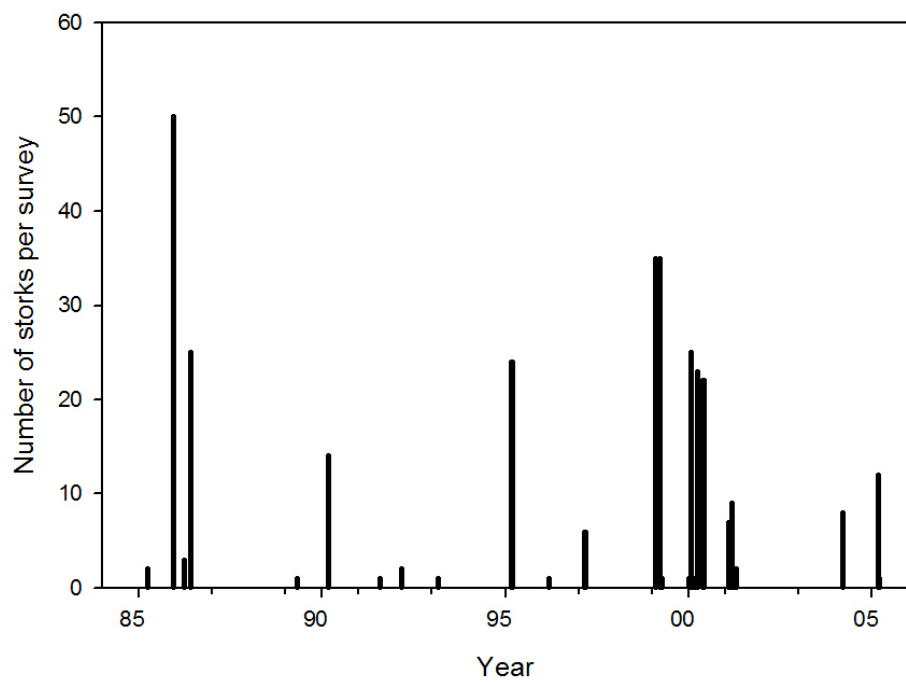


Figure 1.27: Number of wood storks detected in Nobles Grade on each of 81 monthly Systematic Reconnaissance Flight (SRF) surveys 1985-2005.

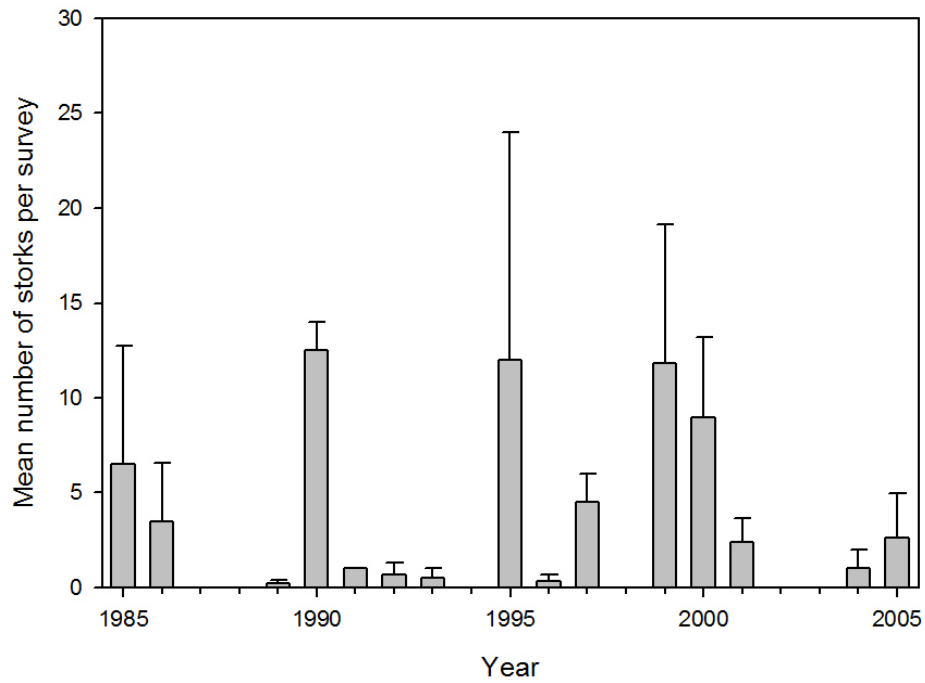


Figure 1.28: Annual mean relative abundance of wood storks detected in the Nobles Grade area during Systematic Reconnaissance Flight (SRF) surveys 1985-2005.

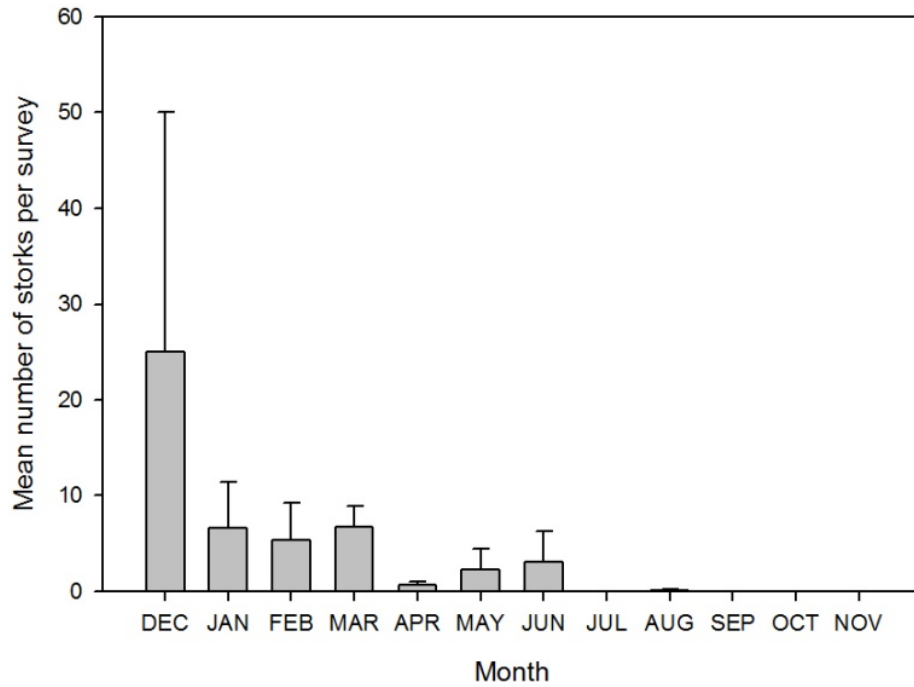


Figure 1.29: Monthly mean relative abundance of wood storks detected in the Nobles Grade area during Systematic Reconnaissance Flight (SRF) surveys 1985-2005.

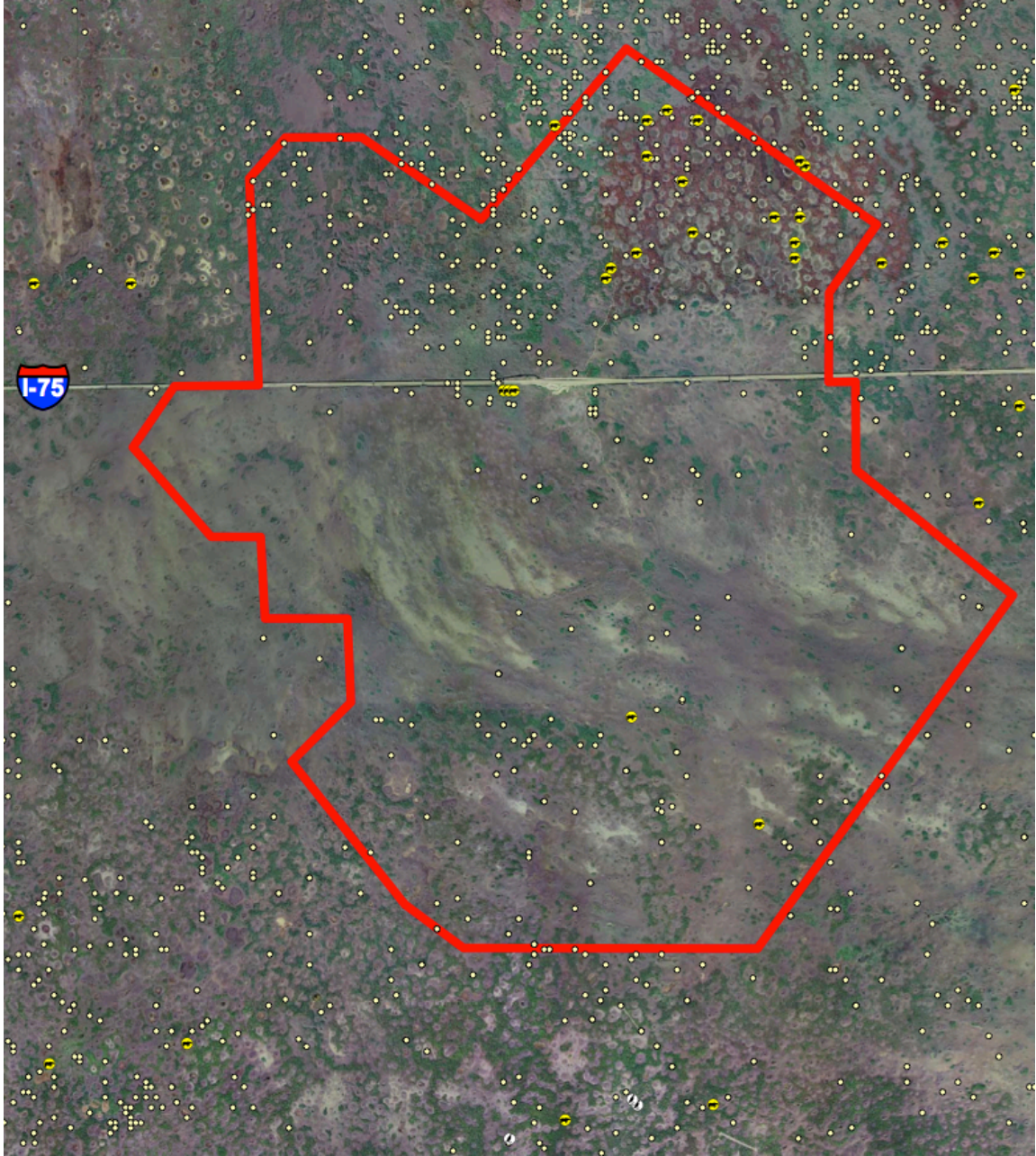


Figure 1.30: Subset of a map showing Nobles Grade area and wildlife sightings or tracking locations for bear (large yellow circles), red-cockaded woodpeckers (large white circles), and panthers (small pale yellow circles). Map was made available courtesy of Wilson Miller Consulting, but may be dated.



Figure 1.31: Threatened and endangered mammals known from Big Cypress National Preserve. Photos clockwise from upper left corner: Florida panther (by John Cox), fox squirrel (by John Cox), black bear (by David Maehr).

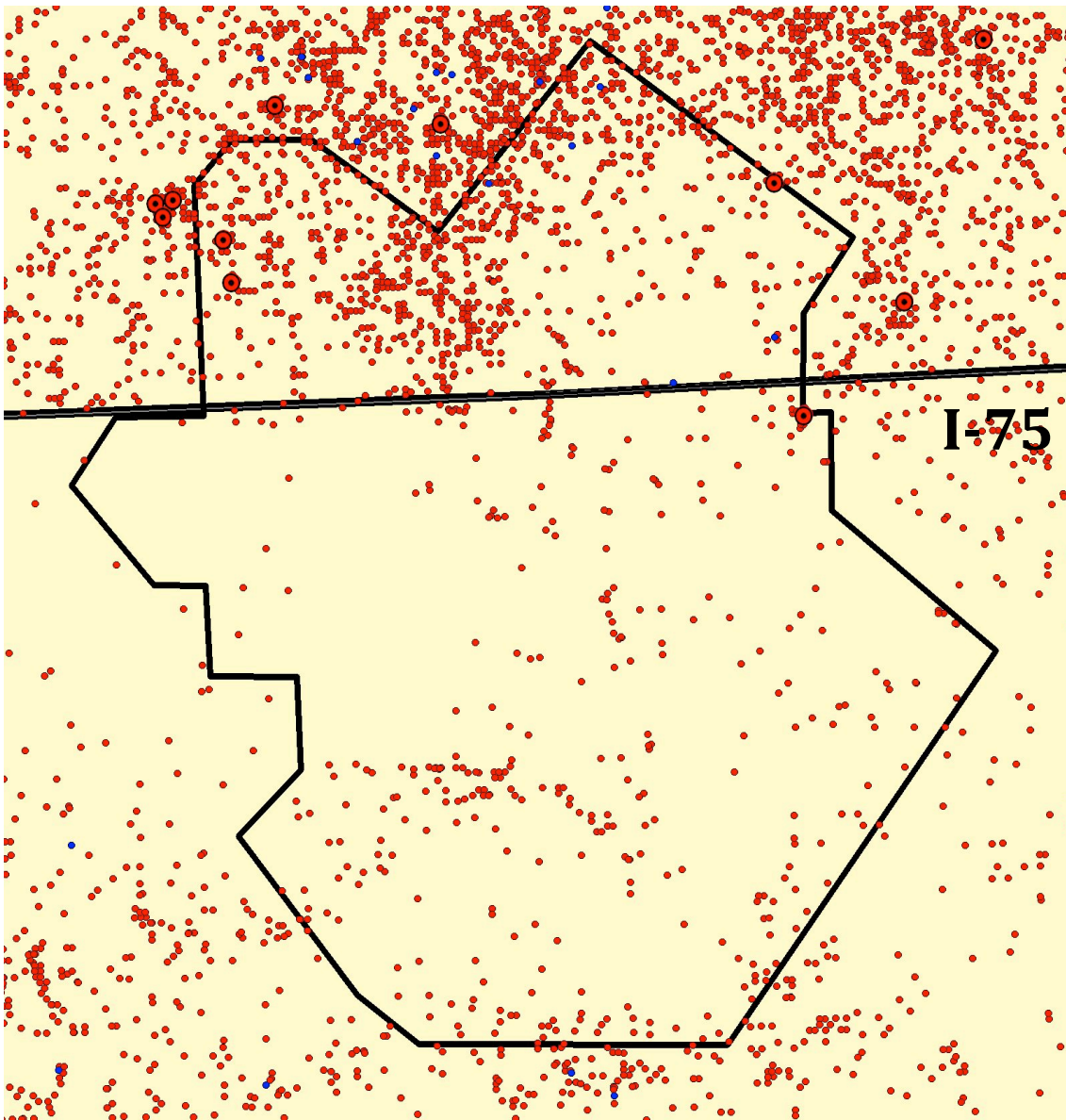


Figure 1.32: Subset of a map showing Nobles Grade area (black boundary) and combined vhf and GPS collar panther telemetry locations (small red circles) and dens (large red bullseyes) from 1981-2009. Panther telemetry locations from 1 Jan 2009 thru 30 June 2009 are represented by small blue circles and are mostly found north of I-75 and just south of the Nobles Grade footprint.

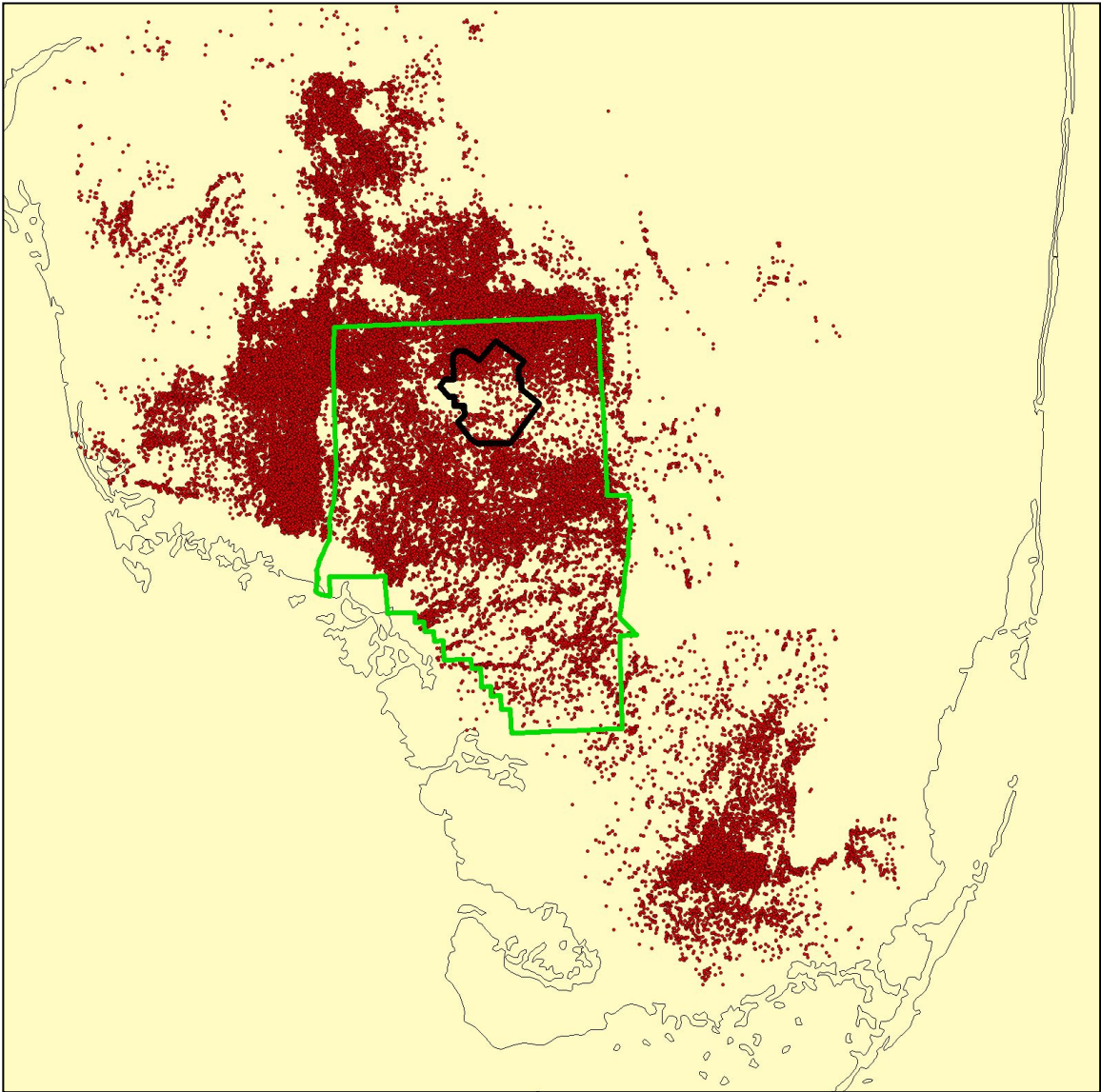


Figure 1.33: Florida panther GPS and vhf telemetry locations in south Florida, 1981-2009, in relation to the Big Cypress National Preserve (green boundary) and the Nobles Grade area (black boundary).

Section 2: The anticipated impacts of proposed 3-D seismic activities in the Nobles Grade area of Big Cypress National Preserve

Despite BCNP's "preserve" status, which requires oversight of multiple uses, resource management should not facilitate private interests at the cost of environmental protection. Private subsurface rights must be recognized, but managers should demand the highest degree of land stewardship from entities pursuing these subsurface interests in order to minimize surface impacts and eventually restore full ecosystem function. Oil and gas activity in BCNP is currently low, but this should not be used as a rationale in support of expansion because these activities are not without consequence.

The impacts associated with today's relatively small-scale operation may increase non-linearly with additional O&G activity and the combined long-term effects may be irreparable—even at levels less than a 10% area of influence. This stipulation, which is in the Preserve's Minerals Management Plan, seems rather arbitrary and lacking in scientific basis. Further, it is not clear how the different area of influence (AOI) radii provided in Figure 9.4 of the *3-D Seismic Plan of Operations* (CRC 2006) were determined. These also seem arbitrary and suggest an additive influence of structures and activities on the wetland ecosystem across BCNP. Studies from Alaska's oil-rich north slope suggest that the zone (i.e., area) of influence for each structure and activity should be quantified and, oftentimes, are considerably greater than speculated (NRC 2003). The area of influence (AOI) should be considered at the exploratory phase because permits granted for 3-D seismic surveying in the NGA will likely open the door for further development in BCNP—expanding the current, yet not entirely quantified, AOI.

This section outlines the impacts of 3-D seismic surveys, but the more significant impacts associated with long-term development (discussed generally in the last section of this report) should be considered beyond the scope of this effort. The impacts of any expansion of O&G activities will accrue in conjunction with activities that are already underway at Raccoon Point so quantification of areas or zones of influence should be made as soon as possible. The intent here is not to dictate whether further O&G activities should be permitted, but rather ensure that such critical information is in place prior to considering any future O&G permits.

2.1 Summary of Nobles Grade 3-D Seismic Plan

The purpose of this section is to evaluate the activities associated with 3-D seismic O&G surveying in the NGA of BCNP in terms of potential impacts on different components of the ecosystem. This section provides both quantitative and qualitative guidance on the degree of severity of discussed impacts, as well as the likelihood that such an impact will arise. In instances where impacts are likely to arise, alternatives (if feasible) are provided to reduce impacts to a more negligible

level if followed. The analysis provided in this section of our document rests on the assumption that activities will proceed as described in CRC's *Plan of Operations* (CRC 2006). The details of construction and operation are summarized below (**Section 2.1**) and would (assuming their schedule can be adhered to) take place over a 22-week period coinciding with one dry season. In a few instances in **Section 2.1**, direct comment pertaining to planned activities is provided.

2.1.1 Staging Areas

Field operations for the 3-D seismic program will be staged from three areas. The primary staging facility will be located outside the BCNP and Addition Lands boundaries on Miccosukee Tribal lands at the intersection of Snake Road and I-75. Two secondary field-staging areas, designated as 63 South and 63 North, will be located in the BCNP-A approximately 250 ft (76 m) south and approximately 1,650 ft (503 m) north of the Mile Marker 63 (MM-63) Rest Area on I-75. Staging areas on both sides of I-75 are required to comply with FAA regulations prohibiting helicopters with slings and long-line loads from flying over I-75. Staging area 63 South will support logistical requirements of field operations south of I-75 and 63 North will support the logistical requirements of field operations north of I-75. Staging area 63 South will serve as "field headquarters" for program operations and will be located adjacent to and south of the I-75 right of way fence.

2.1.1.1 63 South (south of rest area at mile marker 63 on I-75)

This site was selected due to its location near the rest area, which provides access and has some existing level of disturbance. 63 South has a previously existing swamp buggy trail that can be used for access. This staging area will be located entirely on uplands and will occupy an area 200 ft (61 m) x 250 ft (71 m) in size. Construction of 63 South will involve the removal of existing debris and exotic vegetation and grading, as necessary. Wooden mats will be used to minimize impacts to soils and seed bank. A 40 mil high-density polyethylene (HDPE) liner will be placed beneath the wooden mats under the fuel storage and transfer portions of the staging area. Upon completion of the seismic survey, the wooden mats and HDPE liner will be removed and the area will be disked or re-graded as necessary.

The 63 South staging area will serve as the "field headquarters". Specific components of this staging area will include two helicopter landing zones for fueling, which will be underlain by 40 mil HPDE liner. At this site, there will be two truck-mounted, 2,000 gal (7.6 m³) fuel tanks with containment systems for diesel and Jet A fuels; one truck-mounted, 300 gal (1.14 m³) gasoline tank with containment system; and one 5,000 gal (18.9 m³) water tank. The two 2,000 gal (7.6 m³) mobile fuel tanks will also be used at the 63 North staging area as needed. Furthermore, 63 South will have two 8 ft (2.4 m) x 30 ft (9 m) storage containers, one 10 ft (3 m) x 30 ft (9 m) office trailer; one off-road fork lift; and one 20kw diesel generator. Two explosives trailers will only be onsite during daytime. One 4 in (10 cm), 20 gal per minute (gpm) water well will be onsite, and the water will be used in

the placement of charges. One 60 ft (18 m) radio tower will be used for communication. Self-contained restrooms with holding tanks will be provided at the staging area, and the waste will be pumped from the holding tanks and hauled to an approved disposal facility. Trash dumpster(s) will be placed at the site to accommodate solid waste generated during operations. **Comment: All dumpsters should be wildlife-proof.**

2.1.1.2 63 North (north of the rest area at mile marker 63 on I-75)

This site was selected due to its location near the rest area with access and existing disturbance. This site has an existing crushed limerock road connecting the I-75 feeder road to a trail that extends to the staging-area site, which is an old well pad. The construction of the staging area will entail grading and clearing along the access road and staging areas, which will be 200 ft (61 m) x 250 ft (76 m) in size. The 63 North staging site will accommodate one helicopter landing area underlain with a 40 mil HPDE liner; two truck-mounted, 2,000 gal (7.6 m³) fuel tanks with containment systems for diesel and Jet A that will be deployed from 63 South staging site as needed; one truck-mounted, 300 gal (1.14 m³) gasoline tank with a containment system; and one 5,000 gal (18.9 m³) water tank.

Similar to 63 South, there will be one 10 ft (3 m) x 30 ft (9 m) office trailer, one off-road fork lift, one 20 kw diesel generator, and one 4 in (10 cm), 20 gpm water well for use in the placement of charges. The site will also accommodate two explosives trailers, which will only be onsite during daytime. These trailers will be mobile units from the 63 South staging site and will be used as needed. Self-contained restrooms with holding tanks will be located at this site. The tanks will be pumped and wastes will be hauled to an approved disposal facility. Trash dumpster(s) will be at the site to accommodate solid waste generated during operations. **Comment: All dumpsters should be wildlife-proof.**

2.1.2 Access Management Team

The Access Management Team will prepare a field assessment for each survey area to identify any archaeologically or environmentally sensitive areas (i.e., “no-permit” areas and potential field hazards not identified in their operation plan). They will also conduct daily field scouting and ground-truthing ahead of work crews.

2.1.3 Fuel Storage, Transfer, and Re-fueling

Two truck-mounted 2,000 gal (7.6 m³) fuel tanks will move back and forth between 63 South and 63 North as needed. Each truck will have a 125% spill containment system onboard. At the staging sites, trucks will be parked on board mats underlain by 40 mil HPDE liner. Contact stormwater will be removed from the spill containment system and disposed of pursuant to the BCNP General Management Plan (GMP). In all cases, drip pans or impervious ground tarps will be used to

prevent spilled fuel from contaminating the limerock. Furthermore, all vehicles and field equipment will have absorption pads and fire safety equipment.

2.1.3.1 Helicopter re-fueling

Helicopters are required to refuel each 1.5 hours of operation; therefore, each helicopter will likely refuel 2-3 times daily. Refueling will occur over the HPDE-lined area at the staging sites. Overnight storage and maintenance of helicopters will occur at the Snake Road staging area.

2.1.3.2 Sonic rig re-fueling

CRC anticipates each sonic rig will be refueled once per day in the field. The sonic rigs will be refueled with 10 gal (38 L) or 20 gal (76 L) Type II Safety Cans for diesel fuels, which will be transported by helicopters to designated landing zones. Field refueling will be conducted over portable HPDE liners to contain spills and prevent soil contamination. Track mounted sonic rigs are equipped with a drip pan and each rig carries fuel spill cleanup and fire equipment. Sonic rigs transported by helicopters will use a portable HPDE liner in place of a drip pan.

2.1.3.3 Vehicle/ORV re-fueling

Gasoline-powered, non-field vehicles will be refueled at the staging areas. When possible, ORVs and field vehicles will also be refueled at the staging area. When in the field, ORVs and vehicles will be refueled from 5 gal (19 L) Type II Safety Cans. ORVs will carry a small HDPE liner and adsorption pads for use during any refueling that may occur in the field.

2.1.4 Crew Mobilization

With the exception of ORVs, all mobilized equipment will remain in the field until the work is complete. Field crews will report to the Snake Road staging area each morning at 6 AM. From the staging area, crews will be deployed to either 63 North or 63 South via helicopter, ORV, or on foot. Generally, crews will be in the field each day from 7:30 AM until a half hour before sunset. Bottled water and packaged food will be provided to the field crew each day at the staging areas; however, no food preparation of any kind will occur at the staging areas or anywhere else within BCNP or BCNP-A. Trash bags and receptacles will be provided to field crews for trash and debris disposal. The collected trash and debris will be hauled out at the end of each day.

2.1.5 Survey and Layout Equipment Mobilization

One helicopter and up to five ORVs, one per crew, will be used daily for crew deployment and support. Pin flags, bamboo laths, and flagging will be used to mark shot and receiver locations, and these will be removed during cleanup. Where

necessary, crews will trim vegetation to obtain a 36 in (90 cm) wide line-of-site path. Based upon GIS evaluations, CRC anticipates cutting and/or trimming up to 7 acres (2.8 ha). CRC will consult with and obtain NPS approval prior to all cutting and trimming, which will be conducted pursuant to BCNP GMP stipulation #16. All cuttings and trimmings will be cast to the side of the trail and left.

It is anticipated that some trails north of I-75 will be blocked by downed trees and other debris related to Hurricane Wilma. Special crews will be deployed to remove this debris. The *Plan of Operations* states that CRC will use methods similar to those used by the NPS and that all work will be done pursuant to the BCNP GMP and/or under the guidance of the NPS Superintendent.

Comment: All vegetation cuttings should be hauled off site. Extra attention should be given to exotic species, which can often spread rapidly in slightly disturbed areas. Clippings from these plants should be bagged and hauled offsite daily. Snags and trees that have been felled by natural causes should be left on site to retain nutrients, microhabitat, and potential seed sources.

2.1.6 Energy Source Placement

The staging area north of I-75 will be completed first and then the operation will move south of I-75. Six tracked rigs will be used for the operation. Each tracked rig is 16 ft (4.9 m) wide and exerts a ground pressure of approximately 3 PSI. The rigs will remain on an existing trail 90% of time. They will be trucked to staging areas and then will move under their own power to each site of energy source placement. Two portable rigs will be used at the remaining 10% of the sites, and they will be moved using one helicopter. CRC anticipates the heli-portable rigs will compress 38 ft² (3.5 m²) of vegetation at each site.

2.1.7 Seismic Data Acquisition Equipment

The equipment for seismic data acquisition (i.e., geophones, receivers, lines, etc.) will be air lifted from 63 North and 63 South to designated drop points that will be pre-approved by NPS. The equipment will be transported from the drop points to the installation sites by ORVs and/or hand-carried. Nine ORVs will be required for transportation of the equipment. Six crews will acquire seismic data, and with 30-40 shots/day/crew, it is anticipated there will be 180-240 energy source detonations per day.

2.1.8 Cleanup, Restoration and Avoidance Procedures

Cleanup and restoration operations will proceed concurrently with ongoing data acquisition. In their *Plan of Operations*, CRC acknowledges that, on occasion, soil damage may occur at sites. These areas will be noted by the oil exploration crews, and clean-up crews will be sent back to these sites to repair and level the soil with

rakes and shovels. All flagging, laths, pin flags, and other trash will be collected and hauled out for disposal. Helicopters will deploy crews and haul out trash.

CRC will have 18 to 20 personnel onsite with backgrounds in biology, forestry, geology, environmental engineering, and archaeology. An unknown number of NPS and USGS inspectors/observers will be onsite for weekly inspection and coordination meetings.

Reclamation operations will be carried out within 30 days of the completion of field operations. A performance bond in the amount of \$150,000 will be posted with the NPS to cover any reclamation that is not performed by CRC.

Comment: Panelists felt the bond amount was extremely low relative to the potential damage to environmental resources caused by survey activities. It is not clear how the number was calculated relative to the 3-D seismic activities proposed or the potential damage to the area of BCNP to be surveyed.

2.1.8.1 General mitigation measures

CRC will use existing trails and disturbed areas for all aspects of the project to minimize soil, vegetation and wildlife impacts. The sonic rigs to be used in the 3-D seismic survey are designed for low surface impacts. Seismic energy source placement is designed to use a “one pass” system to the extent practical. State of the art technology will be used for project planning and layout in order to facilitate maximum use of existing trails and disturbed areas and to minimize vegetation cutting. Furthermore, receiver technology and software will acquire and interpret the seismic data, thus getting the maximum value for the effort. This reduces the need for drilling exploratory wells during the production phase. Operations will be conducted in the dry season to minimize soil and surface water impacts. Cleanup and restoration activities will occur concurrently with other phases of the operation to minimize the total project time.

2.1.8.2 Florida panther avoidance

Work proposed for the dry season will avoid some of the period of Florida panther denning and birthing, which occurs from March through July. CRC will coordinate field operations with continuing panther tracking programs to avoid denning activities where necessary. Data acquisition recording schedules will be adjusted pursuant to daily input from agency personnel to avoid denning impacts as the denning activity is established in real time. Field crews will be provided with educational materials and panther observation reporting protocols before work begins.

2.1.8.3 Red-cockaded woodpecker avoidance

According to 2006 NPS and FWC data, there are no records of red-cockaded woodpecker cavity tree clusters within 1.5 mi (2.4 km) of the project area. No occurrences of red-cockaded woodpecker within the project area were reported in the FNAI standard data report from January 2006.

Comment: In addition to a comprehensive survey of the area prior to any permitted activities, the panel recommends that an individual in each crew be able to identify RCWs (via sight or call) or RCW cavity trees so that protocols recommended below can be followed. If neither is mandated, some attempt should be made to identify potential RCW habitat within the NGA through a combined remote-sensing/ground-truthed approach.

2.1.8.4 Archaeological, historical, cultural site avoidance

A qualified archaeologist must accompany the field layout crews to insure that archaeological, historical and cultural sites are avoided.

2.1.9 Contingency Actions

2.1.9.1 Staging area fuel leaks/spills

Any leaking tank will be immediately taken out of service, isolated, and observed for containment leaks. Class B fire extinguishing equipment, absorbent pads, and cleanup hand tools will be moved into position near the vehicles for use if necessary. However, there is no information provided on training for fire awareness or use of extinguishers in the field. Absorbent pads will be applied to the inside of the containment system to prevent leakage of any remnant fuel and the leaking vehicle will be removed to the Snake Road staging facility. A vacuum truck will drain the tank and containment system and the fuel will be removed from the staging area to an appropriate recycling or disposal facility. Any fuel inadvertently dripped or spilled onto the HDPE liner will be collected by adsorbent pads, rakes, and shovels, and bagged and removed to a licensed disposal facility. Cleanup operations will be conducted and completed to the satisfaction of the BCNP Superintendent.

2.1.9.2 Field location fuel leaks/spills

If fuel leaks or spills occur at a field location, the drip pan, HDPE liner or both will be cleaned using absorbent pads available on each vehicle. Vegetation contaminated by fuel remnants dripping off the HDPE liner will be cleaned or removed. Any absorbent pads or HDPE liner will be bagged and removed to a licensed disposal facility. Cleanup operations will be conducted and completed to the satisfaction of the Superintendent.

2.1.9.3 Explosives

Blasting agents are not susceptible to detonation by fire, impacts or high-velocity bullet hits. In the event that fire threatens source charges, then all equipment and mobile magazines will be removed from the area if it can be done safely; all personnel will be evacuated; and the appropriate authorities will be notified. There is no mention as to how unexploded ordnance will be treated in the field.

2.2 Placing 3-D Seismic Activities in an Ecological Context

2.2.1 Ecosystem Timeline

Realizing that this document and the process leading up to it was science-based and that the ultimate decision regarding permitting of these activities lies with the NPS and Department of Interior, we refrained from including personal opinions about O&G and professional agendas to the extent possible. We used this general approach and details of the *3-D Seismic Plan of Operations* to develop our summary of impacts to the NGA and the greater BCNP ecosystem. As a first step, the panel developed an “ecosystem timeline” that tracks ecological and biological processes along with the roughly 22-week activity timeline in the *Plan of Operations* (see **Figure 2.1**). This allows for a simple, visual comparison of the degree of overlap between the activities described above and biological/ecological processes considered by the panel. Recognizing that there is variability from year-to-year, each of the components considered by the panel is represented on a generic or average annual timeline.

As mentioned above, the 3-D seismic survey, if permitted, would be executed over a 22-week period from November through May, a period that, in most years, coincides with the transition from the wet season to the dry season—ultimately leading up to the driest time of the year (**Figure 2.1**). Ideally, there would be no standing water and soils would be dried and hardened so that soil rutting and water quality degradation would be minimized. However, it is likely that soils would still be saturated or even inundated in some areas at the outset—even in a “normal” year. Given the logistical rationale and ecological importance (described later in this section) for conducting this survey during a dry part of year, consideration should be given to regional and global climatic cycles when planning this proposed 3-D seismic survey. Particular attention should be given to the potential for late season hurricanes and El Niño—either of which can result in dry seasons that are wetter than normal.

Staging and surveying would commence first and take place throughout November, with surveying activities likely continuing through January. The installation of charges would take place during much of this time, spilling over into February. This would be immediately followed by detonation and equipment removal through April. All the while, cleanup and restoration of damaged areas would be taking place throughout—possibly into May (**Figure 2.1**).

The timeline in **Figure 2.1** identifies how each of the major biological and physical components would overlay with this 3-D survey schedule. It also shows the interconnection of wetlands hydrology and faunal use of areas within Big Cypress. As can be easily inferred from this diagram, much of the faunal activity for the organisms and groups considered seems to also take place in the drier periods of the year—except for alligator nesting and Big Cypress fox squirrel denning (**Figure 2.1**). Even important vegetative components such as baldcypress/pondcypress growth and seed germination are associated with this period of proposed activity. Because of these overlaps, it was particularly important for the panel to establish a system for evaluating impacts of 3-D seismic activities on all aspects of the Big Cypress ecosystem.

2.2.2 Impact Example

The conceptual framework for evaluating disturbance from each of the 3-D survey activities is to consider the impacts of direct disturbance on the various ecosystem components as well as indirect impacts through modifications of another component or habitat. As an example for wading birds, direct disturbances could come from helicopters, trucks and heavy equipment, human presence, and blast noise and blast shock. The direct impacts of these activities could be experienced by wading bird foraging flocks and nesting colonies. If the impacts were strong enough they could lead to lower food intake by adult wading birds from disturbed foraging flocks, reduced survival of young wading birds from disturbed nesting colonies, and reduced food intake by adult wading birds from altered prey species habitat use, vulnerability to capture, and considerable human-induced expenditure of energy by all of the birds.

Using this same example, indirect impacts on the habitat include physical disturbance of vegetation, soil, and surface water, and increased mortality of aquatic prey animals. These impacts could lead to a reduced prey density or a lower vulnerability of prey to being captured, collectively reduced prey availability, which could lead to lowered prey intake and ultimately reduced fitness of both adult and young wading birds.

Sections 2.4 to 2.9 discuss various direct and indirect impacts for a variety of ecosystem components following the conceptual framework presented above for a wading bird example and as they relate to specific 3-D seismic survey activities as presented in the *Plan of Operations* (CRC 2006). In some cases, alternatives to minimize impacts are provided and recommendations for monitoring and mitigation are given when considered appropriate. These impacts along with alternatives are presented according to ecosystem components in **Table 2.1** through **Table 2.6**.

It should be noted that the organization scheme for communicating impacts in this report is different for each of the BCNP ecosystem components considered. In some cases, impacts were considered according to specific activities described in the *Plan*

of Operations for Nobles Grade (e.g., initial survey, energy source placement, etc.). In others, impacts were considered relative to general disturbances associated with these activities (e.g., noise from blasting and drilling, human activity, ORV traffic, etc.).

The level of detail related to impacts is a combined result of panelist expertise in Big Cypress and the quality and quantity of scientific information available for the different components of the greater Big Cypress ecosystem. In some cases, we do not know what the impacts of certain activities would be, and there is no scientific information available to guide us. For these activities, we note this and recommend monitoring or research to further our understanding. As a panel, we agreed that it would be reckless and irresponsible to assume no impact or no significant impact when no information exists to support such an assertion. In these cases, we chose to err on the side of conservation and protection of the environmental resources (both living and non-living) of Big Cypress rather than see activities proceed for which we have no scientific understanding as to their potential impact. Our assessment and recommendations presented herein reflect this philosophy.

2.3 Environmental Education and Awareness

A critical element of CRC's plan for development of their mineral resources must be an effective environmental and educational awareness program for all personnel associated with the 3-D seismic survey and any project that stems from that survey. While CRC does own much of the mineral rights under the BCNP and its Addition Lands and is afforded access to those minerals, CRC must bear in mind that the BCNP is recognized by the citizens of the United States as a national treasure worthy of protection.

While the management of CRC seems aware of the significance of these federal lands and the rare ecosystems they support, their commitment to protecting this resource (through their compliance with regulations and implementation of best management practices) should be regularly conveyed to field personnel at Raccoon Point and other areas of O&G activity in BCNP. It is important for all personnel to understand why the environmental safeguards are both important and relevant. In addition to recognizing the impacts described in **Sections 2.4 to 2.9**, the panel also recommends several actions that would enhance the potential for the CRC program to proceed with lessened impacts to the greater Big Cypress and adjacent ecosystems.

2.3.1 Environmental Training and Awareness

The first, and possibly most important, recommendation is to develop and implement an environmental education and awareness training program for all personnel associated with the project. The intent of the training would be to secure "buy-in" for the environmental protection requirements that will be associated with

the project. The program would need to explain the significance of the BCNP resource, why it has been protected, the basis for the various environmental requirements and the importance of the resource protection to each person individually.

In lay terms, the program should explain the importance of the BCNP to each person individually and how his/her actions, large or small, may directly or cumulatively impact the resource. Each individual should understand that consequences of non-compliance with the environmental requirements could result in the project being halted. The program should offer a clear explanation of why each of the environmental restrictions is in place (e.g., how rutted soils can affect plant communities which can affect habitat value, etc.). It is always more effective to offer an explanation about why a restriction is in place rather than simply stating “because it is required.”

The training need not be complicated or difficult. It will likely be more effective if the program is non-technical and simplified. An effective program could be no longer than 30 to 60 minutes in duration. The program should include handouts that can be taken into the field to assist personnel in identifying plants and animals of concern. Most importantly, the training should be required for everyone associated with the project whether they are CRC personnel, contractors or other associates.

2.3.2 Environmental Compliance Manual

An environmental compliance manual should be developed for the project. The purpose of this document would be to have all environmental requirements in one location for quick reference. The document should contain the specific requirements and examples of all reporting forms or reports that must be completed. There should be a list of contacts for questions, clarifications, and/or emergencies. The benefit of such a document is that it would provide a single location for all pertinent information and reduce potential for misinterpreting operational requirements and what is considered to be within compliance.

2.4 Impacts on Soils and Water

2.4.1 Surface and Groundwater Quality

The impacts of the proposed 3-D seismic survey on water resources in the NGA of BCNP and Addition Lands can be categorized as impacts on water quality (both surface water and groundwater) and local surface water flows. These impacts are summarized in **Table 2.1** and are described below. Note that many of these impacts can be minimized by conducting all 3-D seismic operations in conditions where standing water is absent and (preferably) soils are at their driest. Likewise, surveying activities should avoid sensitive water flow ways in the Nobles Grade area, such as Mullet Slough. It is also worth referring back to **Section 1.1** to

understand the “bottom-up” effects of water on wetland ecosystems. Unnatural (i.e., human-induced) changes in water flows, water levels, or water quality can have significant, unnatural impacts on plants, animals, and ecosystem processes within and around the NGA.

The panel considered a range of potential impacts to water quality from all of the activities proposed in the *Nobles Grade 3-D Seismic Plan of Operations*. These fall into three general categories: 1) impacts from physical disturbance of soils/sediments on surface water, 2) impacts associated with energy source material and detonation in groundwater, and 3) impacts from “other” contaminants in both surface and groundwaters.

2.4.1.1 Crew and equipment movement

Surface water quality can be degraded directly from suspending sediment/soil into surface waters by activities such as vehicle movement, heavy foot traffic, and drilling in ponded or shallow water areas. Increased turbidity from soil disruption in inundated areas will reduce light penetration, which affects the balance between benthic respiration and production in shallow water environments—usually resulting in dissolved oxygen depletion. Sediment suspension also mobilizes nutrients from the soil to the water column, which can enhance processes that lead to oxygen depletion or, after the sediments have re-settled, fuel mats of algae at the surface of the soil.

The delayed impacts of actions that contribute turbidity to surface water would be reduced light penetration and depleted dissolved oxygen levels that may stress both plants and animals in these shallow water areas. The best way to avoid these types of water-quality impacts is to conduct activities only when standing water is absent or, better yet, when soils are dry. As described in subsequent sections, this will avoid impacts to many other components of the ecosystem—especially wading birds that feed on many of the aquatic organisms in these shallow water wetlands.

Surface water quality and groundwater quality can be impacted directly from contaminants that may be spilled or brought from the depths and discharged at the surface. The seismic survey would require significant quantities of water for the drilling of shot holes—estimated at 900,000 gal (3,407 m³). Sonic drilling activities could also bring water of very different quality from depth to the surface. The quality of these waters discharged at the surface is a potentially significant impact, as it would contain higher levels of chloride (i.e., salinity) and sulfate than ambient surface water (see **Figure 1.1**). Care should also be taken to avoid using contaminated water supplies—even canal water and tap water—as these sources will also contain higher levels of nutrients, sulfate, chloride, or chlorine than what are commonly found in NGA surface waters (see sites A 12 and A 13 in **Figures 1.1 and 1.2**). Other chemical/fuel spills, human waste, and human-associated materials can also degrade surface water quality. Spills, leaks, and discharge of refuse and waste at the surface should be avoided at all cost.

To mitigate some of these potential impacts, it is expected that CRC and BCNP will work to ensure that water for drilling is taken from approved local sources. If water must be brought in from outside sources, the quality must be checked beforehand and delivery would be accomplished by low-ground pressure tracked vehicles.

2.4.1.2 Energy source placement and detonation

Despite its status as an industry standard, the use of dbx Pentolite (or any analogous explosive ordnance) is potentially harmful to the Big Cypress ecosystem and its downstream offshore environment. The bioaccumulation potential of this material is low, but this substance is highly toxic to life in the BCNP environment. Dbx Pentolite has a relatively short half-life (< 28 days) based on decay under aerobic conditions. Anaerobic conditions in BCNP wetlands may extend this considerably.

Energy sources will most likely be placed into a relatively anaerobic subsurface aquatic environment, so the half-life of unexploded ordnance could be significantly longer under these conditions. Further, as the material degrades, toxins may be leached and transported downstream within the aquifer having delayed impacts. Therefore, all unexploded ordnance should be counted, reported, and mitigated as to its impact on the aquifer and any organisms in the vicinity of the charge placement site.

When energy source material is detonated, water, carbon (C and CO), and di-nitrogen gas (N₂) are the predominant end products. The downstream transport and fate of this material is unknown. Some of this material will likely be blown out into the atmosphere upon detonation or will gradually diffuse out into the atmosphere. However, a substantial fraction may remain in the groundwater and possibly carried “downstream” towards the coast. The impact of these detonation end products is unknown but worth considering given the concentration and scale at which these materials will be introduced to the subsurface of the NGA.

A single energy source contains approximately one pound of nitrogen, assuming an energy source mass of 5.5 lb (2.5 kg) and a N content of 19% (estimated from an energy source with equal parts trinitrotoluene and pentaerythritol tetranite). This translates to over 5,000 lb (2,268 kg) of N added to an area of 71.5 mi² (185 km²)—assuming 5,200 energy source points. The impact and fate of this added nitrogen in the environment is a big unknown. Therefore, monitoring of groundwater quality from wells along a shot-line transect to the coast is recommended in order to track the concentrations of nitrogen and the downstream transport of this material.

If 3-D seismic activities are permitted, water quality (N, DO, conductivity, pH, and redox) in these wells should be monitored at regular intervals prior to the 3-D seismic survey to get baseline data, immediately following the survey, and continued over the course of the survey for at least a year. The intent of this monitoring would be to ensure no impact of combusted dbx Pentolite end products

on groundwater quality but also to understand the fate of these end products should they be detectable.

Another area of concern related to detonation effects on water quality is the effect of ground roll and the pressure wave that may be transmitted through the cap rock in the direction of nearby pools and cypress domes. It is possible that, if in close proximity to energy source detonation, the shockwave and ground roll may result in the pressurized discharge of reduced groundwater (i.e., water containing low dissolved oxygen and high reduced ions) into these shallow pools. Water in a highly reduced state would be low in dissolved oxygen and potentially high in sulfide and methane, which are toxic to the aquatic life residing in these surface waters. During the dry season, these isolated pools would be used as refugia for fish and other aquatic life and would also represent the remaining sources of aquatic prey items for wading birds and alligators.

Without knowing the magnitude of the effect of the shock wave on groundwater efflux into these pools, it is difficult to assign impacts of such proximal detonations on water quality. As a way to understand this, and perhaps remove any doubt as to the impacts, continuous surface water monitoring of dissolved oxygen, pH, and Eh is recommended before and after detonation in ponds and pools that are in proximity (<50 m) of shot holes. If no effects on water quality or aquatic organisms are revealed after a small sampling of these water bodies (no less than 5), the monitoring could be discontinued.

2.4.1.3 Other potential contaminants

Bentonite clay or “drilling mud” is also an industry standard material used for backfilling holes and capping wells. However, it should be noted that this material contains as much as 0.2% phosphorus pentoxide. Although this is a chemically bound form of P, it is potentially available to plants and microbes in a reduced soil state or may be made available through the release of plant and bacterial enzymes. This is noteworthy because the Big Cypress wetlands (like those of the Everglades) are likely limited by the availability of phosphorus. Assuming one 50 lb (22.7 kg) bags of bentonite clay are used for each shot hole, roughly 260,000 lb (11,794 kg) of bentonite clay will be added to the soil in the Nobles Grade footprint. Given that no material will be removed, this is comparable to the net addition of 520 lb (236 kg) of P to the NGA—all within a period of 6 months. Addition of P at this scale is unknown and may have far-reaching (both spatial and temporal) impacts on plant growth, soil respiration, and plant species invasions—not to mention potential impacts to higher trophic levels.

Groundwater may be negatively impacted by the proposed 3-D seismic activities by other substances used in the process. Without proper management and environmental follow-up monitoring, any field oil and fluid changes that might take place in unapproved locations or without proper preventive equipment could potentially contaminate groundwater. Groundwater impacts would be avoided by

requiring oil and fluid changes to occur either outside BCNP or in selected and properly equipped locations. Spills of any size would need to be cleaned to standards that the NPS deems appropriate.

2.4.2 Soils and Water Flows

The BCNP and Addition Lands consist primarily of wetland areas, which are saturated or inundated for much of the year. Soil compaction and/or rutting resulting from the movement of ORVs and sonic drilling rigs across saturated or inundated soils are primary concerns. Slight changes in ground elevation may result in habitat changes in the wetland areas. Evidence from Alaska has shown that these types of ORV-related impacts can accumulate in tundra ecosystems when repeated activities rut the same trails leading to erosion and changes in vegetation communities (NRC 2003). Although tundra may be more susceptible to this type of impact, aerial views of the Big Cypress clearly show the impacts of rutting caused by ORVs. Therefore, it is worth considering the potential for impacts from ORV and drilling rig compaction of soils to accumulate with repeated use.

In south Florida wetlands, ruts can also lead to unnatural drainage or drying of upper marshes during drier or drought conditions. Water ponding in depressions resulting from soil compaction could change the habitat and species composition of the vegetation within these depressions. Vehicular passages on an individual trail or road should also be kept to a minimum. CRC should coordinate with BCNP staff to minimize rutting and the occurrence of open holes or pits left by the survey. Soil compaction from equipment movement is unlikely to have a significant impact on the recharge of near surface water table but may affect local surface water hydrology and vegetation zonation.

Lightweight tracked vehicles, as proposed in the *Plan of Operations*, will be used for sonic drilling to minimize soil compaction. The “footprint” of the Boart-Longyear drill is described as being comparable to an adult human, thus somewhat mitigating its potential depressive impact on the soils of BCNP and on the root systems of plants. Although human footprints in wet soils may leave a series of depressions, tracked vehicles maintain continuous contact with the ground, leaving long ruts that can accumulate water and create flow channels for water conveyance. The drill rig is much wider than a human (8.5 ft. [2.6 m]), thus potentially impacting a wider swath of vegetation. It is also more resistant to rigid vegetation, thus contact of the moving drill with trees and shrubs is likely to be more damaging. No information was provided on the dimensions and potential on-site movement of the heliportable drill rigs. Thus, aspects of our understanding of the potential impact of this equipment within the BCNP are uncertain.

The impact of energy source detonation on cap rock fracturing is unknown. Cap rock is a relatively thin feature (1-3 ft [0.3-0.9 m] in thickness) that exists near the surface, resulting in very thin soils throughout much of Big Cypress. The ground roll and shock wave around each detonation point may further break up this already

porous layer possibly resulting in subtle areas of subsidence around each shot hole. It may also increase local surface water infiltration or groundwater/surface water exchange throughout the year. The impact of this at a local scale is expected to be minimal, but it is worth consideration given the large number of energy source locations planned for the NGA.

2.5 Impacts on Cypress and Other Big Cypress National Preserve Flora

Potential impacts to flora and, more specifically, cypress will vary according to activities outlined in CRC's Plan of Operations. Impacts of 3-D seismic activities on BCNP vegetation are summarized in **Table 2.2** and are described below. Cypress is obviously an important part of the vegetation community across NGA. However, given the unique array of habitats in the NGA (e.g., Kissimmee Billy Strand), panelists also focused on some of the rare species of plants that may be encountered during survey activities. Damage to any of these plant species should be avoided as much as possible. Even if small spills occur in the vicinity of rare plants, these should be documented and the area cleaned and preserved to the extent possible. In the summary below, the activities, stressors, impacts, severity of impacts, likelihood of impacts, and consideration of how to avoid maximum impacts to vegetative components of the NGA are described.

2.5.1 Immediate Impacts on Flora

2.5.1.1 Initial survey

Surveying activities that occur prior to energy source placement and detonation will use crews that move around by foot and ORVs. This activity will result in disturbance to the vegetation through crushing plants and soil compaction. The severity of these impacts is greater for the ORVs than the foot traffic, and impacts will be greater for endangered species than for common species. Use of existing trails will help to decrease damage by both types of traffic. However, not all activities will take place on what has been identified as existing roads and trails. Further, including a botanist or someone capable of identifying plants in the field would help to avoid impacts to endangered plant species in the initial survey.

There is no detailed information on the extent to which vegetated areas will be entered with ORVs or heliported sonic drilling rigs. ORVs should avoid wet or damp soil. The 3-D seismic survey conducted by CRC at Raccoon Point in 1999 had as a permitting requirement restrictive conditions that there could not be soil compaction greater than 2 in (5 cm) off trails and that there could be no cutting of native trees greater than 2 in (5 cm) diameter at breast height (DBH; Haulk et al. 2000). There was some ORV damage to vegetation as a result of the Raccoon Point seismic survey that required subsequent restoration and monitoring (Haulk et al. 2000, Haulk and Miller 2001, 2002). Follow-up monitoring showed vegetation restoration after 3 years.

Fifteen plant “Species of Special Concern” are either known to be present or are potentially present in the NGA (**Table 1.9**). Eight of these are epiphytic and therefore probably not in danger from foot traffic and ORVs. The other eight are terrestrial herbs or shrubs and are thus more susceptible to impact. Although these species are all rare, and thus less likely to be encountered, chance encounters could be especially damaging. Sampling the area to determine presence and to mark populations, if present, could avoid this damage. Kissimmee Billy Strand and the pineland to the east are known to be areas where a number of rare species occur (J. Sadle, ENP, personal communication). These areas and similar habitat types in the NGA should be targeted in surveys for endangered species populations.

The human activity in the area combined with the disturbance from foot and ORV traffic increases the likelihood of both dispersal of exotic plant species and establishment of those species in disturbed soil. **Table 1.5** lists the invasive exotic species reported from BCNP. Surveys of the NGA have shown that Brazilian pepper, melaleuca, and Old World climbing fern occur in the NGA (J. Burch, BCNP, personal communication). Efforts should be made to avoid or remove exotic species, especially individuals that are reproducing (with flowers or fruit), in order to reduce the possibility of spreading propagules. In addition, disturbed areas should be monitored after completion of seismic activities for 3 to 5 years (depending on the degree of disturbance) in order to minimize invasive species establishing or expanding in these areas.

2.5.1.2 Seismic charge placement

The sonic drill rig will have impacts similar to or more severe than ORVs and is likely to cover a more extensive area. Similar measures should be taken to lessen impacts on vegetation in general and on endangered species in particular. In the seismic survey at Raccoon Point, a drill deployed by helicopter was used in especially sensitive areas (Haulk et al. 2000). If such areas cannot be avoided in Nobles Grade, comparable measures should be employed. Similar efforts to avoid the spread of exotic species and to monitor for potential invasions in areas disturbed by the rig should also be taken.

2.5.1.3 Seismic data acquisition

Seismic data acquisition involves placing the geophones to acquire the sonic data, detonating the charges implanted by the drill rig, and then removing the geophones. Again, this involves the movement of crews and equipment through the area previously traversed by the survey teams, with additional foot traffic and ORV and/or helicopter transportation. Efforts to minimize disturbance of plants, in general, and endangered species in particular, should follow the same guidelines as provided for the survey crews. These crews should also watch for and avoid or remove invasive exotic plant species.

Detonations of energy sources will cause a localized upheaval of the soil. This can be minimized with reliable placement and solid backfill of bentonite clay, as described in the *Plan of Operations*. Still, even with minimal upheaval, this disturbance could break plant roots in an area of unknown extent around the site, which could kill or weaken plant species in the impact area. The severity or extent of such an effect is unknown. Because activities are planned in the dry season, this type of damage could be less severe, because many plants are not actively growing. Alternatively, it could be more severe, because plants are more stressed. Three years of monitoring after the 3-D seismic survey at Raccoon Point reported no negative effect of these activities (Haulk et al. 2000, Haulk and Miller 2001, 2002). However, their follow-up monitoring to this survey was focused on predetermined disturbed areas that required some restoration. For a Nobles Grade survey, a simple before-after/control-impact (BACI) study of the vegetation species around selected detonation points could establish the specific impacts on vegetation and the magnitude of these impacts. The sampling interval and duration would be an important aspect of this design and should take into consideration the seasonal growth patterns of species affected.

2.5.2 Delayed and Long-term Impacts on Flora

Although some of the planned activities are expected to have minimal impacts on vegetation, the combined activities may still have significant cumulative impacts. Some of these can be avoided by having people take different routes to sites in order to avoid creating highly rutted trails. Alternatively, the total amount of area impacted could be reduced by using the same routes. However, the impacted area would require more intensive restoration. It is worth noting that disturbed areas created by these kinds of activities are potential sites for invasion by exotic plants. So, there was divergence of opinion with regard to a recommendation here. Park service staff and ORV experts, such as Dr. M. Duever (SFWMD), should be consulted in this area.

Even though CRC intends to use trails and roads for much of their survey, it is unclear as to the vegetation communities that have re-colonized those that were created in the past and have since been abandoned. Much of the Nobles Grade footprint lies in the Addition Lands. This area has been closed to public ORV activity since its incorporation into BCNP and even before, as it was privately held at that time. CRC's interpretation of existing roads and trails likely contains features that experienced varying levels of use and impact and, therefore, are in different states of recovery.

Some lightly disturbed areas that were interpreted by CRC as roads or trails may contain native vegetation. However, others that were more heavily used in the past might be supporting non-native exotic species that could serve as a propagule source for expansion into newly disturbed areas created by these proposed activities. These sites will need to be monitored for invasion after completion of seismic activities until they have returned to their natural state. As noted earlier, the

recovery of restored sites following the Raccoon Point 3-D seismic survey took 3 years (Haulk and Miller 2002). Follow-up monitoring for invasive species expansion into newly disturbed areas should consider this same timeframe.

2.5.3 Cypress Impacts in the Context of the Entire Plant Community

Oil activities are known to have direct impact(s) on the environment (de al Cruz 1982) and while there is a variety of material available examining the ecological consequences of this industry in coastal wetlands, there is very little available on how cypress wetlands are impacted. Hydrology, fire, and nutrients are all important controlling factors in cypress ecosystems (see **Section 1.2** for details). Thus, any activity that changes the mode or frequency of these factors is going to have some impact on the cypress. Some potential impacts of these activities include crushing or clearing of vegetation along shot lines, creation of water courses by vehicle tracks that can alter runoff and/or flooding regimes, and possible fires from human causes, use of ORVs, or the explosive materials (de la Cruz 1982).

2.5.3.1 Impacts of ORVs and other mobile equipment on vegetation

There is much information on the impact of ORVs in BCNP through the work of Duever et al. (1986b). The following paragraphs are condensed from their reports:

“Vegetation, substrate, fire history, hydrological characteristics, and location all affect site susceptibility to ORV damage. Although this is partially due to the inherent sensitivity of certain types of sites, the ways in which site characteristics affect vehicle usefulness are probably more important. All kinds of ORVs generally avoid densely forested areas, and wheeled vehicles go around low, potentially boggy places whenever possible. Therefore, the habitats that are most heavily used by ORVs are marshes, pinelands, palm hammocks, and the more open cypress and mangrove communities.”

“Draining or burning can alter the way a site is affected by ORV traffic. Since dry sites are less severely impacted than wet areas, a drained marsh would be less disturbed by ORVs than would an undrained one. In burned or grazed areas, there is little vegetation and litter to protect the soil and roots from ORV damage. Severe burning or overgrazing can also reduce the binding root systems that hold the soil together, and subsequent ORV activity can cause severe long-term damage. Farming eliminates native vegetation and disturbs the soil, so that deep rutting is much more likely to result from ensuing ORV use (Duever et al. 1986b).”

“ORV activity often kills or injures vegetation, but it can also have more subtle effects on community species composition, biomass, and productivity. Certain species, such as golden ragwort (*Senecio glabellus*), can be exceptionally common in ORV tire ruts. Unfortunately, most of the research on ORV impacts on vegetation has involved types of vehicles and terrain not normally encountered in South Florida, and its applicability to the BCNP is therefore limited. Schemnitz and Schortemeyer (1973) did study the effects of airboats and track vehicles on marsh vegetation in the Everglades, but the soil types and plant communities they investigated are

relatively uncommon in the Big Cypress and the vehicles they studied are not types widely used in the BCNP. Although ORVs sometimes altogether destroy herbaceous vegetation, their long-term impacts are probably most severe in forested habitats where large trees may be cut for trail construction and smaller ones "bulldozed" by larger vehicles (Duever et al. 1986b)."

"Although ORVs do not appear to cause soil compaction problems in south Florida (Schemnitz and Schortemeyer 1973), and ORV-caused erosion is not a widespread phenomenon in the Big Cypress, rutting and soil displacement do occur. Rock breakage may also be significant in places. Although plant community type undoubtedly influences the likelihood of ORV damage, soils are a more important factor because ORVs have varying impacts on sites with different substrates."

"Sand soils appear to be little affected by ORV use, but, once repeated use begins to destroy the binding root mat, they are subject to displacement. Peat soils offer good traction when dry but are soft and boggy when wet and are frequently rutted. This is also a problem on marl soils. In some parts of the BCNP, rutting has removed as much as 1 m of soil, and the bedrock is exposed. Although they are concrete-like when dry, marls become extremely slippery when wet. Therefore, destruction of vegetation rapidly makes ORV trails through marl prairies impassable, forcing vehicles to repeatedly change their routes and constantly widen the trails."

"Progressive widening is characteristic of ORV trails through some parts of the preserve. This is not just a recent phenomenon caused by an increase in the numbers of vehicles using the area. It can be seen in early aerial photographs taken when few vehicles used the area. Widening takes place when the soil becomes so extensively rutted that vehicles can no longer maintain traction in the trail and must go around difficult spots, making a new set of ruts, which eventually also become impassable. In some parts of the preserve this process has resulted in a 0.4 km wide corridor barren of most vegetation."

"Where bedrock is naturally exposed, a small amount of vegetation may be eliminated from the trail but no rutting or widening occurs. Rock substrates are very resistant to rutting, and where there is rock near the surface, the ground cover often recovers quickly even after heavy use. Duever et al. (1986b) reported that formerly busy trails in rocky areas have become almost invisible after less than one year of recovery time. Although rock makes a firm base for an ORV trail, heavy vehicles can break up outcrops and accelerate the erosional processes at the edge of hammocks."

"Generally, ORV trails have little effect on surface water, although under certain circumstances, they can act as drainage channels and alter natural hydrologic patterns. In most parts of the BCNP the ground surface is sufficiently irregular to interrupt any channelizing effect. Even if a shallow canal develops in the wetland, it usually does not result in drainage because it is normally bounded at both ends by uplands. Drainage is a problem where ORV use has removed the vegetation and rutted the soil, forming a channel that goes through a low and extremely flat habitat more or less surrounded by higher land, which then connects with a canal or major slough. These conditions exist most often at access points, where vehicle use is most concentrated and trails branch out from a roadside canal. Although some drainage can take place anywhere a trail leads into a slough or strand, it is unlikely that the

average shallowly rutted trail has significant drainage impacts (Duever et al. 1986b).”

2.5.3.2 Human activity and the potential for fire

ORVs have also been known to start fires, and requiring spark arrestors on the vehicles will help to reduce this hazard. These devices are designed to trap sparks, which might escape from exhaust systems and should be inspected daily. The exhaust pipes from ORVs may also come into contact with dried or senesced grassy vegetation, resulting in fire—especially in the dry season.

Surface fires typically leave cypress unharmed (see references in Wade et al. 1980), especially where these trees can root at least partially in mineral soil or where peat soils do not ignite (Ewel and Mitsch 1978). Baldcypress is known to be very tolerant of fire with only longleaf pine (*Pinus palustris*), slash pine and loblolly pine (*P. taeda*) being more tolerant given similar bark thickness (Hare 1965). Though fire tolerance of pondcypress was not specifically compared with baldcypress, the bark of pondcypress tends to be thicker and shaggier than that of baldcypress suggesting that it may be even more fire tolerant than baldcypress (1995). Cypress is known to sprout epicormically when branches are killed by fire and will coppice following cutting and burning where above ground stems are killed (Ewel and Mitsch 1978). Cypress coppice, however, is often killed by fire (Ewel 1995).

In south Florida, fires may burn in grasslands and dwarf cypress savanna during years of average precipitation, but will not burn very far into the middle of cypress domes or strands. The characteristic rounded shape of cypress domes and strands appears to be related to peat depth, fire frequency, and site conditions. Trees are generally larger and older on sites with deep peat. The deeper peat is in contact with water for longer periods and dries out more slowly. Fires are therefore more frequent and more severe on the edges of domes and strands than in the center where peat is deepest. The less frequent the fire on a microsite, the more likely cypresses will survive to larger size. Strands and domes probably expand and contract in response to fire occurrence and hydrologic conditions. During extreme drought, even large strands and domes may experience stand-replacing fire (Duever et al. 1984).

In a drought year, however, fires can be severe enough to burn to the centers of domes and strands (Sullivan 1994). When peat is dry enough to burn, the larger amount of litter and organic material in the center of the dome will support a more severe fire than on the edges where peat layers are thinnest. Such severe ground fires can kill mature cypress trees, particularly when growing on deep peat (Ewel and Mitsch 1978). Peat fires can also lead to the conversion of closed-canopy cypress domes into shallow open water lakes (M. Duever, SFWMD, personal communication), thus changing the habitat to an entirely different stable state. Even if cypress trees are not killed by a severe ground fire, they can be wounded leading to fungal infection and heart rot (Ewel 1995). Heart rot may contribute to tree

cavity development. Furthermore, some ground fires that do not cause direct mortality may contribute to secondary mortality from windthrow by consuming soil and roots that function to anchor trees. Fires are rarely severe enough to kill trees in dwarf cypress savanna because of sparse organic matter (Craighead 1971, Brown et al. 1984).

Young cypress trees (less than 200 years old) may sprout after fire if damage to roots is slight (Sullivan 1994). Sprout production and viability decline with tree age (Christensen 1988). Since cypress seed dispersal is limited, recovery from severe fires that consume peat may be very slow, particularly where water flow is slow to negligible. In areas where severe fires have burned old-growth cypress stands, there is little sign that communities recover to pre-fire conditions (Christensen 1988).

2.5.3.3 Soil impacts by vehicles

Different vehicle types produce quite different impacts because the characteristics of each result in their use in different habitats, at different times, and in different ways. The impacts of various patterns of repeated ORV use (the number of times a vehicle travels the trail within different time intervals) can also vary tremendously. Some sites become impassable after a vehicle has traveled across them once or twice, whereas others do not exhibit significant impacts until they have been subjected to heavy use (Duever et al. 1986b). In a study conducted in the BCNP, Duever et al. (1986a) examined different vehicles and little, medium, and heavy impacts from use of the vehicles. After seven years, they found that virtually all of the one-pass impact lanes had completely disappeared as well as most of the medium-impact lanes. The small cypress habitat was the only area where a number of the medium-impact lanes were still visible, but most had recovered. A large percentage of the heavy-impact lanes had not recovered, suggesting that once the soil was severely disturbed, recovery takes a long time.

Vehicle traffic may cause localized and sometimes extensive disturbances to the soil. Numerous studies have examined soil compaction, shallow and deep rutting, puddling/smearing, and churning in moist to saturated soils in the southeastern U.S. (see Miwa et al. 2004 for a review) but not on limestone base areas like the BCNP. The level of disturbance is a function of the type of equipment (especially weight), traveling speed, traffic frequency, soil organic-matter content, soil texture, and soil water content. Disturbances to the soil include increased bulk density, lower organic matter levels, reduced air and water movement, and altered nutrient availability (Aust et al. 1995). In addition, soil disturbances can decrease seedling survival and growth of some species (e.g., loblolly pine [Hatchell et al. 1970]) but improve success for others (e.g., water tupelo [Aust et al. 2006]). Natural soil recovery processes are complex and gradual in most areas. Previous studies suggest that complete recovery of disturbed soils can take 40 years in the North Carolina Piedmont (Perry 1964), 18 years in the Atlantic Coastal Plain (Hatchell et al. 1970), and 8-12 years in the northern Mississippi coastal Plain (Dickerson 1976). Recovery is speeded up in areas where there are annual inputs of nutrient-rich sediments

(Aust et al. 2006). The soil recovery process has been described with an exponential recovery curve (Webb et al. 1983) suggesting a rapid initial recovery followed by a long period for complete recovery.

2.5.3.4 Coppice regeneration

Cypress trees will be damaged as a result of the 3-D seismic activities proposed for the NGA of BCNP and Addition Lands. When cut or snapped, these trees can produce sprouts from latent or adventitious buds, thus allowing them to regenerate following damage. These cypress species and pond pine are among the few conifers that produce sprouts capable of becoming full-grown trees (Wilhite and Toliver 1990). The viability of coppice regeneration is important if one is looking at extensive damage to cypress stems by breaking or cutting as part of the 3-D seismic survey and oil production process.

Cypress will sprout freely under ordinary conditions during the first 50-100 years, and sprouts from 100-200 year-old trees is not unusual according to Mattoon (1915) who found evidence of large coppice on stumps up to 180 years old. In all cases where Mattoon (1915) observed coppice, the parent tree was of slow growth and relatively small. This led him to conclude that reproduction by sprouts is closely tied to age and size of parent tree. Stumps of vigorous growing stock up to age 40-60 years old could be counted on to send up healthy sprouts if cut in the fall or winter (Mattoon 1915) but less so for trees cut in spring or summer (Williston et al. 1980). Slow growing trees beyond 60-90 years old will not ordinarily reproduce successfully by sprouting. The diameter limitation seemed to be 10-14 in (25-35 cm) at 2 ft (0.6 m) above the ground.

Although sprouting usually does occur according to the above-mentioned reports, recent investigators have reported poor growth and survival of stump sprouts. Conner et al. (1986) reported that 80% of baldcypress (*T. distichum* (L.) Rich.) stumps sprouted after logging, but fewer than 25% retained live sprouts 4 years after harvest. Conner (1988), summarizing a number of studies in Louisiana, found 0 to 23% of baldcypress stumps with surviving sprouts after four to seven years. Similarly, Ewel (1996) reported only 17% survival of pondcypress stump sprouts a few years after harvests in Florida swamps. In a more recent study, Keim et al. (2006) examined 18 sites in Louisiana for stump sprout and seedling regeneration. Harvesting of most sites consisted mainly of diameter-limit cutting of baldcypress with less cutting of other species. Thus, stumps were mainly larger in diameter than were the remaining overstory trees in most stands. The proportion of baldcypress stumps having live sprouts ranged from 0-72% by site (median 10%). However, only 2 of the 18 sites had live sprouts on more than 20% of stumps. On four of the sites, no stumps had live sprouts.

Small dwarf cypress communities are found in south Florida where the underlying bedrock is too close to the surface for sufficient soil and nutrients to accumulate. The diminutive size of these trees is due to the nutrient-poor soil in which they

grow. These trees, sometimes called dwarf, scrub, or hat rack cypress, can have huge buttresses, gnarled bonsai-like crowns, and may be hundreds of years old (Flohrschutz 1978). They are usually less than 12 ft (3.6 m) tall with a diameter at breast height of less than 4 in (10 cm), and a canopy cover of 33% or less (Wade et al. 1980). The question becomes whether the small cypress in the BCNP are indeed very old stems or newly regenerated seedlings and how will they respond to snapping with vehicular traffic? With the lack of research on this specific cypress type and the poor coppice regeneration observed in larger cypress trees in other areas (where extensive root systems existed and soils contained plenty of nutrients), extreme care should be taken to minimize damage. Further, extensive follow-up monitoring or re-planting of damaged trees should be considered as a means to ensure no loss of cypress trees.

2.6 Impacts on Herpetofauna

There would be a variety of potential impacts to herpetofauna from the 3-D seismic activities proposed. These impacts are summarized in **Table 2.3** and are described below.

2.6.1 Vehicle Tracking

While far less documented than road- and highway-caused mortality, ORVs do kill amphibians and reptiles by running over them (Maxell and Hokit 1999). Amphibians are particularly susceptible due to their relative slowness and small size (Havlick 2002), making them easily overlooked. This mortality risk may be greatly decreased by travelling at slow speeds while watching ahead for movement or animals of all sizes.

Probably more destructive in the long-term are the impacts from habitat destruction. Reptile numbers have been shown to decrease proportionally with increased ORV use; potential prey sources (birds and small mammals) demonstrate the same decline patterns (Busack and Bury 1974, Bury et al. 1977). One habitat feature that should particularly be avoided by all vehicles during oil survey work is gopher tortoise burrows. Given the apparent rarity of gopher tortoises in BCNP, the chances of seeing a burrow are slim. Nonetheless, the impacts of destroying one would be severe since these burrows not only provide shelter for the tortoises but also for indigo snakes, rattlesnakes, and other herptiles. These burrows are prominent with large aprons at their entrance (**Figure 2.2**) so they can be easily spotted and avoided. Restricting travel to previously disturbed areas will reduce the potential for habitat destruction, as will limiting extraneous travel in the area.

One indirect impact of ORV traffic within BCNP is the potential introduction of exotic plant species. Once introduced, these species require mechanical or chemical control to prevent their spread. Chemical controls should not be used near potential amphibian breeding waters due to their possible negative impacts. Amphibians are

particularly susceptible to toxins and water pollution because of the permeable nature of their skin. Atrazine, the most commonly used herbicide in the U.S., impairs sexual development in frogs (Hayes et al. 2003). Some controversy surrounds glyphosate-based herbicides, the main alternative to atrazine. Studies on one brand suggest little to no impacts on amphibians when used according to instruction (Thompson et al. 2004, Wojtaszek et al. 2004), but other studies suggest reduced amphibian survival for certain other brands (Dinehart et al. 2009). Given the known negative impacts of atrazine and the uncertainties associated with glyphosate-based herbicides, chemical treatments should be avoided where amphibian breeding may occur. Cleaning all machinery and vehicles prior to entering the NGA and after exposure to established exotic plants in the area will reduce the spread of these species, thereby limiting the need for treatment. Effects of other toxic chemicals on herpetofauna that may be spilled (oil, gas, etc.) or placed (dbx Pentolite) in the environment should also be considered, as these will disperse readily into the water and soil where these sensitive organisms reside.

Another indirect impact of ORV use is the potential spread of amphibian diseases. Chytrid fungus (*Batrachochytrium dendrobatidis*) and ranaviruses are known to cause mass mortality in amphibians at all life-stages and can be spread by infected equipment among other methods (Carey et al. 2003). Chytrid fungus is not currently known in the area, but at least one case of ranavirus has been confirmed in adjacent ENP (Rice et al. 2004), thus precautions should be taken to avoid its spread in BCNP. Ranaviruses can be spread in mud and remain infectious for long time periods even in adverse environmental conditions, including dry downs, without hosts (Daszak et al. 1999). To prevent the introduction and spread of ranavirus in the area, all equipment, vehicles, and boots should be disinfected with 4% sodium hypochlorite (bleach) for 15 minutes prior to entering and exiting the NGA (Speare et al. 2004). Muddy clothing, bags or other cloth equipment should also be disinfected by washing at least 15 minutes in hot water (at least 140°F [60°C]) prior to entry or exit from the project area (Speare et al. 2004). Repeat washings should only be needed for equipment or vehicles leaving BCNP and returning throughout the survey process.

2.6.2 Transportation and Equipment Noise

Comparatively little research has been done on amphibian and reptile hearing. Their range of sensitivity is more limited than birds with reptiles generally hearing at 50 Hz to no more than 2 kHz, and amphibian hearing is within the 100 Hz to 2 kHz range (Fay 1988). Within the reptiles, turtles and snakes have the worst hearing while crocodilian hearing is considered excellent (Wever and Vernon 1960, Wever 1978, Fay 1988). Vocalizations are an important part of communication for many amphibians, although they also communicate and time behaviors based on low frequency ground vibrations (Dimmit and Ruibal 1980). Reptiles are also sensitive to low frequency ground vibrations, which provide important information on both predators and prey. It is thought that this vibration sensitivity augments their hearing (Bowles 1995).

Overall, vertebrates have an amazing capacity to adapt to their surroundings, modifying their behavior, physiology, and eventually genetics to suit their environment. Most species habituate to common sounds, including those produced by people, and learn to avoid sounds associated with danger (Soria et al. 1993). Unknown sounds generally elicit a behavioral response, which can be active (fight or flight) or passive (freezing or playing dead) (Grielsen and Smith 1995). Attempts have been made to evoke a behavioral startle response in various reptiles using intense sounds, but these efforts were unsuccessful (Wever 1978). In general, the startle response in amphibians and reptiles is fear immobilization (Grielsen and Smith 1995), which may increase mortality risk from predators or vehicles. The degree of behavioral response depends upon the familiarity of the sound, as well as its intensity, timing and distance from the animal. The animals in the NGA have likely been exposed to helicopter and ORV sounds before and therefore may display limited responses if any to these stimuli. Nonetheless, there are concerns that should be addressed with these vehicles, as well as with unfamiliar sounds such as those associated with the drill rigs, drilling, and energy source detonations.

Regardless of habituation, intense sounds can both physiologically and behaviorally impact amphibians and reptiles. Studies that exposed lizards to simulated ORV sounds ranging from 95 – 114 dB for varying time periods caused shifts in hearing thresholds and in some cases, permanent hearing loss (Bondello 1976, Bondello et al. 1979). The first signs of hearing loss were apparent after less than nine minutes of exposure to sounds at 95 dB, the equivalency of a dune buggy at a distance of 16 ft (5 m) (Bondello et al. 1979).

While one report claimed behavioral alertness in a snake responding to an airplane overhead (Yahya 1978), most behavioral changes in response to vehicle sounds have been recorded for amphibians. Brattstrom and Bondello (1983) demonstrated that spadefoot toads (*Scaphiopus*) emerged from burrows repeatedly in response to simulated motorcycle sounds (95 dB), which they hypothesized resembled rumbling thunder that triggers their emergence in nature. There was a habituation effect over time, but damage may be done prior to habituation. In this case, for example, toads induced to emerge in the wrong season could die from desiccation. Precautions should be taken to ensure that sounds produced during oil activities do not resemble natural auditory signals.

Amphibians are possibly most susceptible to noise disturbance during breeding choruses. Males have been shown to alter their calls in the presence of man-made noise (Narins 1982, Sun and Narins 2005), which may limit their ability to effectively communicate with females. Males may also increase their calling efforts to overcome the ambient noise, which could result in shortened choruses due to the extra energy expenditure (Ryan 1988). Females are also impacted by masked chorus sounds and have been shown to be less responsive in choruses competing with traffic noise (Bee and Swanson 2007). Any limits on breeding choruses will have a direct impact on the reproductive success of present individuals, translating

into a long-term population decline if the disturbance continues. One tactic organisms use to avoid noise impacts is mobility, but amphibians have relatively limited dispersal abilities and there may not be another adequate breeding area within their range. Amphibian breeding choruses generally occur at night in the warm summer months so they may be more protected from oil exploration activities proposed earlier in the dry season. Nonetheless, if a chorus were encountered in the dry season on an overcast day when rain is threatening, equipment should avoid the general vicinity to minimize or avoid disturbance.

2.6.3 Blast Shock

It is unclear how vibrations from detonation of explosives during seismic surveying will impact amphibians and reptiles, but, as mentioned above, vibrations are an important part of their hearing and communication systems. Overstimulation by a detonation may contribute to hearing loss issues and mask or unintentionally mimic natural cues that may lead to decreased survival or reproductive rates. Burrowing species may be particularly vulnerable to these impacts since low frequency vibrations travel better in dense substrates than in air (Bowles 1995). Research should be done to assess the impacts of these blasts on burrowing species. Another concern is the potential collapse of habitat, such as gopher tortoise burrows, due to the ensuing ground roll. Until more relevant data exist, safety standards established for buildings should be used for important features such as gopher tortoise burrows, meaning an appropriate distance should be maintained between blasts and such features to ensure that noise exposure to these structures are below 134 dB (Siskind et al. 1980).

2.6.4 Summary of impacts on herpetofauna

The main concerns of 3-D seismic surveying activities on herpetofauna are potential impacts from ORVs, tracked vehicles, and equipment noise. Such impacts in Nobles Grade will likely be modest or can be mitigated. In general, amphibian and reptile activity levels peak in the warm summer months. As long as exploration is confined to the winter dry season, potential impacts on reproductive behavior will be lessened.

Vehicle operation and other activities of the crews remain a major concern overall. Avoiding impacts to “Species of Special Concern” will require special vigilance. Eastern indigo snakes and other snakes move about all year long and, in the dry season, may move into otherwise wet habitats that should be avoided by vehicles and other direct human interference. The numbers of indigo snakes are low in the area so the likelihood of encountering them is small. The same is true for gopher tortoises, which are also rare in the area. Alligators will be present, but will be comparatively easy to avoid in the dry season when they are concentrated in isolated areas of water. In all cases, positive action through training and operational procedures will need to be taken to avoid running over snakes, turtles, and other slow moving reptiles and amphibians.

With respect to noise, it is clear from the literature that man-made noise and vibrations may adversely affect reptiles and amphibians. Mobile species likely will evacuate the area prior to these activities in response to the sounds of approaching crews. Impacts on slow-moving species can be mitigated if crews move slowly and avoid any animals that appear immobile. It is unclear how the impacts of vibrations from drilling and detonation will impact burrowing species that may not hear or respond to the less impactful “warning” sounds. Research or behavioral monitoring should be done to clarify this point.

In terms of indirect impacts, such as spreading of diseases and non-native plants, these can be mitigated or minimized by thorough cleaning of all equipment and boots. Ranavirus is the only herpetofaunal disease known from the region presently, so recommendations have been made to disinfect according to the standards for ranavirus. If other diseases become a threat, the cleaning protocol should be adjusted accordingly. Any exotic plants that are introduced despite cleaning efforts should be controlled mechanically near optimal amphibian habitats.

These and other recommendations to limit the impacts from 3-D seismic surveying are summarized in **Table 2.3**. If these recommendations are followed, adverse consequences to reptiles and amphibians can be minimized or avoided.

2.7 Impacts on Wading Birds

For a thorough consideration of the potential impacts of 3-D seismic O&G exploration and to make recommendations for minimizing these impacts, the conceptual framework discussed in **Section 1.4** was overlaid with an understanding of wading bird ecology and the latest data on wading bird colony locations and feeding areas. Key to a thorough characterization of impacts is an understanding of how highly mobile birds living in the dynamic south Florida wetland ecosystem use habitat and could be impacted by changes to it (please refer to **Section 1.4** for details). Attempts to apply similar concepts derived from less mobile animals or from equally mobile animals in less dynamic ecosystems will lead to a misinterpretation of what the presence or absence of an animal indicates. Therefore, recommendations below are specific to the BCNP, and more specifically, the NGA. Refer to **Table 2.4** for a summarized list of potential impacts and these recommendations.

2.7.1 Initial Survey

As described for other ecosystem components, stressors from survey activities come from the presence of people, ORVs or helicopters (**Table 2.4**). The potential impact of these stressors is direct and affects foraging flocks of wood storks and other wading birds, as well as on their nesting colonies. There are likely no indirect effects on wading birds from the surveying crew.

2.7.1.1 Foraging flocks of wading birds

Impacts are manifested on foraging flocks by causing them to fly from their feeding sites, which in the worst case could reduce energy intake and ultimately lower fitness of nestlings or adults. Birds that are flushed often move a short distance and resume feeding, but the secondary site may be of lower quality. After the disturbance passes, birds will often return to the original foraging site (DEG, personal observation). Shorebirds can be disturbed up to two times per hour without impacting fitness if feeding conditions are good, but they show reduced fitness with as few as one disturbance every five hours if feeding conditions are poor (Goss-Custard et al. 2006). Some species of herons are easily disturbed by people approaching on foot, and even more so by people in a vehicle (Klein 1993). There are no studies of which we are aware for distances at which ORVs disturb wading birds. However, a wading bird study by Rodgers and Henry (1997) suggests that a 100-meter buffer would be sufficient for minimizing such disturbances. It is likely to be similar to a person on foot if the vehicle is reasonably quiet and moving slowly. In contrast, an approaching helicopter will flush wading birds up to approximately 0.3 mi (0.5 km) in front of the aircraft (DEG, personal observation). These disturbed birds often fly far from the aircraft and do not necessarily settle at a nearby foraging site as they do after being flushed by people on foot or in automobiles.

If initial surveys are being conducted at sites when the hydrologic conditions are ideal for wood stork foraging, there is a very high probability that foraging birds will be disturbed, based on the analysis of the SRF surveys. Because wading birds are so mobile and there are generally more foraging patches available than there are bird flocks to occupy them, it is likely that birds can simply relocate to another suitable foraging patch if disturbed. Therefore, the impacts from surveys to any individual bird will be low. Exceptions would occur with repeated flushing of the same birds or if an entire foraging area were disturbed for a day or more.

If repeated helicopter flights will be made along the same flight path, the helicopter should avoid areas with foraging flocks of wood storks and other wading birds to the extent possible. If flocks must be disturbed, it is preferable to change flight paths and affect multiple flocks one time than to affect one flock multiple times. Personnel on foot or ORVs should stay greater than 328 ft (100 m) from areas with shallow water, which are potential foraging sites, until they dry completely. Also, personnel should not cover a large portion of Nobles Grade at any one time, particularly when the water is shallow enough to allow foraging. The current operations plan of having up to 5 crews in the field at one time is adequate.

2.7.1.2 Wading bird colonies

The potential impacts of disturbance on colonies can be severe, with repeated disturbance causing reduced nest attendance and in the worst case, nest

abandonment. Mueller and Glass (1988) documented that drilling for oil near a colony in Texas caused the abandonment of the colony by some species. They noted that wading birds were more sensitive than other colonial water birds to disturbances from oil drilling. The authors recommended that no drilling take place near a colony during the pre-nesting and nesting period. Rodgers and Smith (1995) recommended that a distance of 328 ft (100 m) was adequate to keep nesting wading birds from leaving a nest when approached by people. However, they did not consider other less obvious impacts such as increased time alert by the adults and reduced time for resting. Erwin (1989) similarly recommend a distance of 328 ft (100 m) as a buffer against human disturbance for tern and black skimmer (*Rhynchops niger*) colonies. Both of the previous studies were conducted in areas that experience human visitation, possibly leaving birds habituated to human disturbance. Nesting colonies in remote areas within BCNP are unlikely to be accustomed to human visitors at colonies. Nevertheless, remote colonies in the coastal Everglades were not affected by a single or infrequent helicopter flights (Kushlan 1979).

The probability of storks nesting within Nobles Grade is low given the frequency in which colonies have occurred there in the past. Because wading bird colonies are particularly sensitive to disturbance, the severity of impacts could be high if they occur. The helicopter should stay greater than 0.3 mi (0.5 km) from a wading bird colony if there will be repeated flights along the same path. Personnel on foot or ORVs should stay greater than 328 ft (100 m) from an active colony.

2.7.2 Energy Source Placement

The stressors from energy source placement come from the presence of people, helicopters, and the tracked vehicles (**Table 2.4**). The potential impact of the people and helicopters is direct and on foraging flocks of wood storks and other wading birds, as well as on their nesting colonies. The likelihood, severity, and recommendations are the same as for the initial survey (see above).

The impact of the tracked vehicle is both direct, as with people on foot, and indirect. The direct impacts are the same as those for survey. The indirect impacts include increased water turbidity and altered microtopography, leading to an increased probability of invasive plants becoming established (USFWS and DESCO 2006, also described earlier). Increased turbidity could reduce foraging success and energy intake temporarily. The establishment of invasive plants could reduce the vulnerability of aquatic prey to being captured by wading birds and ultimately reduce energy intake.

Because the tracked vehicles exert only 3 or less PSI (CRC 2006) on the soil, the likelihood of altering the microtopography and increasing invasive plant density is low—assuming activities are conducted when soils are not wet. Increased water turbidity is moderately likely, but the area of impact is so localized and ephemeral as to be insignificant to wading bird foraging. The likely area of altered

microtopography in which invasive plants could get started and the area of potential water turbidity is small and restricted to the area immediately around the vehicle path. Also, any increased turbidity is likely to be short-lived and therefore of low severity. However, delayed impacts associated with turbidity-generated anoxia and algal blooms (described earlier) should be considered—especially in larger pools. Follow up these efforts with invasive plant control and leveling out the soil surface to pre-disturbance topography. Over all, it would be ideal to simply avoid areas with standing water.

2.7.3 Phone Layout

The stressors from phone layout come from the presence of people, ORVs, and helicopters. The impacts, likelihood of impacts, severity of impacts, and recommendations are the same as for the initial survey (see above).

2.7.4 Seismic Acquisition

The stressors from seismic acquisition come from the blast noise and the blast shock. Blast noise is a direct impact and could affect both wading bird foraging flocks and colonies whereas blast shock is an indirect impact, with a potential affect on wading bird prey.

2.7.4.1 Wading bird foraging flocks (response to blast noise)

The impacts of blast noise on foraging wading birds is to cause them to fly to another site in the worst case, and interrupt their feeding in the mildest case (DEG, personal observation, Rodgers and Smith 1995). A noise level of 132 dB is comparable to a thunder clap, which would likely be loud enough to flush birds if it occurred in an unexpected situation, as with blasting (CRC 2006). At a distance of 354 ft (108 m) (the farthest distance for which data were presented) the blast noise decreases 27% to 97 dB (CRC 2006). At 1,847 ft (563 m) the noise is expected to attenuate to near background under the “most likely” scenario (CRC 2006). There are no published data with which to gauge the response by birds to a blast at that level, but we can expect the distance threshold for a disturbance response by birds to be considerably less than that of background noise.

If there is shallow surface water present and birds are in the area foraging, the likelihood of an impact from blasting is moderate. Given that operations call for crews to spend only minutes at a site before moving on (CRC 2006), the potential for a severe impact to a bird is low. We recommend not to blast within 328 ft (100 m) of foraging birds if possible. If blasting nearer to a flock cannot be avoided, it is preferable to move quickly through the area so as to impact as little of the area at one time as possible.

2.7.4.2 Wading bird foraging flocks (response to blast shock)

There are no direct impacts on wading birds expected from the blast shock; however, blast shock could cause mortality in fishes and therefore could reduce prey availability and ultimately energy intake for wading birds. Whereas there are numerous references on fish mortality from blast shock emanating from charges in open water, there is considerably less published work on fish mortality from blast shock emanating from imbedded charges, other than to note that the effects are weaker in the case of the latter. There is also little information on the effect of blast shock on amphibian larvae (e.g., pig frog tadpoles).

In an unpublished report, Lawler et al. (2002) used a simulation model (I-Blast) that predicted fish mortality in open water as a function of charge size. They then applied a reduction factor to approximate fish mortality from a 35 lb (16 kg) imbedded charge. They estimated that 1 % mortality occurred at 69 ft (21 m) for fish 2.5 lb (1.1 kg) in size, whereas it was 33 ft (10 m) for a larger fish 14.9 lb (6.8 kg). A linear regression model fit to these values predicts that 75.5 ft (23 m) is the distance for 1 % mortality of a 0.2 oz (0.6 g) fish typically consumed by wood storks (Ogden et al. 1976). The simulation study charge was seven times greater than the charges to be used in Nobles Grade. If we assume the relationship between charge size and blast shock is linear, then the expected distance for 1% mortality of a 0.2 oz (0.6 g) fish from a 5 lb (2.3 kg) imbedded charge is about 9.8 ft (3 m). If we apply a buffer of 9.8 ft (3 m) around each of the 5,136 source points (CRC 2006) likely to be placed in the NGA, then the collective area within which wood stork prey fish will be killed is about 37 acres (15 ha). About 80 % of Nobles Grade is wetland habitat, meaning that we could expect that about 30 acres (12 ha) of area would be suitable for wood stork foraging when hydrologic conditions are appropriate.

When fish in BCNP are concentrated during the dry season their biomass ranges greatly (1-173 g/m²; Carter et al. 1973). In the Everglades, mean fish biomass at a large sample of random drying sites, defined as having less than one-third of a site covered with surface water, was 48 g/m² (Gawlik and Botson 2009). That conservative density estimate applied over one-third of the 12-ha of wetland habitat would yield an estimate of 4,233 lb (1,920 kg) of fish. About 76 % of those fish (3,217 lb [1,459 kg]) could be expected to be consumed by wading birds during the dry season (Kushlan 1976). A pair of wood storks requires about 443 lb (201 kg) of food over the nesting season (Kahl 1964), meaning that about seven wood stork pairs and their young could theoretically be supported by the fish in that 30 acres (12 ha) of marsh. However, the number of storks that actually consume that amount of fish biomass is likely to be much smaller because nesting storks in the Everglades almost always feed with other species of wading birds (Herring 2007), which are also consuming fish. Wood storks might make up 10% of a mixed-species foraging flock so therefore we could expect the area of marsh impacted by blasting to represent the food consumed by 0.7 wood stork pairs and their young. This is not a large number of storks. However, because the species is endangered, any potential reduction in numbers is noteworthy.

If blasting is conducted within 9.8 ft (3 m) of surface water, there is a high likelihood of impacts. The cumulative area of impact across the entire NGA would be large, but it would reduce prey for a small number of storks. Therefore, the overall severity of impacts would be low. In this particular case we would recommend not to blast within 9.8 ft (3 m) of any surface water. Further, as recommended earlier in the water quality section, detonation of energy sources within 50 ft of surface water should include monitoring of water quality conditions to understand and minimize impacts on aquatic organisms, which may serve as prey to wading birds.

2.7.4.3 Wading bird colonies

The effects of blast noise were examined qualitatively at a wood stork colony less than 328 ft (100 m) from Tamiami Trail in ENP (Steinkamp 1997). There was no noticeable impact on the colony from blasting approximately 984 ft (0.3 km) away; however, because the location of the colony was along a busy highway it is likely that the birds were already habituated to loud noises and would therefore be less sensitive to impacts from blasting. It is clear that when drilling activity and noise are moved close to an existing colony, wading birds will abandon their nests (Mueller and Glass 1988).

There is not likely to be an impact of blast shock because the impacts from blast noise extend farther from the source and will likely be the first to cause a response from the birds. If a colony is near an area of blasting, there is a high likelihood of impacts from blast noise. However the occurrence of a stork colony within the NGA is rare and therefore the likelihood of impact is low. If impacts from blast noise occur, they are likely to be in the form of nest abandonment, and are therefore severe. Here, we recommend not to blast within 1,640 ft (500 m) of an active colony. We also recommend CRC consider conducting biweekly aerial nest surveys in BCNP to document proximity of colonies to work area.

2.7.5 Phone Pickup, Repair and Restoration

With regard to the stressors come from the presence of people, ORVs, and helicopters. The impacts, likelihood, severity, and recommendations are the same as for the initial survey.

2.7.6 Delayed or Long-term Impacts

The final set of potential impacts considered are those that may not be evident for several years. For example, if the 5000 or more planned blasts fractured the bedrock and shortened the hydroperiod of marshes, it could reduce over several years the production of prey animals that serve as food for wading birds. Whereas there have been a number of long-term impacts stemming from mineral extraction (Ko et al. 2004, Liebezeit et al. 2009), we could find no mention in the literature of such impacts with 3-D seismic exploration.

2.7.7 Summary of Wading Bird Recommendations

The most important recommendation in terms of minimizing a potentially severe impact is to avoid disturbing active nesting colonies of wading birds, particularly those containing wood storks. Effects on colonies could be reduced to negligible if repeated flights from helicopters and blasting were kept at least 0.3 mi (0.5 km) from active nesting colonies and if personnel on foot or ORVs were kept at least 328 ft (100 m) from colonies. Knowing the location of active nesting colonies as they form is critical, so some monitoring prior to work and throughout the dry season is recommended (see monitoring below).

The second most important recommendation is to avoid areas with surface water. This reduces both the impacts to foraging habitat as well as possible impacts to foraging flocks of birds. If personnel on foot or on ORVs stay more than 328 ft (100 m) from areas with shallow water until after they dry, the impacts on foraging birds would be negligible. Blasting should be over 9.8 ft (3 m) from any standing water to reduce the chance of fish mortality and blasting should be greater than 328 ft (100 m) from foraging birds to avoid disrupting feeding patterns. Direct disturbance to flocks can be reduced by altering helicopter flight paths if repeated helicopter flights will be made along the same flight path and it is near large foraging flocks. If flocks must be disturbed, it is better to vary flight paths and affect multiple flocks one time than to affect one flock multiple times. Indirect impacts to foraging habitat can be minimized by restoring the soil surface to pre-blasting condition and by conducting invasive plant control for years after exploration.

2.7.8 Monitoring and Data Needs

Wading bird colonies are very sensitive to disturbance (Rodgers and Smith 1995) and they are important from a population perspective because they contain the annual reproduction for a cohort of birds. The location and species composition of colonies varies annually depending on hydrologic conditions (Bancroft et al. 1994). These parameters cannot be predicted reliably from a model, so it is necessary to collect that information from repeated field surveys. Unfortunately, no such surveys are regularly conducted in BCNP. Thus, a critical information need is the location and species composition of wading bird colonies in the NGA and surrounding marshes. This information must be obtained within the same nesting season in which work is planned but before work actually begins.

Standardized aerial nesting surveys are well established and conducted monthly in the Everglades region as part of the Comprehensive Everglades Restoration Plan. Survey methods could be the same as those in the Everglades or modified slightly to account for the different vegetation in BCNP. Colonies can form fairly quickly so a two-week interval between surveys during the times when colonies could form (January – April) would be desirable.

The location of wading bird foraging flocks would be useful to crews and helicopter pilots trying to avoid them. Such information could be collected by exploration ground crews and pilots while work is underway. Because nesting wood storks in the Everglades feed in mixed species flocks 99% of the time (Herring 2007), it isn't essential that personnel are able to distinguish storks from other species of white wading birds. This is difficult from the air for all but highly trained observers. However, it is recommended that crews undergo training to be able to identify a wood stork from the ground and that they report the location of any wood storks they observe to BCNP staff.

2.8 Impacts on Red-Cockaded Woodpeckers

Although BCNP includes portions of Collier, Monroe, and Miami-Dade counties in south central Florida, the federally endangered red-cockaded woodpecker (RCW) is known to currently occur only in the Collier and Monroe county portions of BCNP where it occupies hydric slash pine flatwoods that are interspersed with sawgrass prairies, baldcypress, and hardwood hammocks (Patterson and Roberson 1981; also see map in Anonymous, undated). Although the Addition Lands were acquired in 1988, there has not yet been a systematic search for RCWs on those lands. The existence of known RCWs on lands with similar habitat to the west, northwest, and south suggest the strong possibility that they may be present in the NGA. Potential RCW habitat in the NGA seems of poor quality, but is similar to that in these other areas. Our recent assessment of Nobles Grade habitat is thus far based on aerial photographs, pine habitats visible from I-75, and pines observed while hiking along the Florida Trail section, which passes north along the old Nobles Grade road from the I-75 rest area—approximately midway through Nobles Grade.

Until systematic surveys have shown otherwise, we can only assume that RCWs are present. Alternatively, GIS-based mapping of potential RCW habitat may help to shed light on quality and quantity habitat available in the NGA. If RCWs are not currently present, the area still remains vital to the survival of the species in south Florida as a habitat link between known populations to the northwest, south, and west. The available pine habitats of the NGA should be protected and managed in a manner conducive to the eventual establishment of populations through natural immigration or translocation. Indeed, Collier County has justified their RCW Habitat Conservation Plan proposal in part on being able to allow development of RCW habitat on private lands to the west of Big Cypress because birds from those lands could be translocated to BCNP where habitat is being conserved and managed for the species (Anonymous 2009).

The following assessment of the potential impacts on RCWs associated with O&G exploration and production within the BCNP is predicated on the likely occurrence of this endangered bird in the NGA now and the need for additional habitat for growth and stability of regional populations of this species. This assessment focuses

specifically on the potential impacts on RCWs from the use of 3-D seismic techniques to search for O&G in the NGA and impacts are summarized in **Table 2.5**.

Activities, equipment, and number of personnel projected to be involved with the 3-D seismic exploration could have a diversity of negative environmental impacts, and many questions remain unanswered as a result of lack of available scientific information. The sensitivity of the birds to human activities during the period from courtship to egg laying, raising of young, fledging of young, and post-fledging care of young varies with (1) proximity to cavity trees – especially an active nest tree; (2) stage of the nesting cycle; (3) time of the disturbance during the day; (4) weather conditions in the days and hours leading up to, during, and following the disturbance; (5) the nature of the disturbance, (6) the duration of the disturbance; (7) the novelty of the disturbance (relative to experience of the birds); and (8) the individual “quirkiness” of the specific birds. Before detailing individual potential impacts we provide background information and rationale by briefly discussing the biological significance of these issues and RCW sensitivity to disturbance.

2.8.1 Proximity of the Disturbance to RCW Cavity Trees

In general, the closer a disturbance is to a cavity tree or nest tree, or to the birds themselves, the greater the potential for an impact. The most recent revision of the USFWS Recovery Plan for the RCW (USFWS 2003) calls for establishment of a buffer of continuous forest, 200 ft (61 m) in width, usually to be established around the minimum convex polygon containing a group’s active and inactive cavity trees. The fragmented configuration of pine forest in the BCNP ecosystem will not always allow for a 200 ft (61 m) buffer of continuous pine forest, thus diminishing the availability of food and the noise and visual buffering effect of forest for the birds within the buffer area. A larger buffer may be needed and should be determined by observations of bird response. The South Florida Ecosystems Multi-Species Recovery Plan (USFWS 1999) section on RCWs does not address buffer requirements for such disturbances near cavity trees in south Florida.

Our expertise in this area suggests that the 200 ft (61 m) buffer requirement as defined in the species Recovery Plan should be considered minimal for intense foot traffic (surveying crews), transient ORV traffic, and sonic drilling activities. Further, activities requiring more than 15 minutes use of noise-producing equipment, and multiple individuals (i.e., sonic drilling for energy source placement) should conservatively be kept outside of a 400 ft (122 m) buffer during the period between 15 March and 15 June. This distance is based on observations of RCW behavior at various stages of the nesting season at Ft. Polk, Louisiana, and Ft. Benning, Georgia, in which the birds responded negatively (i.e., stayed away from the cavity or left the area) when military vehicles and personnel were present at distances of more than 200 ft. and less than 400 ft (122 m) (JAJ, personal observation).

It is essential that, prior to any initiation of the 3-D seismic activities in BCNP, there be a thorough systematic search for RCW cavity clusters within the project area.

Cavity clusters located should be monitored throughout the 3-D seismic activities in order to know the stage of the nesting cycle at each. All activities should be kept away from cavity clusters with an active nest as described above.

2.8.2 Stage of the RCW Nesting Cycle When the Disturbance Occurs

The proposed timing of the 3-D seismic operations between December and May coincides with the period during which RCWs court, lay and incubate their eggs, and raise their nestlings (see **Figure 2.1**). The timing could not be worse. Red-cockaded woodpeckers are known to have eggs in the nest by mid April in southwest Florida and are also known to fledge young by the end of May and late nests or re-nesting efforts have occurred well into late summer (Jansen and Patterson 1983). While these events are sometimes considered indicative of the beginning and end of the nesting season, such consideration is an unjustified imposition of arbitrary boundaries on reproductive activity of the birds. To begin, too few data are available to adequately define when the earliest eggs are laid in the population or even to identify the average date by which eggs are laid. Similarly, we do not know how much later RCWs might have young in the nest. More importantly, reproductive activities do not begin with egg laying. They begin with courtship, which might commence 6 weeks or more before the first egg is laid. Also, fledging of young does not end the reproductive effort. The young continue to be dependent on their parents for weeks following fledging and, for a time following fledging the young stay relatively stationary, depending on the adults to bring food to them.

There is evidence of successful double-brooding in RCWs in three populations in north Florida (Schillaci and Smith 1994, Phillips et al. 1998) and in more northern populations (LaBranche et al. 1994), but none yet reported from south Florida. Double-brooding, however, might be expected in south Florida because of the subtropical climate and late re-nesting is known (Jansen and Patterson 1983). In view of the low productivity of the population, re-nesting could be an important factor in assuring survival and growth of the RCW in the BCNP. We do not currently have this information, but if the BCNP population does successfully produce a second brood, this would further extend the length of the breeding season and any limitations placed on activities during the breeding season for this species perhaps into August.

Nothing is known of the potential impacts of disturbance on RCWs during courtship, but this is likely to be a sensitive time. Since parental investment is low, the potential of aborting a reproductive attempt would be expected to be higher. With each step along the way towards fledging young, parental investment increases and the birds are less likely to abandon a reproductive effort. Thus, potential for abandonment of a reproductive effort would be lower once eggs have been laid than during courtship. It would be even lower once those eggs have hatched and with increasing age of the nestlings. In general, early stages of a nesting effort are the most vulnerable stages.

Other factors, however, are involved. For example, if an adult is kept from entering a nest to incubate, there is a high potential for embryo mortality. If eggs have hatched, but the chicks have not yet developed the ability to regulate their body temperature physiologically, keeping an adult from brooding them has the potential of causing chick mortality. If parent birds are kept from delivering food to chicks, there is a greater impact and increased potential for death in younger chicks.

2.8.3 Time of the Disturbance during the Day is Important for RCWs

Early morning and late afternoon are critical times when there are chicks in a RCW nest. The younger the chicks are, the more critical the timing is. The chicks are not fed at night and thus between the time the adults go to roost in the evening and the time they emerge to begin feeding in the morning, the chicks must fast. In order for the chicks to survive this daily and lengthy period without food, the parents must feed them as much as they can before they go to roost in the evening and must begin feeding them and feed them as much as they can quickly in the morning. In general, for RCWs in south Florida, no activities should be conducted near a nest tree during the periods between 4 p.m. and sunset, and between 6 a.m. and 9 a.m. These are the periods of greatest feeding activity.

2.8.4. Weather Conditions Can Modulate Impacts on RCWs

Rain or unseasonably cool weather can result in the need for more food for both adults and nestlings. These conditions also require enhanced incubation effort requiring the adult birds to spend more time on their eggs and less time gathering food. Such conditions can also result in adults having to spend more time brooding small young, thus having less time to get food for themselves and their young. If the previous day or the day of the proposed activity is rainy or unseasonably cool, there is an increased potential of egg or chick loss. If the day following a proposed activity is predicted to have rain or unseasonably cool weather, it also means that chicks will need all the food they can get on the previous day. Proposed activities with a high level of probability of disturbing the birds should not be conducted near an active RCW nest under these conditions.

2.8.5 The Nature of the Disturbance Affects Severity of Impacts on RCWs

The following statements describe a range of activities (intensity and duration) and expected impacts on RCWs based on details provided above. In each case, the severity of impact to RCWs would increase with (1) increased proximity to a nest tree, (2) with deteriorating weather conditions, (3) with earlier stages of the nesting cycle, and (4) with pre-existing stress in the birds such as caused by bad weather; excessive, prolonged, novel noise [see below]; or presence of a potential predator, cavity competitor, or birds from another group.

- (a) *One or two individuals walking quickly through an active cavity tree cluster* usually would have minimal impact on the behavior of the birds and success of a nesting effort.
- (b) *An ORV quickly passing through a cavity tree cluster* would have a greater impact than individuals quietly walking through, but the impact would likely be inconsequential if it took less than 5 minutes and if the birds were not already stressed as above.
- (c) *A helicopter quickly passing by at 200 ft (61 m) above the trees* would likely have minimal impact, perhaps briefly keeping an adult off a nest. Red-cockaded woodpeckers usually do not fly above canopy level, thus potential of a collision with a bird would be miniscule.
- (d) *A helicopter hovering above an active nest* would have a much greater impact and that impact would increase with the duration of the activity and the proximity (horizontally and vertically) of the helicopter to the birds or their nest. Based on observations of the responses of birds to military helicopters at Ft. Polk, LA and Ft. Benning, GA, helicopter movements other than a quick “pass-through” should be kept a minimum of 1,000 ft (305 m) from active cavity clusters. Section 4 of Federal Aviation Regulations addresses “Bird Hazards and Flight Over National Refuges, Parks, and Forests” and requests pilots to maintain a minimum altitude of 2,000 ft (610 m).
- (e) *A drilling rig moving to within 200 ft (61 m) of an active nest, setting up, drilling a hole, and placing the energy source* could have moderate potential of causing failure of the nesting effort early in the nesting cycle in good weather and without other stresses on the birds. The potential for failure of the nesting effort or loss of one or more embryos or chicks would increase with cooler or rainy weather or the presence of other stress factors. If such activities were 400 ft (122 m) from an active nest, and late in the nesting cycle (when well-feathered young are present) the potential for a negative impact on the birds’ behavior and their chicks is likely (but not certainly) to be minimal.
- (f) *Energy source detonation a horizontal distance of 200 ft (61 m) or more from an active nest tree* is likely to have only a minimal impact on the birds’ behavior – perhaps causing an adult to leave a nest tree for a short time. If other activities are continuous with the discharge and just outside the 200 ft (61 m) buffer, the impact on the birds would increase and the severity of the impact would depend on all of the varying factors mentioned above. For impacts of noise (such as the discharge of an explosive charge, noise made by equipment, helicopter noises, and other noises made by those associated with the project) see the discussion below on the novelty of a disturbance.

2.8.6 Long-term and Indirect Impacts on RCWs

2.8.6.1 Long-term impacts

Potential long-term impacts on RCWs from activities, equipment, and numbers of personnel projected to be involved in O&G exploration in BCNP fall into two categories: those that are related to losses of birds or their nesting efforts and those that are related to fundamental changes in habitat due to the physical disturbances of 3-D seismic activities described earlier. The potential severity of the long-term impact of losses of birds or their nesting efforts depends on (1) how large a population of RCWs exists in the NGA, and (2) the frequency of immigration into the population from breeding groups elsewhere on BCNP or from breeding groups outside of BCNP. The fewer the number of breeding groups in the area and the lower the rate of immigration into the area, the greater would be the potential impact. In a worst-case scenario, loss of birds could result in the extinction of the RCW in the NGA. Such a loss, especially if accompanied by loss or degradation of habitat, could result in increased isolation of other populations, thus threatening the species regionally.

2.8.6.2 Indirect Impacts

Indirect impacts on RCWs can occur as a result of changes in habitat within the NGA as a result of the following 3-D seismic impacts: (1) creation of ruts by equipment used, thus altering the flow of water and the hydroperiod within the area and reducing the quality of the habitat for growth and reproduction of the pines needed by the RCWs; (2) killing of slash pines as a result of infestations of southern pine beetles (*Dendroctonus frontalis*) or other injurious insects attracted by damage to the pine trunks, crushing of seedlings, and compaction and other damage to roots of pines; (3) introduction or spread of exotic plant or animal species within the area; (4) creation of new paths that would likely be used by recreational ORV users; (5) ignition of a wildfire by human action or equipment use; (6) synergism between impacts caused by the 3-D seismic activities and those of other users (hunters, ORV users, etc.) of BCNP; and (7) synergisms between impacts caused by the 3-D seismic activities and those caused by natural events such as lightning-started fires, violent storms, or climate change. South Florida is vulnerable to hurricanes and we have the example of the near total loss of cavity trees in one of the largest populations of RCWs when Hurricane Hugo hit the Francis Marion National Forest (Hooper et al. 1990). Maintaining a population of RCWs dispersed over a large area, but connected by suitable habitat is essential to their survival in south Florida.

Damage to vegetation can be anticipated as a result of the numbers of individuals working in the field, the transport of those individuals via ORVs, and the delivery, deployment, and use of equipment associated with the 3-D seismic effort. Damage can occur as a result of scraping or other injury to pine trunks, crushing of seedlings, and compaction and other damage to roots. All such damage has been associated with increased infestations of southern pine beetles and other insect pests, which cause extensive mortality to pines (Nebeker and Hodges 1985, Hicks et al. 1987, Conner and Rudolph 1995, Meeker et al. 1995). Southern pine beetles are a major cause of the death of cavity trees and potential cavity trees (Conner et al. 1998, 2001).

Damage to young or old pines as a result of drill rig movement, ORV traffic, and increased human activity in BCNP increases the risk of mortality to slash pines due to southern pine beetles. Short-term impacts could be both positive and negative. On the positive side, RCWs are attracted to southern-pine-beetle-infested trees and feed on the beetles, providing them with a short-term increased food supply. On the negative side, the death of a cavity tree due to southern pine beetles would result in an immediate cessation and drying of gum flow in the tree and lead to an increased risk of predation on an adult RCW that had been using the tree as a roost site or to nestlings if the tree was an active nest site. Death of a cavity tree also would likely preclude future use of the cavity by RCWs.

Creation of ruts opens the area to increased potential invasion by cattails (Newman et al. 1998). The increased spread of cattails in the BCNP ecosystem would likely further alter the hydrology of the region, having a negative long-term impact on the RCW and its required pine habitat.

2.9 Impacts on Threatened and Endangered Mammals

Disturbances have qualitative, spatial, and temporal attributes that affect mammalian responses to them. Behavioral response and magnitude differs by species and among individuals within a species depending on the type, novelty, frequency, predictability, location, and timing of the disturbance (Hook 1986, Morgantini and Bruns 1988, Gillin 1989, Morgantini 1991, Cassirer et al. 1992, Knight and Cole 1995, Van Dyke and Cline 1996, Dees et al. 2001, Dickson and Beier 2005, Cline et al. 2007). Although several studies of the impacts of O&G activities on wildlife exist, many of these studies were largely observational, poorly designed and implemented, lacked sufficient controls, replication, monitoring, or duration, and failed to produce results that could be scaled to the population-level (Hebblewhite 2008). Some studies have examined the impacts of resource extractive activities on bears (*Ursus*; Reynolds et al. 1983), but we are not aware of studies that have examined 3-D seismic surveying or oil extraction impacts on panther, fox squirrel, or mink. We will attempt to generalize potential impacts of proposed 3-D seismic activities on threatened and endangered mammals of BCNP, and make recommendations for mitigation. Refer to **Table 2.6** for a summary of these potential impacts.

2.9.1 Direct Impacts on BCNP Mammals

Direct impacts occur where a causal relationship can usually be identified between a disturbance stimulus and an animal response, and without impacts mediated through an intermediate species. These include, but are not limited to, death, injury, physiological changes (e.g., increases in stress hormones), displacement (e.g., abandonment of home range, den, and/or offspring), avoidance (avoiding suitable habitat at or near stimulus), other marked behavioral changes, and altered fitness

(Cline et al. 2007, Hebblewhite 2008). Direct impacts can usually be measured at shorter time-scales, but inferences are frequently limited to individual animals and often cannot be generalized to the overall population (Cline et al. 2007). The most probable direct impacts from 3-D seismic exploration on the four listed mammals include: 1) injury or death from animal-vehicle collision, 2) increases in stress levels, 3) abandonment of home ranges, denning sites, and litters, and 4) avoidance of habitat at or near disturbances.

2.9.1.1 Road mortality

As stated in the species summaries in **Section 1.6**, panthers and bears are frequently killed on roads, the majority of which occur on highways, including Highway 41 and Interstate 75 that bisect BCNP. Panthers are regularly tracked on the many dirt roads that occur throughout public lands in south Florida (McBride 2007). Dickson and Beier (2005) observed that cougars in California avoided two-lane paved roads but may have used dirt roads to facilitate movement. Bears in both Florida (J. Guthrie, unpublished data) and Kentucky (R. Jensen, unpublished data) use dirt roads as travel corridors, especially during crepuscular and nocturnal times when human activity is minimal. However, bear-vehicle collision risk increases where humans dispose of trash or food along roads (Shideler and Hechtel 2000). Although mink and fox squirrel are also killed on roads, the likelihood of this is probably much higher on limited access highways that border or dissect prime habitat for these two species. Construction and use of access-controlled, one-lane roads will likely pose a minimum road-collision risk to these species, and in the case of the panther, its prey (deer and hog), because: 1) exploratory activities will occur during daylight hours when panther, bear, deer, and mink are much less active than at crepuscular or nocturnal times, and 2) traffic is anticipated to be of low volume and speed.

The construction of new roads and improvement of old ones is perhaps more of a threat to listed mammals in this region of south Florida because they provide conduits for ingress into previously inaccessible areas. Illegal use of these roads, particularly by poachers, ORV users, and other persons may create additional sources of disturbance, harassment, injury, and death for wildlife.

Recommendations- To reduce the risk of vehicle-animal collision and illegal use of new or reactivated roads, we recommend:

- ∞ new road construction be minimized
- ∞ security-controlled access to newly constructed roads, particularly from paved roads or current navigable roads and trails
- ∞ maintaining close communication and cooperation with agency law enforcement
- ∞ slow-speed patrol of new roads to prevent back-trail incursions onto new roads

- ∞ slow maximum speed (20-30 mph [32-48 kph]) on newly constructed exploratory roads, and that drivers stop for all wildlife in their path
- ∞ crews should be educated about bear nuisance behavior
- ∞ litter enforcement should be emphasized, and bear-proof garbage cans and dumpsters should be installed and located away from main roads

2.9.1.2 Physiological stress

Wildlife studies during the past two decades have increasingly examined physiological stress responses of animals to various stimuli (e.g., Millspaugh and Washburn 2004, Millspaugh et al. 2007). Noise, visual sightings, and scent of humans, vehicles, and equipment are types of disturbances that may cause animals to become acutely or chronically stressed depending on when, where, and how long exposure to the stressors occur (e.g., MacArthur et al. 1982). Stress-induced changes in animal behavior can lead to decreased fitness or even death.

The short-term duration (~6-7 months) of the proposed exploratory activities, from initial survey through restoration and cleanup, are most likely to cause acute rather than chronic stress to animals that experience them. Given the intense management efforts and recent historic patterns of recreational users, most animals in BCNP are likely to have experienced some form of human disturbance, including hunting, ORVs, hikers, research activities, fire crews, invasive species crews, low altitude fixed-wing survey flights, helicopter surveys, and helicopter-based invasive species eradication. Some individual animals may be conditioned to a multitude of human activities and experience little stress when the proposed oil exploratory activities occur (Tietje and Ruff 1983), while others may experience high stress levels, particularly those with increased sensitivity and vigilance to human activities (e.g., hunted species such as deer), younger animals which lack exposure to human activities, or those disturbed during sensitive biological periods such as denning (Cassirer et al. 1992). Animals will not have experienced noise from underground seismic detonations, although at a distance this may approximate noise generated by a thunder clap or gun shot for some species.

2.9.1.3 Abandonment of home ranges, dens, and offspring, and avoidance of suitable habitat

Human disturbances can cause wildlife to temporarily or permanently abandon feeding areas, home ranges, denning sites, and offspring (Altman 1958, Easterly et al. 1991, Gillin 1989, Wilker and Barnes 1998). Large, wide-ranging carnivores are more likely to persist when they have expanses of relatively undisturbed, quality habitat (Clark et al. 1996). Panthers have increased in number despite continued recreational activities in BCNP. Female panthers have not been observed to abandon a den site or kittens after researchers visited these sites (D. Land and D. Jansen, personal communication; albeit this occurred when females were away from the den). Although Janis and Clark (2002) did not detect negative influences of hunting

on Florida panther, other studies examining human activities on the subspecies are lacking.

Because panthers have such large home ranges, they, like many wide-ranging mammals, can temporarily shift activities to other portions of their home range to avoid disturbance. Although unlikely, disturbances from oil exploratory activities and associated human activities could cause panthers, particularly younger individuals and those unconditioned or sensitive to such stimuli, to temporarily or permanently abandon preferred habitats and territories. Movements of panthers into unfamiliar areas occupied by other panthers increases the likelihood of intraspecific strife and mortality, crossing of highways and risk of vehicle collisions, and other injurious or lethal encounters with humans. While the perceived risk for these types of events may be small given the transient nature of the proposed exploratory activities, each panther would represent approximately 1% of the current estimated total population.

Both white-tailed deer and hogs (i.e., panther prey) have coexisted with human disturbance and hunting pressures in BCNP, and thus are likely vigilant to and will flee from any human activity to reach escape cover. However, white-tailed deer exhibit a very high fidelity to home ranges and rarely abandon them as a result of human disturbance (Thomas et al. 1964). Hebblewhite (2008) examined several studies of ungulate species in the western U.S. and found that spatial and temporal avoidance of extractive activities varied by species and individuals within; avoidance responses to human development averaged 0.6 mi (1,000 m) from the human disturbance. In most studies, ungulates returned to areas of extractive disturbances once they became conditioned to them or after extractive operations ended.

Black bears are perhaps the world's most adaptable bear species because they can use a variety of native habitat types and tolerate many human activities and associated disturbances (Pelton 2000). Even at den sites, bears tolerate high levels of disturbance (JJC, unpublished data, Pelton 2000), particularly females that usually den in more secure and inaccessible locations. When humans disturb dens, females with newborn cubs may temporarily flee and return later when the disturbance is gone. Like panthers, black bears are wide-ranging and can have large home ranges in which they can shift activities to avoid humans. As such, the likelihood of exploratory activities permanently displacing a bear from its territory is low. However, given the number and size of bears in BCNP, it is likely that the species will be encountered, particularly by helicopter.

The secretive habits of mink have largely precluded behavioral studies and made population assessment difficult. As such, the scientific literature provides little guidance as to the potential behavioral response of or fitness costs to the species as a result of oil exploration activities. Fox squirrel would be most directly impacted by removal of nesting trees, but their response to other oil exploration activities is unknown. Fox squirrel in south Florida occasionally use golf courses and suitable

habitat near urban areas, and thus appear to have some tolerance of human activity. However, removal or reduction of the canopy layer could lead to increased local predation of fox squirrel by raptors. We can only speculate that mink and fox squirrel would likely be only temporarily displaced and not permanently abandon dens, litters, or territories as a result of seismic oil exploration activities, particularly if activities were limited to upland habitat that avoided sites where fox squirrel were known to occur.

Recommendations- To reduce the likelihood of habitat avoidance, stress, and risk of abandonment by TEMS, particularly during critical biological periods, we recommend operators:

- ∞ Conduct operations outside of mating and denning seasons. The least amount of overlap with these critical biological periods during a continuous 6-month window would be from July thru December To best avoid these periods, all activities should be conducted in a \leq 3-month October to December window during a single year, or divided across 2 consecutive years during this fall period.
- ∞ Minimize the number of personnel, equipment, space used, and time spent in one area for all operations.
- ∞ Synchronize charge detonation to reduce disturbance duration.
- ∞ Shut down loud vehicles and equipment when not in use.
- ∞ Minimize low altitude helicopter use and time per unit area.
- ∞ Minimize new road and staging area construction footprints.
- ∞ Locate staging area as close to I-75 as possible
- ∞ Work closely with wildlife agencies to avoid active panther areas, including den locations.
- ∞ Establish and enforce policies that prohibit wildlife harassment.
- ∞ Minimize destruction of vegetation and other habitat
- ∞ Immediately contain and clean-up contaminant spills
- ∞ Restore damaged habitat

2.9.2 Indirect Impacts on BCNP Mammals

Indirect impacts occur where a disturbance stimulus is mediated through an intermediate species, and where cause-effect relationships are more difficult to determine (Hebblewhite 2008). These include effects such as alterations in habitat quantity, quality, or species composition, and increases in predator or prey numbers that ultimately affect fitness (Cline et al. 2007, Hebblewhite 2008). Indirect impacts are usually measured at longer time-scales and are more difficult to study (Cline et al. 2007). The most probable indirect impacts from 3-D seismic exploration on the four listed mammals include: habitat changes and alteration of prey numbers.

Where there is human activity, large carnivores have fared poorly or become extinct (Woodroffe 2000), primarily as a result of direct killing of carnivores and their prey, but also because of habitat loss and fragmentation. The proposed 3-D

seismic activities will cause some habitat changes as a result of removal, cutting, and trampling of vegetation, road building, altered hydrology, and soil compaction. Cumulatively, these alterations could result in several dozen to a few hundred acres of habitat loss, but with the exception of the staging area, would be widely dispersed over NGA. These activities would likely influence a relatively minor portion of the home range of any individual panther or bear, and thus would be unlikely to cause significant short or long-term negative effects, so long as these changes did not significantly influence fire regimes. Habitat loss and fragmentation could be more influential on the less far-ranging fox squirrel and mink.

New road construction and reactivation of old roads would likely create fire breaks that could cause local reduction of fire frequency and intensity. That in turn, would lead to an increase in understory growth that reduces soft mast availability for deer that panther must now increasingly rely on. Dees et al. (2001) attributed panther selection of pine flatwoods because it was more frequently burned and likely provided increased forage for deer. Decreased fire frequency would also negatively impact black bear and fox squirrel. Black bear benefit from relatively frequent fire because they feed on soft mast from early successional understory plants (Maehr et al. 2001), and fox squirrels prefer to forage in a fire-maintained savanna landscape. Habitat fragmentation also creates edge habitat where both deer and bear frequently find important plant foods.

For fox squirrel, loss of important nesting, mast-producing, or stringer trees could lead to prolonged declines in fitness at the individual or population level. Habitat loss and fragmentation could isolate fox squirrel populations of which we know little about the size and trends.

The construction of roads will likely alter local hydrology in several ways that impact mink. Road impoundments could lead to local water pooling and concentration of prey species that provide more efficient foraging opportunities for mink and wading birds. Elevated roads may create additional land-water interfaces that mink could use to efficiently move and hunt from, but decreased vegetation cover along these areas and the increased threat of predation from aerial hunters (e.g., hawks and owls) may decrease use by mink. Additionally, structural alterations of wetlands may negatively affect water quality or wetland morphology in ways that cause declines in prey numbers or vulnerability.

Contaminant run-off, leaks, and spills from oil exploration activities could contaminate or kill mink prey and in turn lead to local population decline of mink. In particular, the short- and long-term effects of widespread release of energy source material (dbx Pentolite) on wetlands and associated biota are unknown.

Recommendations- To reduce the likelihood of long-term decrease in fitness and population declines of TEMs as a result of habitat loss, modifications, and fragmentation we recommend operators:

- ∞ minimize road construction and reactivation of old roads

- ∞ minimize habitat loss
- ∞ avoid areas where fox squirrels are found
- ∞ minimize alterations to wetland hydrology
- ∞ immediately contain and clean-up contaminant spills
- ∞ restore damaged habitat, and
- ∞ work with management agencies to ensure fire regimes are maintained.

Table 2.1: Summary of potential impacts on water and soils from 3-D seismic oil and gas exploration in the Nobles Grade area of Big Cypress National Preserve.

Activity	Stressor	Impact	Severity	Likelihood	Recommended alternative to reduce impact	Resulting likelihood
Immediate/ short term effects						
<i>1. Seismic survey</i>	foot traffic	increased water turbidity affecting aquatic life and soil processes	low	high	use extant trails, avoid making new trails	moderate
	foot traffic	soil compaction and rutting affecting surface water pooling and flow	low	high	avoid wet, damp areas; work after drydown; avoid making trails	moderate
	ORV traffic	increased water turbidity affecting aquatic life and soil processes	low	high	avoid low-lying or inundated areas	low
	ORV traffic	soil compaction and rutting affecting surface water pooling and flow	high	high	avoid wet, damp areas, prohibit vehicles from crossing flooded sites; work after drydown	moderate
	ORV traffic	spills of fuel, oil, or other foreign fluids	moderate	moderate	use protective barriers and specialized fuel cans to minimize spills	low
<i>ii. Seismic charge placement</i>	sonic rig	spills of fuel, oil, or other foreign fluids	moderate	moderate	use protective barriers and specialized fuel cans to minimize spills	low

	sonic rig movement	increased water turbidity affecting aquatic life and soil processes	high	high	use extant trails, avoid making new trails	
	sonic rig movement	soil compaction and rutting affecting surface water pooling and flow	high	high	rake ruts, loosen compacted soil, break edges/ridges	low
	drilling	increased turbidity around hole from cuttings and process water	moderate	moderate	avoid drilling in standing water	low
	drilling	discharge of process water and drilling mud	moderate	moderate		
	energy source placement	toxic substance release to groundwater with unexploded material	unknown	unknown		
	bentonite fill	Possible P enrichment, enhanced short-term soil respiration, plant production, etc.	low	low		
<hr/>						
<i>iii. Seismic data acquisition</i>	phone layout and removal	same as foot and ORV traffic above				
	detonation	detonation and ground roll may lead to localized fractures in the cap rock, affecting local surface/groundwater interactions	unknown			
	detonation	lateral movement of shock wave may force reduced groundwater into nearby shallow pools	unknown		monitor immediate surface water in pools in proximity to shot-holes	

	end-products of detonation	excess oxidized N from detonation toxic to fish and other aquatic life	unknown		groundwater should be monitored	
<i>Delayed and Long-term impacts</i>	nutrient additions and soil alterations activities that contribute to surface water turbidity	increased potential for exotic invasion	moderate	high	minimize inputs and avoid soil compaction/disruption	moderate
	end-products of detonation	increased water turbidity may lead to changes in soil respiration and possibly algal mats at the surface	low	unknown	use extant trails, avoid making new trails	moderate
	end-products of detonation	if transmitted downstream via groundwater towards near-shore zone, may fuel offshore algal blooms	unknown	unknown	should be monitored	
	bentonite fill	P enrichment may lead to long-term change in soil and plant structure	unknown	unknown		

Table 2.2: Summary of potential impacts on vegetation from 3-D seismic oil and gas exploration in the Nobles Grade area of Big Cypress National Preserve.

Activity	Stressor	Impact	Severity	Likelihood	Recommended alternative to reduce impact	Resulting likelihood
Immediate/ short term effects						
<i>1. Seismic survey</i>	foot traffic	crushing plants	low	high	use extant trails, avoid making new trails	moderate
	foot traffic	crushing endangered plants	severe	moderate	mark populations in pathways, have photo IDs of key rare species in the field, avoid them	low
	foot traffic	dispersal of exotic plants	high	moderate	know major exotics and avoid contact or remove them	low
	foot traffic	soil compaction and rutting	low	high	avoid wet, damp areas; work after drydown; avoid making trails	moderate
	ORV traffic*	crushing plants	high	high	use extant trails, avoid making new trails	moderate

	ORV traffic	breaking trees such as cypress	high	high, especially in dwarf cypress areas	Use existing trails whenever possible; minimize total number of trips along same path; travel over naturally high areas rather than depressions	low
	ORV traffic	crushing endangered plants	severe	unknown because they are rare	mark populations in pathways, have photo IDs of key rare species in the field, avoid them	low
	ORV traffic	soil compaction and rutting	high	high	avoid wet, damp areas, prohibit vehicles from crossing flooded sites; work after drydown	moderate
	ORV traffic	wildfire	severe	low-moderate	Do not park vehicles with hot engines in dry, high grass. Discard cigarette butts properly. Watch for sparks from explosive detonation. Be sure to have fire fighting apparatus.	very low
NB: this happens immediately but needs to be monitored for subsequent effects	creation of disturbed habitat from cumulative effects	invasion of exotics	severe	high	monitor disturbed area for new exotics, remove immediately	low
	creation of disturbed habitat from cumulative effects	invasion of exotics	severe	high	minimize repeat visits to sites	low

ii. Seismic charge placement

sonic drill rig movement	crushing plants	low	high	use extant trails, avoid making new trails	moderate
sonic drill rig movement	crushing endangered plants	severe	unknown	mark populations in pathways, avoid them	low
sonic drill rig movement	dispersal of exotic plants	high	moderate	know major exotics and avoid contact or remove them, Clean equipment prior to start of work to remove any material from previous areas of use. Follow up with invasive plant control if necessary.	low
sonic drill rig movement	soil compaction	high	high	use extant trails, avoid making new trails	
sonic drill rig movement	creation of ruts	high	high	rake ruts, loosen compacted soil, break edges/ridges	low
sonic drill rig movement	breaking trees such as cypress	high	high	Use existing trails whenever possible	moderate
sonic drill rig movement	wildfire	severe	low-moderate	Do not park vehicles with hot engines in dry, high grass. Discard cigarette butts properly. Watch for sparks from explosive detonation. Be sure to have fire fighting apparatus.	very low

	drilling	disturbance of soil and plants in immediate area	severe but localized		unavoidable, but shouldn't drill in areas of rare/endangered plants	low
	placement of bentonite	alteration in soil characteristics; potentially more moisture and nutrients	moderate		monitor subsequently for invasion by exotics on disturbed soil; remove if appear	low
<hr/>						
<i>iii. Seismic data acquisition</i>						
phone layout and removal	foot traffic	crushing plants	low	high	use extant trails, vary routes	moderate
	foot traffic	crushing endangered plants	severe	moderate	mark populations, avoid them	low
	foot traffic	dispersal of exotic plants	high	3	know major exotics and avoid contact or remove them	low
	foot traffic	soil compaction	low	high	avoid wet, damp areas; work after drydown; vary routes	moderate
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detonation	explosion	disruption of plant root systems	unknown	unknown extent and unknown effect	monitor immediate area	unknown
	explosion	disruption of endangered plant root systems	unknown	unknown extent and unknown effect	avoid placing charges in vicinity of endangered species populations	low
<i>Delayed and Long-term impacts</i>	nutrient additions and soil alterations	increased potential for exotic invasion	moderate	high	minimize inputs and avoid soil compaction/disruption	moderate

* = ORV effects same for all other activities that utilize ORVs

Table 2.3: Summary of potential impacts on herpetofauna from 3-D seismic oil and gas exploration in the Nobles Grade area of Big Cypress National Preserve.

Activity	Stressor	Impact	Severity	Likelihood	Recommended alternative to reduce impact	Resulting likelihood
Surveying	Direct Impacts:					
	Vehicle Tracking	running over individuals	High	High	vigilance and avoidance	Low
		collapsing gopher tortoise burrows	High	Low	vigilance and avoidance	None
	ORV & helicopter noise	noise leads to fear immobility	Moderate/High	Moderate	approach slowly to allow habituation time	Low
		permanent hearing loss	High	Moderate	limit duration of noise to less than 9 minutes per location	None
		interference with amphibian breeding choruses	High	Low	avoid breeding choruses	None
	Indirect Impacts:					
Vehicle Tracking	introduction of exotic plant species leading to water contamination from chemical treatment	High	Moderate	clean equipment and boots prior to use in area & after exposure to exotic species; control exotics near amphibian habitat mechanically	None	
	spread of ranavirus or chytrid fungus	High	Low	Disinfect equipment and boots with 4% bleach for 15 minutes prior to use in area	None	
Energy Source Placement	Direct Impacts:					
	Vehicle Tracking	running over individuals	High	High	vigilance and avoidance	Low

		collapsing gopher tortoise burrows	High	Low	vigilance and avoidance	None
	ORV & helicopter noise	noise leads to fear immobility	Moderate/ High	Moderate	approach slowly to allow habituation time	Low
		permanent hearing loss	High	Moderate	limit duration of noise to less than 9 minutes per location	None
		interference with amphibian breeding choruses	High	Low	avoid breeding choruses create less intense noise prior to drilling to allow reaction time	None
	Drill Noise/ Vibration	noise leads to fear immobility	Moderate/ High	Moderate	create less intense noise prior to drilling to allow reaction time	Low
		permanent hearing loss	High	Moderate	create less intense noise prior to drilling to allow reaction time	Low
		interference with amphibian breeding choruses	High	Low	avoid breeding choruses	None
	Indirect Impacts:					
	Vehicle Tracking	introduction of exotic plant species leading to water contamination from chemical treatment	High	Moderate	clean equipment and boots prior to use in area & after exposure to exotic species; control exotics near amphibian habitat mechanically	None
		spread of ranavirus or chytrid fungus	High	Low	Disinfect equipment and boots with 4% bleach for 15 minutes prior to use in area	None
Seismic Acquisition	Direct Impacts:					
	Vehicle Tracking	running over individuals	High	High	vigilance and avoidance	Low
		collapsing gopher tortoise burrows	High	Low	vigilance and avoidance	None

ORV & helicopter noise	noise leads to fear immobility	Moderate/High	Moderate	approach slowly to allow habituation time	Low
	permanent hearing loss	High	Moderate	limit duration of noise to less than 9 minutes per location	None
	interference with amphibian breeding choruses	High	Low	avoid breeding choruses create less intense noise prior to detonation to allow reaction time	None
Detonation Noise	noise leads to fear immobility	Moderate	Moderate	create less intense noise prior to detonation to allow reaction time	Low
	permanent hearing loss	High	Moderate	create less intense noise prior to detonation to allow reaction time	Low
	interference with amphibian breeding choruses	High	Low	avoid breeding choruses create less intense noise prior to detonation to allow reaction time	None
Blast Shock	vibrations contribute to permanent hearing loss	High	High	ensure airblast impacts at burrow site are less than 134 dB	Moderate
	collapsing gopher tortoise burrows	High	Low		None
Indirect Impacts:					
Vehicle Tracking	introduction of exotic plant species leading to water contamination from chemical treatment	High	Moderate	clean equipment and boots prior to use in area & after exposure to exotic species; control exotics near amphibian habitat mechanically	None
	spread of ranavirus or chytrid fungus	High	Low	Disinfect equipment and boots with 4% bleach for 15 minutes prior to use in area	None
Repair	Direct Impacts:				

Vehicle Tracking	running over individuals	High	High	vigilance and avoidance	Low
	collapsing gopher tortoise burrows	High	Low	vigilance and avoidance	None
ORV & helicopter noise	noise leads to fear	Moderate/High	Moderate	approach slowly to allow habituation time	Low
	permanent hearing loss	High	Moderate	limit duration of noise to less than 9 minutes per location	None
	interference with amphibian breeding choruses	High	Low	avoid breeding choruses	None
Indirect Impacts:					
Vehicle Tracking	introduction of exotic plant species leading to water contamination from chemical treatment	High	Moderate	clean equipment and boots prior to use in area & after exposure to exotic species; control exotics near amphibian habitat mechanically	None
	spread of ranavirus or chytrid fungus	High	Low	Disinfect equipment and boots with 4% bleach for 15 minutes prior to use in area	None

Table 2.4: Summary of potential impacts on wading birds from 3-D seismic oil and gas exploration in the Nobles Grade area of Big Cypress National Preserve.

Activity	Stressor	Impact	Severity	Likelihood	Recommended alternative to reduce impact	Resulting likelihood
1. Survey	Crew, helicopter, and ATV presence (direct effect)	Disturbs foraging flocks of wood storks and other wading birds and reduces E intake and lowers fitness and productivity	Low	High	Avoid flocks on repeated overflights of helicopter; If can't avoid then preferable to change flight paths with each flight; personnel on foot or on ATVs should stay > 100 m from flocks and shallow water until it dries completely.	Negligible
	Crew, helicopter, and ATV presence (direct effect)	Disturbs nesting colonies of wood storks and other wading birds causing reduced nest attendance and reduced nest success	High	Low	Keep helicopter > 0.5 km from a wading bird colony if there will be repeated flights along the same path. Personnel on foot or ATVs should stay greater than 100 m from an active colony.	Negligible
2. Energy Source Placement	Crew, helicopter, and ATV presence (direct effect)	(Same as survey - foraging flocks)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)
	Crew, helicopter, and ATV presence (direct effect)	(Same as survey - nesting colonies)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)
	Crew and tracked vehicle (direct effect)	(Same as survey - foraging flocks)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)
	Crew and tracked vehicle (direct effect)	(Same as survey - nesting colonies)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)
	Tracked vehicle (indirect effect)	Increased turbidity temporarily reduces prey availability and E intake of foraging	Low	Low	Level out soil surface to pre-disturbance topography	Negligible

flocks

	Tracked vehicle (indirect effect)	Altered microtopography increases invasive plant frequency and reduces prey availability and E intake of foraging flocks	Low	Low	Follow-up with invasive plant control	Negligible
3. Phone layout	Crew, helicopter, and ATV presence (direct effect)	(Same as survey - foraging flocks)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)
	Crew, helicopter, and ATV presence (direct effect)	(Same as survey - nesting colonies)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)
4. Seismic acquisition	Blast noise (direct)	(Same as survey - foraging flocks)	Low	Moderate	Do not blast within 100 m of foraging flocks. If it cannot be avoided it is desirable to move quickly thorough the area.	Negligible
	Blast noise (direct)	(Same as survey - nesting colonies) Mortality of aquatic prey reduces prey density and wading bird E intake	Severe	Low High if < 3 m from surface water	Do not blast within 500 m of an active colony. Conduct biweekly aerial nest surveys in BCNP to document proximity of colonies to work area.	Negligible
	Blast shock (indirect)		Low		Conduct only where no standing water	Negligible
5. Phone pickup, repair and restoration	Crew, helicopter, and ATV presence (direct effect)	(Same as survey - foraging flocks)	(Same as survey)	(Same as survey)	(Same as survey)	(Same as survey)

Crew, helicopter,
and ATV
presence (direct
effect)

(Same as survey -
nesting colonies)

(Same as
survey)

(Same as
survey)

(Same as survey)

(Same as
survey)

Table 2.5: Summary of potential impacts on red-cockaded woodpeckers from 3-D seismic oil and gas exploration in the Nobles Grade area of Big Cypress National Preserve.

SHORT-TERM IMPACTS

Activity	Stressor	Impact	Severity	Likelihood	Recommended Alternative to reduce impact	Resulting likelihood	Potential Most Serious Outcome for this Impact	General Guidelines to Minimize Potential for Severe Impact
1. Survey	Human activities and equipment use	Disruption of courtship	Severe	Low	Do not work in pine areas If foot travel only, no closer than 61 m to RCW cavity tree, no mechanized equipment, and duration of presence is < 15 minutes If mechanized equipment is used, no closer than 122 m, and duration of presence is < 15 minutes	No impact	Lack of nesting or delayed nesting.	Minimize time in mature pine habitat; Avoid potential RCW areas prior to 10 AM; leave if birds are present.
		Disruption of incubation	Severe	Moderate to high if closer than 122 m for > 15 minutes; likelihood depends on number of personnel, nature, intensity, noise, novelty and duration of activity and recent, current, and next day weather conditions.	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June; minimize loud noise, including voices; minimize movements.	Minimal to no impact	Death of embryos; failure of nest attempt; abandonment of site.	Minimize time near RCW cavity trees; stay at least 122 m from cavity trees.

Disruption of brooding and care of nestlings	Moderate to severe	Moderate to high if closer than 122 m for > 15 minutes; likelihood depends on number of personnel, nature, intensity, noise, novelty and duration of activity and recent, current, and next day weather conditions. Time of day can be crucial: before 9 AM or after 5 PM are prime feeding times. Impact severity can be expected to decline as young mature.	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June; minimize loud noise, including voices; minimize movements. Especially avoid activity near sites before 9 AM and after 5 PM.	Minimal to no impact	Death or reduced growth rate of nestlings; abandonment of site.
Disruption of feeding of fledglings	Low to Moderate	low to moderate if closer than 122 m for > 15 minutes. likelihood depends on number of personnel, nature, intensity, noise, novelty and duration of activity, and recent, current, and next day weather conditions. Just out of the nest, young tend to remain relatively in place and depend on parents for food. As they gain experience they will move from disturbance and are less vulnerable.	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June; minimize loud noise, including voices; minimize movements.	Minimal to no impact	Death of individual fledglings as a result of increased vulnerability to predators if forced to move or if parents are kept away from them.

2. E Source Placement		Movement and use of drilling rig	Severe	moderate if as close as 61 m to an active nest for more than about 15 minutes; increasing in severity of impact with increasing time at the site.	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June; minimize loud noise, including voices; minimize movements.	Minimal to no impact	Lack or loss or delay of nesting effort.
3. Phone layout		Geophones deployment	Minimal	Moderate if closer than 122 m	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June; minimize loud noise, including voices; minimize movements.	Minimal to no impact	Likely no more than a temporary disturbance, but could briefly make birds more vulnerable to predators, increase adult energy expenditure, and/or reduce rate at which young are fed.
4. Seismic acquisition	Blast	Disturbance from Blast Noise	Minimal to Moderate	Minimal to moderate likelihood since each blast should be little different in general nature from thunder; the major difference will be the number and perhaps regularity, proximity, and associated human activities. See comments for those above.	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June.	Minimal to no impact	

5. Phone pickup, repair, and restoration	Disturbance of courtship, nesting, or feeding of fledglings	Minimal	Minimal	Remain at least 122 m from any RCW cavity tree between 15 March and 15 June.	Minimal to no impact
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LONG-TERM DIRECT AND INDIRECT IMPACTS

could also result from the above actions -- alone, or in synergy with natural or other human-induced stresses to the ecosystem.

Direct Impacts -- Loss of birds and as a result impacting any population of red-cockaded woodpeckers in the NGA and regionally.

These include:

1. Extinction of the local population.
2. Reduction of the local population such that recovery efforts are hampered.
3. Reduction of the local population such that the genetic diversity of the local and regional population loses significant genetic variability.

Indirect Impacts -- Alteration of habitats, thus impacting the population of red-cockaded woodpeckers in the NGA and regionally.

These include:

1. Creation of ruts and other soil disturbance that alters water flow and/or local hydroperiod such that plant and animal communities are changed. Specifically, a reduction in the habitat suitability for the pines RCWs are dependent on would result in their abandonment of the area.
2. Introduction of exotic plants or animals on vehicles or on clothing of workers could result in competition with and alteration of native species, ultimately having a negative influence on RCWs.
3. Injury to slash pines through scraping of trees, crushing of roots, or breaking of limbs could attract southern pine beetles or other injurious insects that could result in loss of RCW nest trees and habitat.

Table 2.6: Summary of potential impacts on threatened and endangered mammals from 3-D seismic oil and gas exploration in the Nobles Grade area of Big Cypress National Preserve.

Activity	Stressor	Impact	Severity	Likelihood	Recommended alternative to reduce impact	Resulting likelihood
Staging Area Construction and Related Activities	Ground Vehicle and Human Noise	Low	Low	Low	Minimize time of operations and limit to Oct-Dec. period. Reduce unnecessary vehicle and equipment idling. Enforce wildlife anti-harassment policies.	Decreased stress and impact on wildlife
	Habitat Loss and Fragmentation	Very Low	Very Low	Very Low	Minimize pad size. Place as close to Interstate 75 as possible.	Decreased habitat loss
	Pollution	Very Low	Very Low	Very Low	Air pollution should be minimized by operating equipment only when necessary	
	Road Construction	Low	Low	Low	Install guards at road entrances; patrol roads at low speeds to avoid road collision w/ animals; post no trespassing signs	Decreased likelihood of poaching, illegal ORV use, and other injurious or lethal human-animal encounters
	Trash	Low	Low	Low	Educate employees about dangers of trash attracting bears; strict enforcement of littering; install bear-proof dumpsters and garbage cans.	Decreased likelihood of attracting bears and encouraging nuisance behavior

Survey of Charge Locations, Installing and Firing Charges, Equipment Removal, Cleanup and Restoration	Ground Vehicle and Human Noise	Low-Medium	Low-Medium	Medium	Minimize time of operations and limit to Oct-Dec. period. Minimize number of personnel and number of crews. Reduce unnecessary vehicle and equipment idling. Enforce wildlife anti-harassment policies. Synchronize firing of charges as much as possible.	Decreased stress and impact on wildlife
	Habitat Loss and Fragmentation	Low	Low	Low-Medium	Minimize removal and damage of vegetation and alteration of wetland hydrology. Immediately contain and clean up contaminant spills and trash. Replant damaged vegetation. Treat and remove exotic species. Remove roads and other potential fire breaks. Restore hydrological structure and function.	Decreased habitat loss and fragmentation. Rapid initiation of plant succession. Restoration of hydrology and fire regimes.
	Pollution	Very Low	Very Low	Low	Air pollution should be minimized by operating equipment only when necessary	
	Road Construction	Low	Low	Low	Minimize new construction and reactivation of old roads. Install guards at road entrances. Patrol roads at low speeds to avoid road collision w/ animals. Post no trespassing signs.	Decreased likelihood of poaching, illegal ORV use, and other injurious or lethal human-animal encounters
	Disturbance of Den Site and Animal Neonates	Low-Medium	Low-Medium	Medium	Avoid areas where fox squirrel occurs, and work with wildlife agencies to avoid active panther den sites. Avoid any suspected den site by at least 1 km.	Decreased likelihood of den site or litter abandonment.

Helicopter Disturbance	Low- Medium	Low- Medium	Medium	Minimize helicopter use in general and time per unit area.	Decreased likelihood of disturbance from helicopter.
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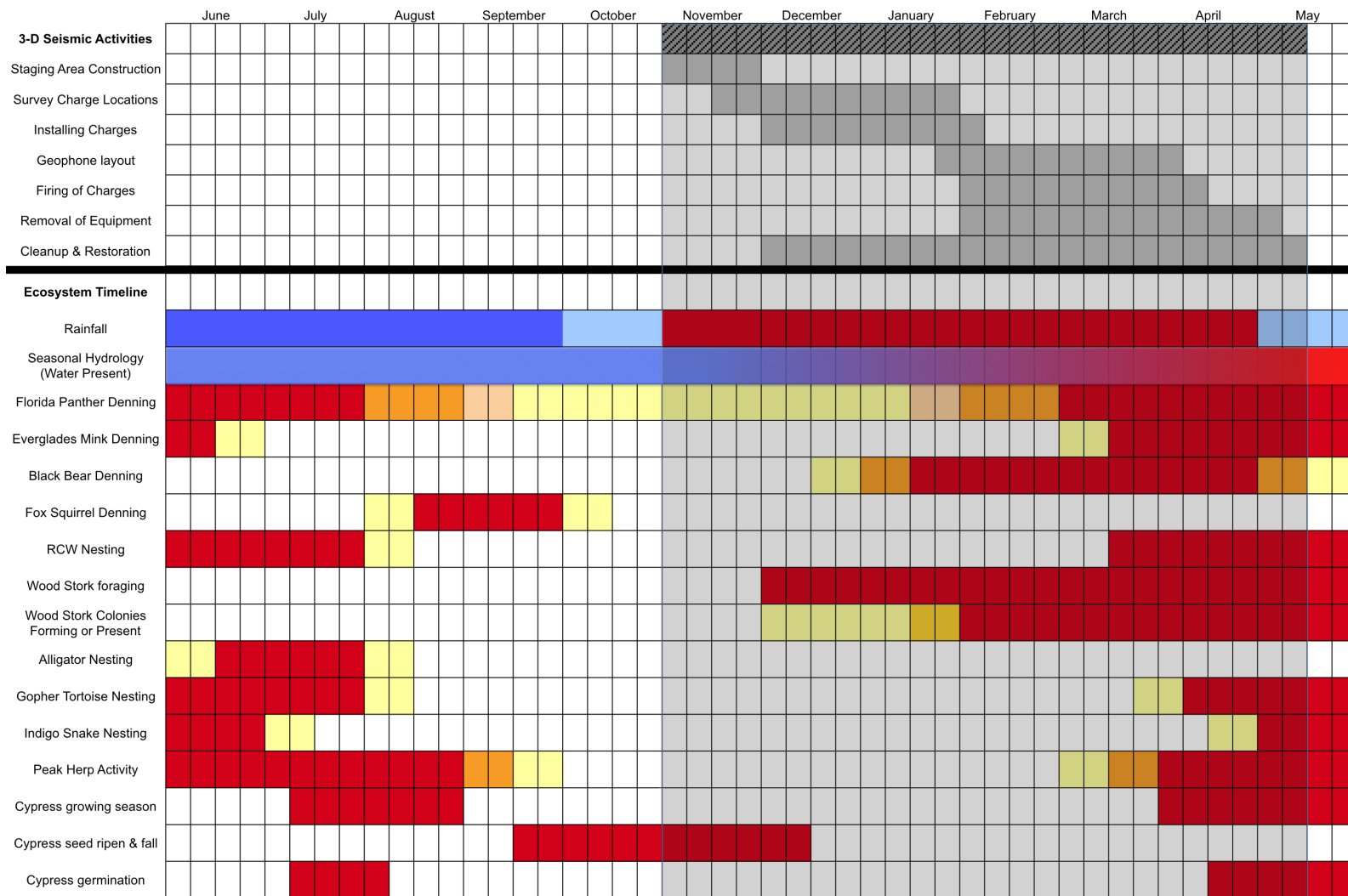


Figure 2.1: Ecosystem timeline showing the timing of proposed 3-D seismic survey activities in Nobles Grade area relative to annual cycles of wetland hydrology (rainfall and water presence), key fauna, and cypress in Big Cypress National Preserve. For rainfall and seasonal hydrology, blue areas indicate water presence or intensity of rainfall while red indicates dry periods or low water levels. For faunal and cypress categories, red indicates periods of heightened activity, grading to orange and yellow which indicate transition between inactivity and heightened activity.



Figure 2.2: Photo of gopher tortoise entering its burrow (Photo by Kirsten Hines).

Section 3: Impacts of Long-term development of oil and gas resources in a Nobles Grade-like area of Big Cypress National Preserve

3.1 Introduction

The purpose of this section of the report is to provide a summary of impacts on the same array of ecosystem components considered in **Sections 1 and 2** should O&G extraction be permitted in the NGA of BCNP. In some cases a qualitative assessment of possible effects is provided. It is probably not a stretch to assume that environmental impacts from O&G activity have been documented for every case in which they have been investigated. Impacts occur from all levels of human activity and development in natural ecosystems. In fact, the panel noted a few potential impacts on adjacent BCNP wetlands in a rather small amount of time spent at Raccoon Point. Environmental impact investigations have been made for the coastal areas of Louisiana (Ko and Day 2004) and Texas (Tunnell et al. 1995), the North Slope of Alaska (NRC 2003), and more recently off the coast of Australia (AES 2009). This is either because of a specific environmental disaster (e.g., Montara Field oil leak or Exxon Valdez spill) or because of the high density of O&G operations within a specific geographic region (TX, LA, or AK).

Recent research has shown an array of impacts on wetlands and other coastal ecosystems from O&G development (as summarized in Ko and Day 2004). The impacts of spills have been well documented—even aside from the Valdez disaster—and show significant impacts at all levels of a given ecosystem (Harrel 1985, NRC 2003, Ko and Day 2004, AES 2009). Other aspects of O&G activity, especially infrastructure, in places such as Alaska are also to blame for increased predation of animals (Liebezeit et al. 2009) and expanded impacts on adjacent natural areas leading to a higher than expected area of influence (Walker et al. 1987, NRC 2003). Given the relatively low level of O&G activity in the BCNP, these impacts have not been readily observed. However, we are confident in saying that these types of impacts will accumulate and become more noticeable with expanded O&G infrastructure and activity in the region.

As described earlier, the August 2009 panel meeting focused on a projection of activities associated with long-term development of O&G resources based on a 3-D seismic model created for the NGA. At this meeting, Bob Duncan presented an overview of activities, structures, impacts, permitting, and timeline associated with O&G development, production and reclamation. While this presentation provided important insights into the process, it is important to note that specific details, such as location, were based upon a hypothetical model since actual plans require results of a 3-D seismic exploration, which has not yet occurred.

If CRC is permitted to conduct 3-D seismic surveys in the NGA and should sufficient reserves be identified, CRC would then need to request permits for long-term development of those resources. Only then could the magnitude of development and location of structures needed to support that development be surmised. If permitted, the activities

associated with long-term development could require 20 years or longer of occupation and activity at the surface. In order to effectively consider the impacts of long-term development in the NGA, more detailed information would be needed with regard to the number and location of wells; the number, size, and location of pads planned; the length, location, orientation, and engineering of roads; etc. At that point, a similar panel and study should be convened to consider impacts as they pertain to these details.

For the purposes of this general impact analysis, we assumed that O&G development would occur in the NGA following seismic data acquisition and interpretation. We also assumed that development would require the basic structures such as roads, pads, wellheads, power supply, and flowlines/pipelines. It would also require 24-hour manning and vehicle traffic. To better visualize this, we considered activities and structures associated with the current center of CRC's O&G operations in Big Cypress—Raccoon Point. Based on our visits to Raccoon Point and our understanding of the current technologies that could be considered for use (e.g., directional drilling, in-line well pumps, etc.), we have considered the impacts that would be associated with any future O&G development in the NGA as a result of the following activities.

3.2 General Activities Associated with Long-term Development

The exploration/production portion of oilfield development will consist of six general phases. These will include (1) exploratory well(s), (2) production wells and associated facilities, (3) production, (4) pipeline construction, (5) spill control and cleanup, (6) completion of production and restoration.

3.2.1 Exploratory Wells

Once CRC completes its evaluation of the seismic data and determines the most likely location for productive oil reserves, they will drill one or more exploratory wells to confirm what they believe the seismic data are showing them. If multiple exploratory wells are drilled, they could all be drilled from a single well pad or multiple well pads could be constructed. The specific construction activities associated with the exploratory well(s) will include road construction, well pad construction and the drilling of the well(s).

Construction of the access road(s) and well pad(s) will involve hauling in roadbed material from a source outside of Nobles Grade. Road construction will begin at an existing roadway (well field road, park road, or public highway) and progress out to the intended well site(s). Trucks will be confined to and work off the new road to minimize the impact area of the road. Depending on the length of the new section(s) of roadway(s), wide passing areas and/or turn-around areas for the trucks will need to be incorporated. It is possible that these could be accomplished using temporary wooden mats that could be removed once construction is completed.

Construction of each pad will include a berm surrounding the pad to contain stormwater and/or any spills that could potentially occur. A drilling rig and the associated equipment

will then be moved onto the pad and drilling will commence. The drilling rig will use a closed system for drill mud and cuttings, as well as any other materials that may be used in the drilling process.

3.2.2 Installation of Production Facilities

If the exploratory well(s) confirm the commercial viability of the field, CRC will convert the exploratory well(s) to production wells and/or construct new wells at various locations within Nobles Grade to maximize their access to the reserves. This phase of the work may involve the construction of additional roads and well pads. These will be constructed as described in the previous paragraph. Small pipelines, gathering lines, will be constructed from each well to a central gathering point where the produced oil is dewatered and stored for shipment to market. Typically, these will be 4 in (10 cm) diameter pipelines. CRC has stated that all gathering lines will be placed along the surface of the road corridors at the edge of the road. They also committed that the gathering lines will be located within a berm to prevent any potential spills from entering the adjoining environment. A second gathering line, depending on the rate of production, may be installed from each well location to carry produced water to a disposal site. When oil is pumped to the surface it contains some amount of highly saline water that must be removed. This is referred to as “produced water”. Initially, all produced water will be placed into the existing injection well located at the Raccoon Point processing facility. Additional injection well locations may become necessary as the production facilities expand geographically.

During the early stages of production, CRC has stated that they will route all gathering lines to their existing processing facilities at Raccoon Point. As production expands to new well locations, it will likely become necessary to construct an additional processing and storage facility at another location. This will involve the construction of a large pad (comparable to the Raccoon Point facility), a produced water disposal well, a battery of storage tanks, generator(s) with fuel storage, and office facilities. As with the Raccoon Point facility, oil will be trucked to Port Everglades.

3.2.3 Production

Once the oil has been brought to the surface, produced water will be removed from the oil either at the well site or at the Raccoon Point processing facility. The produced water will then be injected back into the ground either at the Raccoon Point injection well or at a remote injection well location. At some well sites during the early stages of production, the produced water may be stored at the well site and then trucked to Raccoon Point or another disposal well location for injection back into the production formation. Oil will be transported from the central collection point(s) to Port Everglades for shipment to market by truck until such point as a pipeline becomes feasible.

3.2.4 Pipeline Construction

At some point, oil production quantities may become sufficient to warrant the construction of a large-diameter pipeline to carry oil from the onsite processing and storage facilities to

Port Everglades or whatever “market-connection” point is appropriate at that time. Transportation pipelines of this type will be coated to prevent corrosion and will be buried below ground. Branches of the pipeline would have to extend to Raccoon Point and any other similar facilities that have been constructed within the field.

3.2.5 Spill Control and Cleanup

A Spill Prevention Control and Countermeasure Plan (SPCC) will have to be developed and implemented for any new exploration and production facilities. CRC will modify its existing SPCC or create a new one. Additionally, a Stormwater Pollution Prevention Plan (SWPPP) will have to be prepared and implemented for any new construction that occurs.

Spill control and cleanup contingencies will need to be in place at each well pad, along gathering lines, along pipelines and with all truck transport of oil, produced water or other potential contaminant. Stormwater control and management will have to be in place at each well pad as well as along all roads and gathering lines; i.e., berms along the edges to keep stormwater contained on the road rather than freely draining off into the surrounding habitat.

3.2.6 Completion of Production and Restoration

Once the field is no longer commercially productive, CRC will begin closing the field and restoring the affected areas as required by the National Park Service (NPS). This likely will not occur until 20-25 years after production begins. It could be longer if new technologies extend the life of the wells.

Plugging and abandoning of wells will be conducted according to the State of Florida requirements. A cement plug will be placed into the well bore at several locations to isolate the well bore from groundwater strata and at the surface.

The NPS will require all surface equipment to be removed. If the gathering lines are on the surface, they too would likely be cut up and hauled off. Typically buried pipelines are not removed as digging up the pipeline and removing it can cause as much or more disturbance than the original installation. The pipeline will be flushed to remove all oil and other contaminants and then both ends will be plugged. The pipeline will then be left in place to corrode and deteriorate.

Typically all fill material hauled in to construct roads and pads will be excavated and hauled off of the federal property. The NPS may request that some or all of the roads and pads remain for their own use. If they are removed, all fill material that was hauled in will have to be dug up, loaded into trucks and hauled off site. The material could also be stockpiled for future use by the NPS.

Once all of the fill material has been removed, re-vegetation will begin. At Big Cypress this may include bringing in suitable soil unless there is a layer left after the roads and pads have been removed. Re-vegetation would be accomplished by using soil that has a desired

seed mix in it, by transplanting vegetation into the areas or by allowing the adjoining vegetation to encroach into the disturbed areas.

3.3 Considering Impacts at the Wetland Ecosystem Scale

Assuming no major spills, one of the greatest impacts associated with long-term O&G development in Big Cypress will be associated with the footprint of activities and surrounding area of influence. This includes the area of wetland-scape lost to pad and road construction in addition to an impacted zone along each of these major structures. From an ecosystems standpoint, filling wetlands represents a direct loss of ecosystem services from this area of landscape—including functions supported by natural fauna, flora, soil, and water—until all activity has ceased and the area has fully restored to its original state. This could take 30 to 40 years (20 years to develop and extract O&G reserves, plus 10-20 years to fully restore). Given the duration of which this area will be out of service from a wetland perspective, appropriate mitigation should be required from the outset of construction to replace the loss of 40 years of service of this footprint from this landscape. This is in addition to a requirement to fully restore these areas upon completion of O&G activities.

In considering mitigation of this type, one must recognize that once roads are constructed into these wild and undeveloped areas, they serve multiple uses to NPS staff (fire, science, resource management, etc.), other scientists, and recreationalists, in addition to O&G operators. In some cases, this type of infrastructure becomes so useful to these “other users” that their maintenance is justified beyond the scope and timeframe of their original intent. It is through this means that these structures can outlive their original intent and become subsumed into park infrastructure. The result is an increased burden to the preserve and an absolution of mitigation responsibility to the original party involved with the construction. In order to deal with both issues raised here—i.e., time of ecosystem services lost and the potential for absolved mitigation at the end of operations—mitigation prior to any activity on the surface should be required. This would then be followed by an option for additional mitigation at the conclusion of operations—to be determined by the NPS and BCNP staff—based on history of activity and the need for this added infrastructure.

3.4 Impacts on Hydrology and Water Quality

3.4.1 General Impacts on Water Flows and Water Quality

Aside from the direct “footprint” impacts described above, roads and pads serve as a barrier to vertical exchanges of water and materials above and below the land surface—often facilitated by natural soil and vegetation. In their report of cumulative O&G impacts on the North Slope of Alaska, a panel of experts concluded that the impact of O&G activities “are not limited to the footprint of a structure or to its immediate vicinity; a variety of influences can extend some distance from the actual footprint” (NRC 2003). The blockage

of flowing water is but one impact that would be expressed beyond the footprint of development in a wetland such as Big Cypress.

In a natural ecosystem state, rainfall in Big Cypress would accumulate at the surface and flow downstream with some fraction infiltrating the soil and moving into the shallow groundwater pool. On roads, rainfall hits the road surface and runs off into adjacent wetlands carrying sediments and soluble materials that are associated with the fill rock or from materials deposited by human activities (e.g., vehicles). In the case of pads, rainfall accumulates on the pads dissolving and mobilizing substances associated with fill rock or O&G activities. A portion of this will infiltrate into the shallow groundwater, but the remainder will pool on the pad surface as a result of berms that are designed to contain surface fluids—but only so long as the berms are not breached. During one of the panel's visits to Raccoon Point, a berm had been breached to drain standing water (along with other dissolved materials, pollutants, etc.) into the adjacent swamp (**Figure 3.1**). This may not have been a management decision, but it is illustrative of the need for training at all levels, vigilance for infractions, and action taken to mitigate infractions and to prevent future infractions. It also points to the need for sound stormwater management on pads.

Along the surface of the land, these structures represent an obstruction to the horizontal flow of water and exchange of materials from upstream to downstream. Although culverts can facilitate the movement of water through these obstructions, there is no functional replacement for the sheetflow supported across the natural landscape, particularly in key flow ways of water in the NGA (e.g., Mullet Slough). Culverts concentrate flow that has backed up along the obstruction to maintain head pressure equilibrium of surface water. This concentration of flow can lead to a spatial imbalance in sedimentation and erosion patterns across the landscape, as well as spatial imbalance in nutrient loading, and reflects the time lag needed for head pressure equilibrium to be reached. The combined impacts of this are temporary pooling of water on the upstream side of the obstruction that leads to changes in seed distribution and bursts of flow (through culverts) that contribute to topographic variability and high nutrient load-related variations in production and respiration on the downstream side. As a way to mitigate these effects, lengths of road running perpendicular to flow paths should be elevated in a bridge-like fashion to avoid damming effects and concentration of flows so that sheetflow is preserved as much as possible. In addition, construction of roads and pads should be avoided at locations where standing water is present, particularly sensitive water flow ways in the NGA, such as Mullet Slough.

Again, using current activities at Raccoon Point as a reference for how future work will be conducted in Big Cypress, we can consider impacts O&G activities have on water quality around existing pads and roads. Over the past several years, water quality data have been collected from Raccoon Point by Hydrologic Associates U.S.A., Inc. and submitted to Brietburn Florida, LLC (the operator of Raccoon Point) and CRC in annual reports. We were able to review reports from 2002 and 2007 as part of this study. Both reports indicate that the water quality sampling program has not changed over that period of time.

Ten locations around the pads at Raccoon Point have been sampled monthly. Five of these locations contain a well from which a groundwater sample is collected. The depths of the wells are approximately 15 feet. However, the depth of the samples collected could not be ascertained from the reports. The areas around 11-Mile Road and Pad 1 are not monitored. Pads 4 and 5 each contain two surface water sample sites and two groundwater sites. Pad 2 contains only one groundwater and one surface-water sampling site. This is surprising given that this pad not only contains a few active wells but also represents the processing area for Raccoon Point. As such, it contains all of the oil-water separation units, brine storage and dumping well, and represents the beginning of the journey for oil that is transported via pipeline 18 miles to the Devil's Garden offloading facility in Miccosukee Indian Territory.

The spatial and temporal resolution of this water quality program is inadequate, and data collected from such a program do not meet minimal scientific or legal standards. Criteria are lacking to justify the number of sampling stations, and the layout of sites does not seem to coincide with structures, activities, or topographic slopes that would drive surface flow patterns. All structures, regardless of current levels of activity, should be included in the water quality sampling program. Leached materials from pads and roads in addition to past spills may not be observed in surface or groundwater around each pad or road for some time. Sampling is needed particularly along roads and near flow line manifolds or areas where flow lines merge because those sites will be most likely to show the development of potential problems. Similarly, emphasis should be placed on the source of potential altered water quality so that impacts with distance downstream of these structures and activities can be determined. Un-impacted, reference sites well outside of the footprint of activities are needed to provide a context for variations due to seasonality and other natural sources of variation apart from O&G activities.

Another problem with the existing program is that it considers water quality only at a monthly time-step. Sampling at this time-step does not provide an understanding of the variability in water quality that may arise from the flashy rainfall events (particularly in the wet season) or the dynamic variability in water level and flow over the course of a year. In addition to monthly sampling, surface water sampling should also be event-based to capture rainfall events that can mobilize substances on the surface of pads and roads and wash off into the adjacent wetlands over time intervals much shorter than one month. Although pads are designed to be self-contained with respect to storm water, observations have been made where this is not the case. Runoff from rain events should be sampled—particularly when rainfall events exceed 1-in in a given 24-hour period. Continuous sampling of TDS, conductivity, dissolved oxygen, pH, and temperature near a few, high-activity locations is also recommended as a way to capture fine-scale resolution of parameters that may be indicative of contamination or some other process that may help to understand variability in data from water quality stations. This can be easily accomplished through the use of data sondes that are relatively low in cost and easy to maintain.

In addition to monitoring of surface and groundwater, we also recommend that O&G operators monitor sediment contamination at sites around pads and roads. This could be done quarterly near some of these same sites that would be strategically positioned around

each of these structures. Analysis of sediments would reflect long-term integration of impacts and could include analysis of parameters such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), grease, surfactants, boron, barium, and other chemical compounds that would be indicative of spills of oil, gas, drilling fluids, brine, etc. Overall, water sampling should be done in duplicate for all sites and sampling events, and sediments should be sampled in triplicate to account for the higher micro-scale variability in parameters measured.

Recent trips to Raccoon Point indicated the need for elevated roads and improved storm water management on pads. Heavy rains in the early summer of 2009 resulted in noticeable head differences between sides of the 11-Mile Road, resulting in concentrated flow through culverts. Rainfall during this period also resulted in a few inches of standing water across the surface of a few pads at Raccoon Point. However, at pad #5, a breach in the berm near where the road and pad connect allowed turbid (and likely contaminated) water from the pad to drain freely into the nearby natural wetlands (**Figure 3.1**). The amount of contaminated water that drained into the wetland during this visit was not determined; however, one can speculate based on area and an estimate of water depth at other pads.

To illustrate the volume of potentially contaminated water on the surface of a pad, we assumed a modest pad size of 5 acres (2 ha). With 2 in (5 cm) of water on the surface this equates to approximately 0.83 acre-feet or nearly 270,000 gal (1,022 m³) of stormwater on the surface of a single pad. Evaporation is likely to remove much of this through time, but subsequent rainfall events contribute more water to the surface. Conducting O&G operations in such standing water conditions is likely difficult and possibly hazardous, but the water should not be allowed to flow into the adjacent wetland. A sound and environmentally safe stormwater management plan should be considered. In attempt to deal with stormwater while maintaining a minimal pad footprint, standing water from all pads should be collected with pumps and conveyed into tanks containing “produced” water. As with produced water, this polluted stormwater should then be injected into the boulder zone—a deep (typically >2,000 ft [610 m]) porous area belowground where treated wastewater is permitted to be dumped.

Figure 3.1 also shows that, in some cases, Raccoon Point flowlines come into direct contact with surface waters in the adjacent natural wetlands. The rationale for this is that it would take up too much space to put them on the surface of a minimally sized (i.e., 15 ft [4.6 m] crown) oil road. Active flowlines at Raccoon Point are hot to the touch—likely greater than 110°F (230°C) and considerably hotter than surface water in wetlands. As a result, surface water temperature will increase in the immediate area along the immersed flowline, which can lead to decreased oxygen holding capacity, increased respiration rates, and thermal effects on biota in these areas. Given the length of flowlines and the potential zone of impact (possibly >1.6 ft [0.5 m] width), the impact of thermal pollution alone can be significant. In the future, we recommend that all flowlines associated with O&G development in Big Cypress be elevated off the side of the road. This would not only minimize contact with standing water, it would also allow for easier inspection of leakage

and corrosion and subsequent maintenance. Further, this flowline “easement” should be considered as an impacted zone and mitigated accordingly.

In order to track changes in water quality as a result of proposed O&G activities in the NGA, there also needs to be an understanding of historic patterns at locations within or near the Nobles Grade footprint. There are a number of long-term water quality surveys conducted across south Florida. Two of the most notable programs are those managed by the SFWMD and the USGS. Both of these programs have sampling sites within or near the Nobles Grade footprint. There are also a number of other sites surrounding this area that could serve as un-impacted reference sites.

A recent water quality survey by Miller et al. (2004) shows surface water quality at sites A 12 and A 13 to be very good relative to sites in nearby canals or those along roads (see **Figures 1.1** and **1.2**). Both sites are within the NGA and seem to exhibit very low levels of sulfate and chloride as well as relatively low concentrations of nitrogen and phosphorus compared with surrounding areas. The ranges of values for these parameters suggest little influence of agricultural or canal nutrient inputs in the upper half of the Nobles Grade footprint. Reference sites (i.e., sites outside and preferably not downstream of the NGA) should also be tracked in concert with sites in Nobles Grade in the event that water quality near O&G operations changes through time. A few potential reference sites could include sites A 14 and A 4 (Miller et al. 2004; **Figures 1.1** and **1.2**), as these both show similar levels of water quality to A 12 and A 13. Sampling of reference sites has a two-fold advantage in that it provides a means for determining the degree of change at local scales (i.e., between sites) as well as changes that may occur at more regional scales (i.e., across sites).

Again, if 3-D seismic activities are permitted, consideration should be given to monitoring the surface water quality of a select few ponds and pools near shot holes before and after detonation. The purpose of this is to track the influence of a shock wave transmitted through the porous cap rock on groundwater efflux into these long hydroperiod water bodies. These activities should be conducted during the height of the dry season, when there is no standing water present (not including ponds and pools). We also recommended tracking the groundwater quality as energy-source detonation proceeds along a line. Should development of O&G resources proceed in this area, we strongly recommend surface water monitoring along roads (at both culverted and non-culverted areas) and around pads on a regular basis (i.e., weekly) throughout the wet season. These data should be submitted to the BCNP Resource Manager annually and compared with existing surface-water monitoring results from long-term sampling sites like A 12 and A 13. Monthly intervals are simply too long to be able to differentiate changes related to leaks/spills, event-driven pulses, season, and storm water runoff/infiltration from roads and pads (as in the situation described above).

3.4.2 Impacts According to Specific Activities

The potential impacts of O&G development activities on the hydrology of the NGA as we see them has been divided into the six (6) phases of the extraction and production. Preventive

measures are also presented to mitigate these potential impacts. For the purposes of hydrology, the potential impacts have been classified into two major groups: surface water and groundwater, addressing both quantity and quality issues, as well as pointing out water-related issues that connect to other parts of the Nobles Grade ecosystem in the BCNP.

3.4.2.1 Exploratory wells

Potential impacts during the exploratory well phase may be manifested in terms of water quantity (disruptions to the existing flow patterns) and quality (potential for contamination). In terms of quantity, the source of water for the exploratory drilling activities will be supplied from a pumping well at the rig site and will originate from groundwater. It is important to insure that the continued pumping at a rate from groundwater is much lower than the inflow rate by lateral flow and recharge from surface water areas so that changes in aquifer storage, manifested by eventual declining water levels, are negligible. In terms of quality, during drilling, the main risk of impact to water quality is from drilling fluid losses due to inadequate sealing or casing, or leakage from the cuttings pit. However, it is expected that the drilling mud to be used is water-based and of low inherent toxicity.

During well testing, produced water may contain O&G products that could potentially contaminate water resources if not properly controlled using adequate waste management techniques. The risk in the event of a spill or release of potentially contaminative material is high in this case because of the proximity of surface water features at Nobles Grade and the shallow depth to groundwater and the permeability of the intervening materials (except in the case of a release at or below the water table, which may occur during drilling). In the event of a blow-out, there could be a considerable threat to groundwater quality due to the infiltration of a potentially large volume of liquid hydrocarbons. In the event of a fire or explosion, some of the hydrocarbon materials may be burnt off, but some may be released onto the soil surface allowing infiltration.

3.4.2.2 Installation of production facilities

Wastewater generated in drilling and production operations can be highly contaminated with oil related products. Typical examples of such wastewater generated includes:

- ∞ spent and surplus water-based mud (WBM) fluids;
- ∞ associated WBM and low toxicity oil based drilling mud (LTOBM) fluids retained on the cuttings;
- ∞ runoff water from rig
- ∞ generated wastewater disposed on the ground or into surface water without treatment

Other potential sources of impacts to water during production include the disposal of solid waste products, such as:

Non-Hazardous Solid Wastes: Solid non-hazardous waste includes domestic waste, paper, plastic and metals, which is mainly generated due to staff accommodation.

Hazardous Solid Wastes: Generated hazardous solid wastes include absorbents used for spill clean-up, oily rags, batteries, used oil filters of engines, fluorescent light bulbs, paint materials generated from any painting or coating activities, and empty drums with chemical/oil residue.

Mud Cuttings: Mud cuttings generated as a result of the drilling operations, which have an affect on all natural resources in the dumping area.

3.4.2.3 Production

The main source of impact to water resources during the production phase is the generation and disposal of produced water. Produced water is a by-product of the oil production process. There are often substantial amounts of water contained in subsurface formations where O&G occur. When O&G are produced, this water is brought to the surface and must be disposed of in some way. Produced water contains high concentrations of volatile (e.g., benzene, toluene), and semivolatile hydrocarbon contaminants (e.g., aliphatic hydrocarbons, alkylated polycyclic aromatic hydrocarbons), as well as high concentrations of aromatic acids and aliphatic fatty acids. Some produced water also contains metals such as vanadium, arsenic, and copper.

These toxic metals and organics may accumulate in the wetland area around Nobles Grade, particularly during the dry season when negligible surface water is available to “flush” out these pollutants. Produced water also typically contains high levels of brine. In view of this, it is recommended that produced water be biochemically characterized in its initial stages of production to avoid negative impacts to groundwater at the injection location at Raccoon Point or elsewhere in the production formation.

3.4.2.4 Pipeline construction

At some point, oil production quantities may become sufficient to warrant the construction of a large-diameter pipeline to carry oil from the onsite processing and storage facilities to Port Everglades or whatever “market-connection” point is appropriate at that time. Transportation pipelines of this type will be coated to prevent corrosion and will be buried below ground. Branches of the pipeline would have to extend to Raccoon Point and any other similar facilities that have been constructed within the field.

Potential impacts of the pipeline construction stage are primarily driven by two sources: the removal of material to accommodate the pipeline layout, and the potential for leaks or spills from the pipeline in operation. The latter are addressed in the discussion of the next phase. Localized changes in topography/surface elevation are likely to originate from the layout of the pipeline since soil material will be removed (and backfilled) to accommodate this layout. In addition to this, the pipeline will be bermed, thus potentially causing an alteration of surface drainage (lateral) and infiltration (vertical) patterns of water along the pipeline.

Changes in the natural existing connection between surface and groundwater may be caused by alterations in the soil cover to accommodate the pipeline. Also, an increase in suspended solids and sediment distributions can be expected once runoff water (particularly in the wet season) transports loose materials that may be generated on the soil surface.

3.4.2.5 Spill control and cleanup

A Spill Prevention Control and Countermeasure Plan (SPCC) will have to be developed and implemented for the extraction and production facilities at Nobles Grade. Since no exploratory drilling or production operations are addressed in the existing SPCC (contained in CRC's *Nobles Grade 3-D Seismic Plan of Operations, 2006*), CRC will need to amend its existing SPCC or develop a new one. Additionally, a Stormwater Pollution Prevention Plan (SWPPP) will have to be prepared and implemented for any new construction that occurs. This SWPPP should contain the best management practices (BMPs) that will be applied on site to prevent contamination of stormwater (surface runoff water) that may affect the quality of water in areas adjacent to Nobles Grade.

Spill control and cleanup contingencies will need to be in place at each well pad, along gathering lines, along pipelines and with all truck transport of oil, produced water or other potential contaminant. Stormwater control and management will have to be in place at each well pad as well as along all roads and gathering lines; i.e., berms along the edges to keep stormwater contained on the road rather than freely draining off into the surrounding habitat.

3.4.2.6 Completion of production and restoration

Following development and extraction, surface water quality may be degraded from sedimentation (eroded soils or cuttings). Groundwater may be negatively impacted as well. Over time, field oil and fluid changes may take place in unapproved locations. Oil and other spilled fluids may not be dealt with properly and potentially contaminate groundwater without proper management and environmental monitoring follow up.

Assuming no accidents or spills, the quality of the surface water in the vicinity of the extraction and production operations will not be further impaired upon completion, although shallow or ephemeral ponds such as those found in the BCNP may experience increased turbidity due to passage of heavy equipment and other closure related activities. Vehicular activity in the vicinity of the drills and actual drilling activities will also increase turbidity in marshes and other inundated areas. These effects will be short-term and localized. Groundwater impacts would be mitigated by requiring oil and fluid changes to occur either outside the BCNP or in selected and properly equipped locations. Any spills should be cleaned to standards deemed appropriate by BCNP resource managers. Also, poorly constructed (cased, cemented) wells may accelerate erosion and sedimentation further impacting soils, vegetation, and water; wells should be constructed, developed and operated using appropriate standards (Society of Petroleum Engineers [SPE], American Water Works Association [AWWA]) to avoid groundwater contamination.

3.4.2.7 Mitigation measures

General Mitigation Measures - Drilling should be conducted from uplands, existing drill sites, or canals, wherever possible, rather than dredging canals or constructing board roads. When wetland use is unavoidable, work in previously disturbed wetlands is preferable to work in undisturbed wetlands. Temporary roads to provide access are more desirable than dredging canals because roads generally impact less acreage and are easier to restore than canals.

The following apply to mitigating impacts of well sites:

- ∞ Proposed road alignments and well pads should use upland or already disturbed marsh areas and should be no larger than necessary to conduct exploration/production activities. All borrow material for the ring levees should come from within the leveed areas.
- ∞ Borrow pits for fill material, if necessary, should be dredged adjacent to and on alternate sides of the roads and should be no more than 500 ft (152 m) long. Continuous borrow pits are to be avoided.
- ∞ Culverts or similar structures should be installed under the road at sufficient intervals to prevent blockage of surface drainage, tidal flow, and sheet flow (at least every 500 ft [152 m]), with all culverts maintained open for the life of the roadway.
- ∞ If the well is a producer, the drill pad should be reduced to the minimum size necessary to conduct production activities and the disturbed area should be restored to pre-project conditions.

Upon completion or abandonment of wells in Nobles Grade, all unnecessary equipment should be removed and the area restored to pre-project elevations. The well site, various pits, levees, roads, and other work areas should be graded to pre-project marsh elevations and then restored with indigenous wetland vegetation. Abandoned canals frequently need plugging and capping with erosion-resistant material at their origin to minimize bank erosion and to prevent saltwater intrusion. In addition, abandoned canals will frequently need to be backfilled to maximize native fish and wildlife production in the area and to restore natural sheet flows. Spoil banks containing uncontaminated materials should be backfilled into borrow areas or breached at regular intervals to re-establish hydrological connections.

Mitigation Measures for Potential Impacts to Water - Water to be supplied for the project will be sourced from groundwater reserves that are being recharged and are in close connection with surface water sources. It is important to verify that the total quantity of water to be used during the project is a negligible fraction of the total water resource, so a hydrologic budget is recommended as part of the extraction and production permitting

process at Nobles Grade. Nevertheless, CRC should promote water conservation practices at all stages of the project. Water conservation will notably be achieved by:

- ∞ optimizing the separation of cuttings from the drilling mud and its recycling
- ∞ ensuring sealing and casing procedures are adequate and conducted in a timely manner to minimize drilling fluid loss
- ∞ monitoring water volume extracted from the water well.
- ∞ ensuring the water pit is not leaking
- ∞ reusing standing water in the cutting pit where possible
- ∞ promoting employee awareness via training on how to minimize water use
- ∞ applying water conservation measures at the camps

The risk of contamination of groundwater reserves from project activities will be minimized by the adoption of appropriate operating procedures as follows:

- ∞ appropriate completion of the water well to ensure it does not create a conduit for contaminant migration in the event of a fuel spill or well blow-out
- ∞ appropriate lining of the cutting and flaring pits
- ∞ adoption of best industry practice for well casing design and implementation to ensure groundwater resources are adequately sealed off
- ∞ adoption of best industry practice for the management of potentially contaminating liquids, such as fuel, oil and chemicals (storage, handling, disposal, treatment). In particular, a waste management plan will specify procedures for controlling potential risks of leakage from any liquid wastewater
- ∞ spill response equipment and procedures will be in place in all areas where the potential for spills exist
- ∞ employees will be appropriately trained to apply spill response procedures in an efficient and timely manner
- ∞ the wells will be appropriately completed and plugged at the end of the project
- ∞ site reclamation procedures will be implemented to ensure that no potential source of contaminants remains at the site following project completion. In particular, the water-well should be appropriately abandoned and sealed.

Waste Treatment and Disposal Mitigation Measures - Disposal, as the last option, should be confined to a designated and managed area. The following general principles of waste management will be applied throughout the project:

- ∞ The types and quantities of waste that will be generated from operations must be specified in a *Plan of Operations* for development and the proposed facilities at Nobles

Grade. This plan should address the handling, collection, storage, and transportation procedures, together with the ultimate disposal option for each waste type.

- ∞ Waste will be segregated for efficient treatment and disposal.
- ∞ All waste will be securely stored and covered to avoid attracting animals.
- ∞ Hazardous waste will be handled by appropriately trained personnel:
 - Adequate and appropriate personal protective equipment must be worn while handling hazardous materials as specified in the waste management plan.
 - Solid hazardous waste will be placed in appropriate, clearly labelled containers, in accordance with manufacturer's/supplier's instructions and industry good practice.
 - Oily rags will be placed in a metal container provided at each workspace and subsequently incinerated when practical. Oily rags must not be mixed with other combustible materials or stored in direct sunlight.
 - Used oil filters will be drained into a waste oil container and placed in a dedicated collection bin.
 - Oily filter containers must not be stored in direct sunlight as this could lead to over-heating and combustion.
 - Waste non-chlorinated solvents, cleaners, and thinners will be properly contained and labelled, segregated, and stored until disposal. The proposed means of disposal must be specified by the drilling contractor.
 - Any waste aerosol containers will be stored separately from other waste products. Aerosols must not be disposed of through incineration. Aerosol containers should be de-pressurized before being placed in waste containers for scrap metal.
 - Used batteries (both wet and dry) will be transported to an appropriate disposal facility.
 - Wet cell batteries will be drained prior to storage and transportation, and cell fluids will be neutralized.
- ∞ Open waste burning will not be undertaken. A closed, mobile waste incinerator will be used for suitable materials, as needed.
- ∞ A bioreactor treatment unit will be used for all black and grey water.
- ∞ Waste treatment and disposal will not take place near surface water.
- ∞ All waste disposal pits (including the cuttings and water pits) should be properly abandoned and the ground surface reinstated, including covering with at least 1m of clean material.

3.5 Impacts on Vegetation

The degree and severity of impacts on vegetation from exploration and production of oil fields found in the 3-D seismic surveys will depend on where the oil is found. The discussion below is therefore dependent upon the location and scale of development. Regardless of where the oil fields are located, current drilling technology allows some flexibility in location of wells in relation to the oil. The location of drilling and production pads as well as roads linking these pads with I-75 should avoid sensitive habitats such as Kissimmee Billy strand and Kissimmee Billy pinelands east of the strand, if drilling permitted in the NGA. These are habitats for threatened and/or endangered plant species (**Table 1.10**) and would be severely impacted by the habitat destruction associated with oil field construction and operation activities. In general, cypress domes, which are deeper, wetter habitats, are more likely to be severely impacted by activities associated with oil development.

Prior to any construction, populations of threatened or endangered plant species in the proposed construction areas should be located, marked and avoided during construction. Construction sites should be located so as to maximize distance from known populations of threatened or endangered plant species.

3.5.1 Immediate Impacts from Site Construction

Threats and impacts from site construction will be similar to but probably more severe than impacts from 3-D seismic exploration. Construction activities will damage vegetation around the construction areas as people, supplies and machinery move into and out of the area. The construction itself will destroy the vegetation on the road and pad sites. The extent of the disturbance can be reduced by concentrating construction in the dry season when soil compaction is likely to be less severe and run-off of nutrients and chemicals from the sites reduced.

Efforts to reduce the size of the construction footprint will also reduce the amount of damage. The constructed sites will create completely new habitats that are covered with fill and will be prime sites for invasion by exotic plant species. These sites will need to be monitored for exotic plant colonization. An exotic plant removal program should be implemented and maintained throughout the duration of construction and production activities.

CRC discussed plans to store the soil scraped from the construction sites adjacent to the sites. This soil would then be used to reclaim sites as they are abandoned. Because this soil storage enlarges the habitat destroyed and creates a new disturbed habitat, we recommend moving this soil offsite for the necessary 20 or so years. Even then, it is unlikely to be of any use as it will accumulate exotic plants and seeds over that time frame.

Roads will be constructed from major access points to the sites, with additional roads connecting the sites. Because roads are linear features that can block water flow, orienting roads perpendicular to flow will alter vegetation on both sides of the road, favoring

communities with longer hydroperiod up flow and communities with shorter hydroperiods down flow. Construction plans should orient roads parallel to flow as much as possible in order to minimize this impact. Using longer raised sections of roads in places, instead of or in addition to culverts, will also help to prevent ponding. As at Raccoon Point, all roads will need to be monitored regularly after construction to remove invasive exotic vegetation.

3.5.2 Long-term Impacts from Site Operations

Construction of roads and pads, and potentially of an oil pipeline, will remove land from the BCNP for the life of the oil field. This habitat loss is estimated to be 20 years at a minimum, and if the field is large and/or other wells are drilled, the habitat could be unavailable for a longer period. This time is at least one generation for species such as baldcypress, and it is many generations for some species, such as the Florida endangered species Fakahatchee bluethread (*Burmannia flava*; **Table 1.10**). In addition, once drilling is finished and sites are restored, full restoration will take an additional, unknown number of years until the restored habitat again functions as the surrounding landscape. Compensatory mitigation ("Compensatory mitigation for losses of aquatic resources." Federal Register 73:70 (April 10, 2008) p. 19593) is required to replace the loss of these wetlands for the life of the oil field.

Once construction of roads and facilities is complete and oil production is ongoing, disturbance to the surrounding vegetation will come from the effects that increased human activity in the area will have on vegetation. Direct disturbance and destruction should not occur if people keep to the constructed areas and if there are no major oil spills, fires, or other human-induced disasters. Impacts from human activity in this phase, therefore, will be through indirect effects on hydrology and nutrient inputs, as well as through increased invasion pressure from exotic plant species.

Efforts to decrease impacts on hydrology were discussed above. Roads and pads need to have berms to avoid increasing nutrient flow from these areas into the surrounding landscape through runoff. Procedures for sanitary waste disposal and removal must be implemented and maintained. Because increased travel to the sites increases the chances of bringing in invasive exotic plant propagules, and because the roads and pads represent disturbed habitats readily colonized by invasive plants, ongoing exotic/invasive species monitoring and removal is necessary. Monitoring both sides of the roads and upstream and downstream from the pads before construction and at 2- to 5-year intervals should be implemented to look for indirect effects on vegetation, such as tree dieback or community change. Detection of change could trigger restoration or mitigation efforts prior to major community loss.

3.5.3 Effects on Cypress

Each of the developmental stages associated with oil production has the potential to impact the cypress wetland environment. While numerous reports exist detailing development-related impacts to marshes and mangrove systems associated with exploration, site access, site preparation, drilling, production, spill control and clean-up, and site closure (see de la

Cruz 1982, Cahoon 1989, Ko and Day 2004), cypress wetlands have received very little attention. The major potential consequences to the cypress ecosystem are 1) changes in hydrologic patterns, 2) pollution from leakage of oil or other material into adjacent wetlands, and 3) removal of wetland habitat. For a list of potential impacts developed for O&G activities along the Louisiana coast see **Table 3.1**.

3.5.3.1 Flooding and productivity of trees

Raised roads can severely disrupt surface sheet flow patterns. Roads parallel to the flow can minimize impacts, but those perpendicular to flow often act as levees, causing longer and deeper inundation on the upstream side and reduced inundation downstream. Culverts and bridges are used to minimize road impacts, but sheet flow is still concentrated to a point source on the downstream side unless special canals redistribute the water (Duever et al. 1986b).

Wetland hydrology and vegetation are closely linked, and most wetland functions rely on their interaction. The most frequent and widespread hydrologic alterations typically result in reduced or increased depth and duration of inundation. This tends to lead towards a shift in the affected vegetation communities towards a drier community when inundation is reduced or a wetter community when inundation is increased (Alexander and Crook 1973, Duever 1984). Even though many of the forest species growing in wetland areas are adapted to prolonged inundation (Kozlowski 1984), extended flooding during the growing season can cause mortality and loss of productivity of these tree species (Mitsch and Ewel 1979, Conner and Brody 1989, Conner and Day 1992, Megonigal et al. 1997, Pezeshki et al. 1990, Young et al. 1995).

Studies by Carter et al. (1973) showed that drained cypress areas had a significantly lower productivity rate (367 g/m²/yr) than did undrained strand edges (1,170 g/m²/yr). Megonigal et al. (1997) found that water depth/duration was negatively correlated to aboveground NPP in wetland forests. The slope of the mean water depth–net primary productivity relationship was more negative on sites that showed evidence of severe hydrologic alteration (25% dead stems) than on sites with comparatively unaltered hydrologic regimes. In fact, the stress associated with inundation increased by fivefold when forest communities were not in equilibrium with the current hydrologic regime (**Figure 3.2**).

Growth rates of baldcypress trees in two Louisiana stands decreased over 30 years (**Figure 3.3**), coinciding with increased flooding, especially in a non-riverine area (Keim et al. 2006). The mechanisms by which flooding affected growth rates in the two stands was not clear, but the reduction in growth at the non-riverine site may have been caused by a change in hydrological conditions, which has been more severe than in the riverine site.

3.5.3.2 Oil spill impacts

Duever et al. (1986b) reported that oil operations in the Big Cypress Basin have resulted in only a few minor spills, and those have been quickly and thoroughly cleaned up. Such oil

spills have invariably been associated with pipeline breaks or transfer pump leaks, and most of the spills took place after the equipment had been in use for a number of years. Routine maintenance and inspection should catch these types of spills.

There have been numerous studies on the impacts of oil spills on marshes and mangrove forests (see Proffitt et al. 1995 for references), but no information is available for cypress forests. The following information, while specific for mangroves, may provide possibilities to be considered when looking at other forest types. One has to be careful though in that different species of mangroves do not respond uniformly to spilled oil (Getter et al. 1985). Published results show that damage to forests varies by the type, amount, and toxicity of the oil; currents, winds, and tidal patterns; season; the compounding effects of environmental factors (e.g., temperature or salinity) and other pollutants present; and many other factors (Proffitt and Devlin 1998).

The immediate impact of spilled oil is that it can sink into the sediment and/or coat exposed trunks, causing extensive mortality, declines in productivity, or growth irregularities (Proffitt et al. 1995, Proffitt and Devlin 1998), while long-term chronic impacts can result in elevated concentrations of polynuclear aromatic hydrocarbons in the sediments that produce chlorophyll-deficient mutations (Klekowski et al. 1994). Oil coated surfaces decrease oxygen movement, resulting in more anaerobic soil conditions and increase oxygen stress on plant roots (Pezeshki et al. 2000). In one of the few studies with cypress, Latimer et al. (1996) found a correlation between lead (Pb) level in tree rings within 1.3 mi (2 km) of an oil refinery and the history of the refinery opening and dredging, implying a translocation of Pb along the xylem rays in cypress trees. Marcantonio et al. (1998) reported that Pb uptake by cypress was controlled by hydrological factors, in addition to the availability of Pb from oil-related pollutants.

It may be that it is not the impact of an individual well that should be of primary concern, but the cumulative impact of all wells. Construction of each well pad also entails a road leading to it and possibly a pipeline right-of-way. Forest regrowth along these corridors is suppressed for the entire duration of their use. There are no limits on cumulative road densities or pipeline densities. The clearing of trees associated with the construction of well sites, access roads, and pipelines is associated with progressive loss and fragmentation of habitat, increased access, and damage to aquatic systems. Well sites, roads, and pipeline right-of-ways are essentially permanent features of the landscape, given their prolonged use and absence of reforestation requirements.

3.5.3.3 Habitat recovery

Duever et al. (1986b) described the successional process of oil well sites in the Big Cypress during the first few years after abandonment. Since these sites originally had sizeable trees and/or a dense saw palmetto understory, and woody species had not been reestablished; realistic evaluation beyond the early stages of recovery was impossible. Generally, however, the prospects were good that the native plant community could recover. Invasion occurred within a few months, either on the residual native limestone rock used in pad and road building, or on the original surface, if re-exposed. On prairie sites, they suggested that

it is possible for recovery to be nearly complete within four years. The species invading the sites are mostly those recognized as representative of the early stages of secondary succession. Diversity increase begins to be obvious in about three years, and in some places understory species of the original community were already present and spreading.

It appeared that exotics would not be as serious a problem as had been anticipated. *Melaleuca* occurred on several former well sites, but the plants were not numerous, and a modest control program could prevent them from becoming established. Recovery takes different routes in different situations relative to original habitat, proximity of propagule sources, extent of fill removal, etc. Their overall conclusion was that it appears that oil well pads and roads, when removed, do not represent a long-term obstacle to the recovery of native vegetation in the Big Cypress. This is true even where no replanting is done.

3.6 Impacts on Herpetofauna

Human development of any type results in habitat loss and introduced challenges to the natural system. Herpetofaunal species respond differentially to man-made activities and structures, with some flourishing and others diminishing. A local example of this phenomenon is the introduced marine toad (*Bufo marinus*) that readily disperses along roads and breeds in roadside ditches versus the listed eastern indigo snake, which is threatened primarily because of development and human expansion. This information is neither available nor intuitive for all species, particularly in relation to oil development as opposed to urban expansion. This section will focus on highlighting the main areas of concern for amphibians and reptiles with regard to long-term O&G development, but further assessments will need to be made for each project once specific details have been laid out.

3.6.1 Roads and Herpetofauna

Barring no major accidents, roads are the single-most detrimental aspect of oil development and production for small wildlife such as amphibians and reptiles. There are myriad direct and indirect impacts associated with roads, but they ultimately have the most severe and long-lasting impacts when they inevitably initiate the degradation and sometimes loss of wilderness areas. While this affect could be reversed with road removal at the end of the project, the reality is that people value the access provided by roads and are reluctant to fully eliminate them. Discussions about Raccoon Point with researchers and park personnel in preparation for this report verify this notion (KNH, personal observation). Research and management around Raccoon Point has improved because of the associated roads, and the general opinion seemed to be that these roads should remain beyond the life of oil production. Decommission of these roads will be an important measure to conserve habitat for many wildlife species and for returning disturbed areas to their pre-oil extractive state.

In terms of herpetofauna, roads represent a source of mortality, habitat degradation or loss, noise pollution, a barrier to movement, and a conduit for predators and non-native

competitors. Several studies have reported high mortality rates for amphibians and reptiles due to roadkill in a variety of geographic locations and on a range of road types (ex. Ehmann and Cogger 1985, Fowle 1990, Carr and Fahrig 2001). Even within national parks where people are more conscientious of wildlife, large numbers of road-killed snakes have been recorded (Bernardino and Dalrymple 1992, Rosen and Lowe 1994, Fahrig et al. 1995). Estimates for amphibians are generally on the low side because of their small size and inaccurate road records due to the rapid deterioration of their remains (Langen et al. 2007).

The vulnerability of various species to road mortality is dependent upon their natural history. Species with high mobility, large home range size, multiple resource needs, general habitat requirements, or an attraction to roads are at greater risk than others (Forman et al. 2003). For example, many species of snakes are susceptible to vehicle strikes because of their use of roads for passage and thermoregulation, especially on cool nights when some road substrates retain and radiate warmth more than surrounding areas. As another example, pond-breeding amphibians whose breeding and feeding habitats are separated by roads often experience mass mortality during migratory periods when their concentrations are high. Slow moving species, such as turtles, are also at a higher risk. It is important to note that low traffic usage does not necessarily reduce herpetofaunal road-kill risk since species respond differentially to varying traffic intensity, including some whose mortality rate increases with decreased traffic (Mazerolle 2004). At low enough numbers, traffic may be an infrequent disturbance that invokes a startle response as opposed to the chronic disturbance of ongoing traffic to which animals may habituate or avoid (Forman et al. 2003). Nonetheless, slow speeds and controlled usage should help limit this impact.

Roads also affect herpetofauna through their impact on habitat. There is a direct and immediate loss of habitat where roads are constructed, which promotes fragmentation and an increase in edge habitat that may not be suitable for some species. Once established, roads create barriers both within and between habitats, limiting successful movement and thereby resource use in the area (Minton 1968). Studies should be conducted prior to road construction to determine migratory routes or habitats of importance that should be avoided by road placement. If following old tracks or trails, these should be monitored prior to construction to verify that they have not become important wildlife trails. In addition, road construction should incorporate animal crossing areas as this has proven to be an effective mitigation technique (Foster and Humphrey 1992).

Road use presents several more challenges. Habitat degradation results as pollutants are introduced to the system from vehicular liquids and stormwater runoff. Amphibians are particularly susceptible to pollutants so roads should be kept at an acceptable distance from amphibian breeding areas, as well as areas of high densities. Further degradation is possible from the potential introduction of exotic, invasive species. Roads are known to serve as conduits to non-native plants and animals that outcompete native species (Forman et al. 2003, Gann et al. 2007). Control of any introduced non-native plants with herbicides provides another source of pollution that should be kept from important amphibian habitats (see **Section 2.6** for a full discussion). Roads also provide access to predators and

potentially ill-intentioned humans such as poachers, both of which may deplete or disturb amphibians and reptiles.

The noise associated with road use provides yet another source of disturbance for amphibians and reptiles. Noise levels vary with traffic intensity, speed of vehicles and size of vehicles with cumulative noise increases associated with increased density of traffic, higher speeds and larger vehicles. Heavy trucks, such as those likely to be used during oil exploration and development, produce 10dB more noise than an average automobile (Lee and Fleming 1996). The magnitude of impacts will depend upon the volume, frequency, and timing of road noises, but may interfere with amphibian communications during breeding choruses, affect hearing loss and alter species distribution. Please refer to **Section 2.6** of this report for a more detailed discussion of the impacts of noise on breeding choruses and hearing loss. As for species distribution, once a road is established and used regularly, a road avoidance zone often develops wherein species diversity is considerably lower than surrounding areas (Forman and Alexander 1998). Avoidance of traffic noise is considered a potential explanation for this phenomenon, along with road-kills, pollution and visual disturbance. Regardless of reason, there are many studies that demonstrate this avoidance pattern (e.g., Fahrig et al. 1995, Findlay and Houlihan 1997, Rudolph et al. 1999). Again, the use of surveys prior to construction could reduce this affect by allowing avoidance of areas with high concentrations of amphibians and reptiles.

3.6.1.1 Population impacts of roads

The culmination of ecological impacts associated with roads has even greater population-level impacts. Roads become an ecological sink for both reptiles and amphibians, though in different ways. The thermal properties of bare road surfaces are such that they remain warm for some period after dusk. Reptiles are often attracted to the warmth in late afternoon and remain on the warm surface after dark – thus are more vulnerable to being killed by vehicles. For amphibians the problem is that drainage ditches on either side of the road collect water in which many amphibians breed. As a result of movements to, from, and between these ditches, on rainy days and nights many amphibians are killed crossing the road.

As individuals are lost to road-kill or area avoidance, local population size may decrease dramatically and in some cases, may be lost. Even if populations subsist, their local fitness may be compromised due to breeding impediments. A loss of breeding habitat or migratory routes between feeding and breeding habitats is an obvious breeding impediment, as is noise interference with amphibian breeding choruses. Studies have also shown less intuitive, social demographic changes associated with roads, such as higher rates of female turtles being killed within a population (Aresco 2005). As populations become fragmented by roads, metapopulation dynamics are also compromised with the loss of gene flow.

3.6.1.2 Suggestions to minimize road impacts

Because roads present a huge ecological cost in any system, much work has been done to identify steps that can be taken to minimize these negative impacts. Here is a summary of

suggested actions to reduce road impacts on amphibians and reptiles in the project area (modified in part from Corridor Design 2009):

- ∞ Conduct surveys prior to construction to identify significant herpetofaunal habitats, features (such as gopher tortoise burrows) and areas of density that should be avoided
- ∞ Reduce habitat loss by building at previously disturbed areas after verifying that former trails are not currently being used by wildlife
- ∞ Maintain a slow speed limit
- ∞ Post signs and further reduce speed at proven wildlife “hotspots”
- ∞ Include culverts or other underpasses periodically and vary these to accommodate diverse species needs (ex. some large, some small, some dry, some wet, some with natural light, some dark)
- ∞ At least at hotspots along roads, include berms with a smooth, 3.3-6.6 ft (1-2m) tall fence (such as metal flashing) with an outward facing lip extending from one culvert to the next; herptiles are less likely than mammals to learn culvert locations and pass them on generationally, thus such fencing is important in guiding herptiles to culverts.
- ∞ Monitor wildlife activities, such as amphibian breeding migrations, and eliminate traffic flow at critical times.
- ∞ Road access must be strictly controlled with posted, enforced signs and a locked gate at the entrance.
- ∞ Control any introduced exotic plants near wetlands mechanically rather than chemically.
- ∞ Roads and pads must be removed and the area restored once oil extraction is complete.

3.6.2 Impacts of Exploratory Drilling

Concerns associated with drilling include habitat loss, noise, vibrations, the potential introduction of pollutants and the potential spread of invasive-exotic species. Except for habitat loss, the impacts of these and potential mitigations are discussed extensively in relation to 3-D seismic activities (**Section 2.6**). In terms of habitat loss, efforts should be made to minimize impacts by limiting pad size and numbers by placing multiple wells on one pad with little to no excess room.

3.6.3 Problems Associated with Oil Production

As with many other O&G related activities, the oil production phase is characterized by noise and potential introductions of pollutants and non-native species. While all of these issues are important and must be taken seriously, from a herpetological perspective, only the gathering and flow lines present novel issues. These pipes contain hot liquids that may heat surrounding soils and waters. It is unclear what impact this might have on adult amphibians and reptiles, but turtles have temperature-dependent sex determination and often nest in muddy banks. If a nest were placed near the pipes, it could result in a heavily gender-biased clutch, which could have negative long-term population impacts if it

occurred repeatedly. Having a fence or some other barrier around the temperature-influenced area would preclude this problem. Another issue to be aware of is that treefrogs in particular seek shelter in accessible pipes. Any open pipes should be covered with screen or checked prior to use to avoid inadvertently killing animals.

3.7 Impacts on Wading Birds

The conceptual framework for evaluating activities is to consider the effects of both direct disturbance on wading birds as well as indirect influences through modifications of habitat. Direct disturbances come from helicopters, trucks and heavy equipment, human presence, and noise of drilling and generator. These activities could directly impact wading bird foraging flocks and nesting colonies. If strong enough, they could lead to impacts in the form of lowered food intake by adult wading birds from disturbed foraging flocks, reduced survival of young wading birds from disturbed nesting colonies, and reduced food intake by adult wading birds from altered prey species habitat use and vulnerability to capture.

Indirect effects on the habitat include physical disturbance of vegetation, soil, and surface water, and increased mortality or altered movements of aquatic prey animals. These effects could lead to a reduced prey density or a lower vulnerability of prey to being captured, collectively reduced prey availability, which could lead to lowered prey intake and ultimately reduced fitness of both adult and young wading birds.

3.7.1 Exploratory Wells

The specific construction activities that occur as part of the exploratory wells are road and pad construction and drilling. The stressors from the road and pad construction activity come from the presence of people and equipment, and associated noise. Direct impacts could occur on foraging flocks of wood storks and other wading birds as well as on their nesting colonies. Indirect effects come from the loss of foraging habitat, altered surface water flow and the possible increase in invasive species of plants, which could affect food availability.

3.7.1.1 Foraging flocks of wading birds

The activity of helicopters, heavy equipment and people in the area will almost certainly preclude birds from foraging nearby. The analysis of the SRF data suggests that there is a high probability that birds will occur in the NGA at some point in a dry season. The size of the construction area and distance from the staging area will dictate the magnitude of the potential impact.

3.7.1.2 Wading bird colonies

Construction activities near colonies can severely impact stork reproduction. The relative risk to colonies will depend on the probability of occurrence of colonies and the proximity of colonies to construction activities.

3.7.1.3 Indirect effects on wading birds

The indirect effects include loss of foraging habitat, increased water turbidity, and altered microtopography, the latter leading to an increased probability of invasive plants becoming established. The loss of foraging habitat is directly related to the size of the pad and road footprint that occurs in slough or wet prairie vegetation.

Increased turbidity could occur when runoff from the pads and roads get into the surface water in sloughs. This could reduce foraging success and energy intake temporarily. Berms surrounding the pads and road can reduce the potential for turbidity from runoff, but berms do not always contain the runoff, as was noted at Raccoon Point.

Berms and roads also have the potential to alter the normal concentration pattern of wading bird prey, affecting the movement of aquatic fauna as water levels drop. This can be minimized to some degree by orienting the pads and roads with the flow of surface water rather than perpendicular to it. It can also be minimized by increasing the flow under the road to the greatest extent possible. The placement of culverts should not just be in the lowest elevation areas because flows and movements of aquatic animals as prey must also occur when water levels are high and marshes at higher elevations are flooded.

The establishment of invasive plants could reduce the vulnerability of aquatic prey to being captured by wading birds and ultimately reduce energy intake. As with the exploration phase, the impacts of invasive plants can be reduced with aggressive control throughout and after the life of the project.

3.7.2 Production Wells and Associated Facilities

It is assumed that small pipelines will be constructed from each well to a central gathering point, which will involve the construction of a large pad, a water disposal well, storage tanks, generators, fuel tanks, and an office building. Construction activities associated with the wells and facilities include the same stressors as those that arise from exploratory wells with the additional complication of long-term truck traffic in and out of the area. Because the traffic is long-term and rather continuous throughout the season, it is likely that it will affect foraging flocks of wading birds when they form in the area. This is not something that can simply be put off by a few weeks until shallow water dries.

Another potential stressor is a chemical spill along pipelines or at the gathering point. One impact would be through mortality of wading bird prey resulting in reduced prey availability for wading birds. Also, if the spill were large enough, foraging birds could become “oiled” and thus experience mortality or severe injury. The potential effect would depend on the timing of the spill and its spatial extent. Timing that coincided with the occurrence of concentrated prey pools would have the most severe effect.

Finally, the noise created by the generators would likely exclude birds from habitat some distance from the facilities. The specific distance and area of exclusion would depend on

the volume of the noise. The impact of that exclusion distance would depend on its proximity to foraging habitat or nesting colonies.

3.7.3 Pipeline Construction

It is assumed that if oil production quantities become large, there will be construction of a large-diameter pipeline to carry oil from the onsite processing and storage facilities to some transfer facility. The potential impacts from the construction activities include those discussed under exploratory wells. There is also the potential of spills and leaks, which are described under production wells. However, because of the increased size of the pipeline it is likely that any resulting spill would be larger than with the smaller gathering pipes, and therefore have a greater potential impact.

3.7.4 Completion of Production and Restoration

If the fill material used to make roads and pads is excavated and removed by truck, there will be the potential for disturbance, as with the exploratory wells. Nevertheless, it is probably preferable to remove as much of the elevated areas as possible, and to revegetate those areas after production has ended. The control of exotic plants will be required long after the life of the project to ensure native vegetation becomes established and there is no seed source for further spread of exotic vegetation. Any increase in invasive species has the potential to alter the vulnerability of wading bird prey to being captured.

3.7.5 Delayed or Long-term Impacts

There are potential impacts that may not be evident for several years. For example, the extraction of O&G has the potential to alter the surface elevation (e.g., Ko et al. 2004). In such a flat landscape where small elevation differences greatly affect the ecological processes that drive wading bird prey availability, anything that affects surface elevation will likely affect the concentration pattern of wading bird prey. The extent to which these alterations are negative depends on the extent to which they impact the production of prey during the wet season and the concentration of prey during the dry season.

A second potential impact that may not become evident for many years is the invasion of the area by animals that find the construction and production facilities attractive (e.g., Liebezeit et al. 2009). Such animals could either act as predators on wading bird eggs and young, or they could feed on wading bird prey and thus act as competitors. American or Fish crows are an example of such species that could prey on wading bird eggs and chicks and that are known to benefit from human activities.

3.7.6 Summary of Impacts to Wading Birds

The potential for impacts related to O&G extraction in the NGA of BCNP depends greatly on the specific activities planned, their location, and timing. The potential impacts outlined above represent a starting point for an evaluation of impacts and in some cases they provide qualitative guidance for ways in which they may be minimized. The general

recommendations for minimizing impacts during 3-D seismic exploration, such as operating only where there is no shallow water, and for staying away from wading bird colonies, will largely apply here as well. However, there are potential impacts associated with O&G extraction that will require additional considerations. The specific degree to which operational changes mitigate for or prevent impacts can only be known after a thorough evaluation of gas and oil extraction plans.

3.8 Impacts on Red-Cockaded Woodpeckers

The future for RCWs in the NGA of BCNP is intimately linked with management and habitat use decisions made for the NGA, the BCNP as a whole, and other natural areas throughout the region. Also intimately influencing the future for RCWs in the area are more stochastic catastrophic events such as major hurricanes, wildfires (of either lightning or human origin), the establishment of invasive exotic species, and on a longer time scale, climate change. At the present time we do not know the status of RCWs within the NGA, but potential habitat for the species does occur in the area and they may be there. Whether or not RCWs currently exist in the NGA, the habitat of the area is important – at the very least – as a bridge for dispersal and maintenance of the species’ genetic diversity and ultimately to the regional survival of this endangered species.

Here, we assess the potential future of RCWs in the NGA, the BCNP as a whole, and in the region as it might be affected by O&G development in the NGA. In addition to discussing potential direct impacts of O&G exploitation on the RCW, we will also consider the potential synergies between impacts of O&G development and these other influences.

3.8.1 Potential Direct Impacts on RCWs

3.8.1.1 Road mortality

The RCW cavity cluster that straddles the 11-Mile Road leading to the well pads at Raccoon Point provides an example of a situation that could lead to the loss of an active cavity cluster. Much of the social activity of the group takes place within the cavity cluster and birds roost in cavity trees within the cluster each night. During the breeding season, birds enter and leave the cluster repeatedly while incubating eggs and brooding or feeding young. Male and female RCWs use the species’ niche differently – males foraging high in pines and females foraging primarily on the trunks of pines below the lowest branches (Ligon 1968, Ramey 1980). As a result, females typically fly lower than males and are thus more vulnerable to being hit by vehicular traffic.

Because of their social system that results in dispersal of young females and normal presence of only a single, breeding female within an active group, loss of that female could result in loss of the active cluster. When such losses occur, the males remain at the site until a dispersing female is recruited into the group or the males die. One of the major problems facing RCWs today is fragmentation of populations such that there are few dispersing females available for recruitment (Jackson 1971, 1978, 1994).

Although the potential for such a loss is very low due to the restricted access, relatively low speed, and low volume of traffic on oil well roads, the threat is real. It could be mitigated by locating roads away from pine habitats in general, and specifically away from RCW cavity clusters. It could also be mitigated by further limiting vehicle speed along any road that passes through the polygon and a reasonable buffer (e.g., 200 ft [61 m]) defined by the outer cavity trees in the cluster.

3.8.2 Potential Indirect Impacts on RCWs

3.8.2.1 Increased risk of predation

Creation of open areas and the bare dry land of the well pads and access roads create environments that generate thermals. Diurnal raptors such as the American kestrel (*Falco sparverius*) readily take advantage of thermals, using them to reduce energy expenditure in gaining altitude during migration and forays in search of food. Kestrels and other diurnal raptors are opportunistic hunters that would readily take a bird the size of a RCW and are known to attempt to take them (Wood 1983, Jackson and Parris 1995). These predators would also take advantage of tall structures on well pads as perch sites and feed on mice or rats that became established at well sites. See also comments below about invasive exotics that are potential predators or might favor potential predators on RCWs.

3.8.2.2 Increased risk of fire affecting habitat

Fire is an essential component of RCW ecosystems and is naturally a result of the high incidence of lightning in the region. In south Florida, there are about 90 days per year on which there are electrical storms and most of these occur during mid-May through August. This is the highest incidence of lightning in North America and one of the highest in the world. Lightning strikes can start fires and under natural conditions, some forests in south Florida would have burned on an almost annual basis.

Plants of the region have adapted to live with fire and pines not only survive the fires but promote them with resinous needles and cones that ignite and quickly burn, resulting in fires that race through the ecosystem. Such a fire is known as a “cool fire” – akin to passing one’s finger quickly through a candle flame. As a result of such cool fires, the pines and some other fire-adapted plants survive, but many hardwood trees are killed. Thus maintaining an open habitat – one that provides for the shade-intolerant pines and for RCWs that nest in living pines.

A major factor in the decline of RCWs to their current endangered status has been a reduction in the frequency of fire in pine forests. Today, we recognize that fire plays many positive roles in ecosystems and fire is used in both forest and wildlife management. To overcome the problem of roads and other human altered habitats serving as fire breaks, deliberately set fires known as “prescribed burns” are used to manage industrial forests and to maintain the open pine forests needed by RCW. For safety reasons, foresters prefer to run prescribed burns during winter months. Fires at such times do not get as “hot” and

thus pose fewer hazards. However, ecologists now understand that winter prescribed burns do not have the same ecological impact as natural summer burns. Use of prescribed burns during the time natural fires would occur is important to restoring the RCW and its ecosystem, but becomes very difficult near human habitation.

Use of prescribed fire near oil or gas exploitation sites poses potential for conflict between the needs of the RCW and the safe extraction of the resource. The lack of use of prescribed burning in RCW habitat, however, could pose even greater threats to the O&G exploitation. If an area of pine forest does not get burned frequently, fuel in the form of needles and limbs of pines and other vegetation build up, setting the stage not only for the abandonment of the area by RCWs, but also for catastrophic fire.

Many areas of the Big Cypress have not been burned frequently and the stage is set for potentially hot fires. Ignition of an unplanned fire could result from sparks from vehicles, other equipment, or cigarettes. If the fire occurred in an area where fuel had built up, it could kill the pines and also do substantial damage to the oil or gas production facility. Some areas of Nobles Grade and elsewhere on the BCNP with a high fuel load have experienced such fires in recent years. Fire management, particularly around O&G equipment and structures, is critical to maintaining proper habitat but also to reduce fuel loads that could result in an environmental catastrophe.

3.8.2.3 Impacts of altered water flow and quality

Flow of water through the BCNP is slow and primarily from north to south. Thus, having roads running primarily north-to-south minimizes blockage of water flow. The major access road leading to the well sites at Raccoon Point does run north-south, however, roads between adjacent wells generally do not, and the well pads themselves are large enough to be obstructions to the natural flow of water. Culverts under all roads at Raccoon Point accommodate some exchange of water, but not the free exchange that would occur if the roads were not there, and the linear accumulation along the roads of plants requiring longer hydroperiod indicate the effects of pooling and reduced flow. More culverts would be an improvement but not a replacement for sheet flow.

To the extent that road and well-pad construction alter the hydroperiod of RCW cavity cluster sites and foraging habitat, it would alter (1) the ability of the land to support slash pines, (2) the ability of the habitat to carry a fire and thus keep the habitat open as required by RCWs, and (3) would allow the invasion of other plant species that would compete with the pines and thus diminish the quality of the habitat for RCWs.

The roads and well pads at Raccoon Point are made of crushed limestone – natural to the region’s geology, but when piled on the surface, crushed limestone is capable of altering water and soil chemistry. Slash pine requires an acidic environment, but “does poorly in basic soil (high pH)” (Gilman and Watson 1994) such as might be associated with runoff from the crushed limestone roads and well pads. Pines near the roads and well sites may be stressed by the altered chemistry of the local microclimate, thus reducing habitat quality for RCWs.

3.8.2.4 Impact of exotic species

Some invasive exotic species have the potential to significantly alter the habitat of RCWs or influence RCW populations through competition, disease, or predation. Oil and gas exploitation in the region has the potential to introduce invasive exotic plants and animals to the heart of the Nobles Grade ecosystem as a result of plant propagules or animals arriving on equipment brought to the site. Some of these are species that are anthropophilic, thus favoring sites occupied by humans. Such animals would include things like the house mouse (*Mus musculus*) and rats (*Rattus rattus* and *R. norvegicus*), all of which would favor the human disturbed areas, but which would also spread into adjacent areas. The rats – especially *R. rattus* – are excellent climbers and often predators on birds, their eggs, and nestlings (Atkinson 1985, Campbell 1991). In addition, these rodent species are prolific and become a source of food for other predators whose populations can build up, thus further threatening native species such as the RCW.

Among invasive plant species, Melaleuca, cattail, and giant reed (*Arundo donax*) are all in the region and ecosystem-modifying species. These species alter the hydrology and thus can influence slash pine growth and therefore RCW habitats.

3.8.2.5 Synergistic impacts of O&G activities with hurricanes

In September 1989, Hurricane Hugo hit the coast of South Carolina, dealing a devastating blow to the RCW population on the Francis Marion National Forest (Hooper et al. 1990, Conner et al. 2001). This category 4 hurricane (on the Saffir-Simpson scale, indicating winds of 131-155 mph) had diminished to category 2 status (96-110 mph winds) as it moved inland and hit the Francis Marion National Forest. It destroyed 87% of the RCW cavity trees, killed 63% of the birds, and destroyed 70% of the birds' foraging habitat (Hooper and McAdie 1995). As Conner et al. (2001:144) note:

“The presence of large openings near red-cockaded woodpecker clusters makes them especially vulnerable to wind damage.”

At the time of Hurricane Hugo, the Francis Marion National Forest was being managed by harvesting pines in small clearcuts, making the birds more vulnerable to wind. The mosaic of pine islands and open wetlands characteristic of the BCNP thus makes RCW cavity clusters generally more susceptible to wind damage than clusters in more continuous pine forest. The creation of openings for access roads and well sites for oil or gas production near RCW cavity clusters or foraging habitat further increases the vulnerability of the RCW to losses as a result of hurricanes. Conner and Rudolph (1995) described how trees are damaged both at the edge of an opening and well in from the opening (**Figure 3.4**).

Conner and Rudolph (1995) found that wind-damaged RCW cavity trees averaged 361 ft (110 m) from clearings and that most had been snapped off by the wind. The magnitude of such losses depends on the severity of the storm, the path of the storm relative to the location of RCW sites, and the condition of the forest prior to the storm. Landsea et al.

(1996) indicate that on average 2.2 hurricanes of a Saffir-Simpson magnitude of category 3, 4, or 5 occur in the Atlantic basin per year, but add that metropolitan Miami went 42 years without experiencing such a storm. Barton and Nishenko (2003) analyzed Atlantic basin hurricane records differently, calculating the probability that a category 2 or larger hurricane (wind speeds ≥ 100 knots (115.2 mph)) would hit various regions of Florida (**Figure 3.5**). The BCNP, including the NGA, falls within the region with an 80-100% probability of being hit by such a storm within 20 years. Doyle and Girod (1997) gave yet another view, suggesting that the BCNP region experiences a catastrophic hurricane about once every 30 years.

3.8.3 Suggestions for Minimizing Impacts on RCWs

Surveys need to be conducted in order to know the status of RCWs and their habitat in the NGA. Without such knowledge little more can be said relative to potential impacts of O&G activities on the species. Because of the threat from catastrophic hurricanes in the region, we must maintain active clusters of RCWs over as wide an area as possible. When considering the potential impact of activities in the NGA, we must also be looking at potential impacts on the RCW populations elsewhere in south Florida. Survival of the south Florida population of this species will depend on linkages among these birds and their widely distributed cavity clusters.

To mitigate for potential RCW population fragmentation in the NGA, suitable habitat in the NGA should be linked by corridors of suitable habitat to RCW groups existing in BCNP, to the west in Collier County (Anonymous 2009), and to the north in Lee and Charlotte counties. Providing such corridors would provide not only for RCW population stability, but also for the well being of other endangered species such as the Florida panther. Without such broader thinking and collaboration among landowners, the potential for the existence of RCWs in the NGA is very slim.

3.9 Impacts on Mammals

The direct and indirect impacts of oil exploration and production on threatened and endangered mammals of BCNP are similar in many ways to that predicted to be caused by seismic exploration, but primarily, these activities differ in duration, and potentially in scale and intensity, and thus may have dramatically different effects on local wildlife. Although seismic exploration activities are projected to occur within a year, oil production could last decades, and its potential to impact wildlife at least that long and perhaps beyond. Although some generalizations on potential impacts and recommendations for mitigating these effects on threatened or endangered mammals can be made, without knowing the scope of activities, it is difficult to predict the long-term impacts, thus we strongly recommend these considerations be reevaluated before exploration and extraction are initiated. In this section, we will expand on those potential impacts and mitigation measures for listed mammals of BCNP previously discussed in the seismic exploration section and list, and discuss new potential listings that may result from oil exploratory drilling and production.

3.9.1 Direct Impacts

The most probable direct impacts from oil exploration and drilling on the 4 listed mammals include: 1) injury or death from animal-vehicle collision, 2) injury or death from contact with or ingestion of spilled oil or other harmful chemicals, or inhalation of toxic compounds, 3) increased stress levels, 4) abandonment of home ranges, denning sites, and offspring, 5) decreased fitness (e.g., fecundity, survival), and 6) avoidance of habitat at or near disturbances.

3.9.1.1 Wildlife-vehicle collisions

All phases of oil exploration and production rely on vehicular transportation that creates a constant risk of animal-vehicle collision that exists for the duration of the project. If roads are not closed at the conclusion of extractive operations, the risks to wildlife can remain and even be greater depending on their use. The likelihood of wildlife-vehicle collisions will increase as a function of road density and traffic intensity, speed, and volume. For any given area, a vast, spider-like network of roads will usually have more impact on wildlife than a few roads similarly used, particularly for species with large spatial requirements, such as panther and black bear. Brocke et al. (1990) found that black bear numbers were inversely related to road density in the Adirondacks, and others have found that large carnivore populations are unlikely to persist long-term if road densities exceed 0.6 km/km² (Forman and Alexander 1998).

As previously discussed, panthers and bears are frequently killed on limited access roads, yet they have also been observed to use dirt and gravel roads during their daily movements (McBride 2007, J. Guthrie, unpublished data). We know little about the influences of roads on fox squirrel and mink except that both are found as road-kills. Although access-controlled, one-lane roads will likely pose less of a risk than public paved roads, vehicle-collision risk on the former will nevertheless increase with total road length per unit area. Furthermore, illegal traffic on oil infrastructure roads (such as by ORVs that enter at points other than the locked gates) will be increasingly difficult and expensive to control as total road length (and potential access points) increases.

Recommendations - To reduce the risk of vehicle-animal collision and illegal use of new or reactivated roads, we recommend:

- ∞ new road construction be minimized and road densities minimized in accordance with published road density thresholds of large carnivores;
- ∞ security-controlled access to newly constructed roads, particularly from paved roads or current navigable roads and trails;
- ∞ maintenance of close communication and cooperation with agency law enforcement;
- ∞ use of slow-speed patrol of new roads to prevent back-trail incursions onto new roads;

- ∞ travelling at a slow maximum speed (20-30 mph [32-48 kph]) on newly constructed exploratory roads, and that drivers stop for all wildlife in their path;
- ∞ education of crews about bear nuisance behavior;
- ∞ placing emphasis on litter enforcement and use of bear-proof garbage cans and dumpsters located away from main roads;
- ∞ permanent closure and reclamation of roads in conjunction with phased closure and reclamation of oil production pads.

3.9.1.2 Oil and chemical spills, air pollution

The potential for oil or other chemical spills and subsequent contamination depends heavily on the spatial extent of oil production and transportation infrastructure; more pipeline, haul roads, and production pads increase the likelihood of a spill. Species such as carnivores that occur at the top of food chains are often more vulnerable to the affects of bioaccumulation of toxic compounds found in the environment. Both bears and mustelids can be injured or die from oil contamination via grooming and consumption of contaminated prey (Oristland et al. 1981, Kannan et al. 1998), and bioaccumulation of heavy metals has been documented in Florida panthers and their prey in south Florida (Roelke et al. 1991). Increasingly, air pollutants (e.g., PCBs) are showing up in high concentrations in tissues of animals thousands of miles from the pollution source, and in some cases have been observed to influence a variety of physiological parameters, including reproduction and immune response (Braathen et al. 2000, Lie et al. 2003).

Recommendations - To reduce the risk of toxic contamination of threatened or endangered mammals at BCNP we recommend:

- ∞ construction and implementation of plans for contaminant spills and subsequent clean-up operations;
- ∞ frequent practice of contaminant spill drills;
- ∞ frequent inspection of machinery and pipelines for liquid and aerosol leaks;
- ∞ rapid clean-up and containment of contaminant spills;
- ∞ proper off-site disposal of garbage/waste and liquid contaminants and prohibition of onsite burning of garbage/waste;
- ∞ reduction of excessive vehicle use and operation (e.g., idling) to minimize air pollution;
- ∞ fencing off or cover waste stored on site, and;
- ∞ using biodegradable materials in construction where possible.

3.9.1.3 Physiological stress

Oil drilling and production will create noise and disruption during all operational phases. The long-term duration of oil drilling and production activities are likely to cause some degree of acute, and potentially chronic stress to animals that experience them. Even though most animals in BCNP have likely encountered some form of temporary human disturbance, it is unlikely they have continually experienced these stimuli over periods that exceeded a few hours or days. Some individual animals may readily adapt to these new

disturbances, particularly if they are not directly affected by them and do not perceive them as a threat; other individuals may completely avoid oil extractive infrastructure. Prolonged stress could lead to alterations in physiology via endocrine, immune, and/or metabolic mechanisms that result in decreased fitness of individuals as manifested in reduced survival, reproduction, and fecundity. Physiologic responses to stressors may be affected if animals have been contaminated with toxic compounds (Braathen et al. 2000).

3.9.1.4 Abandonment of home ranges, dens, and offspring, and avoidance of suitable habitat

Unlike the proposed seismic exploratory drilling, oil production and supporting activities will be a year-round activity. Prolonged disturbances from oil production could cause wildlife to temporarily or permanently abandon feeding areas, home ranges, denning sites, and offspring. Animal responses to these disturbances will vary by species, by individuals within species, and by the spatial extent, type, frequency, intensity, and duration of disturbances. Abandonment of traditional ranges and preferred habitat by wildlife can lead to short and long-term decreases in fitness via: 1) suboptimal foraging, 2) intraspecific strife and killing, 3) decreased breeding opportunities, 4) excessive energy expenditure, 5) decreased prey quality and availability, and 6) increased dispersal and movement sallies into unfamiliar territory with greater likelihood of injurious or lethal encounters with humans.

Although black bears, panthers (and some prey species), and fox squirrels can be tolerant of human disturbance, their responses to sustained disturbances caused by oil production will depend on the extent and types of those activities and the experiences they have had to these novel stimuli; less is known to guide us in how mink would respond. These species may be particularly sensitive if habitat loss and fragmentation caused by roads and production infrastructure is widespread enough to reduce landscape-scale connectivity.

Recommendations - To reduce the likelihood of habitat avoidance, stress, and risk of abandonment by threatened or endangered mammals we recommend:

- ∞ minimizing habitat loss and fragmentation; concentrate activities and development where possible;
- ∞ minimizing the number of personnel, equipment, space used, and time spent in one area for all operations;
- ∞ working closely with wildlife agencies to avoid active panther areas, including den locations;
- ∞ establishing and enforcing policies that prohibit wildlife harassment;
- ∞ immediately containing and cleaning-up contaminant spills, and;
- ∞ restoring damaged habitat.

3.9.2 Indirect Impacts

The area affected by oil drilling and production will be dependent on the location of oil reserves and their accessibility. The indirect impacts of these activities on threatened or endangered mammals primarily includes habitat and prey alterations (quantity and

quality) influenced by the collective infrastructural and operational footprint that could range from small (few pads and roads; tens of acres) to large (multiple pads and extensive road network; hundreds to thousands of acres). Small-scale operations would be less disruptive than those that alter larger scale disturbance regimes (e.g., fire frequency and intensity) or local hydrology (e.g., prey availability and quality) in ways that ultimately reduce fitness of individual animals and populations sensitive to loss of prevailing conditions and patterns. Extensive oil extractive operations could have landscape-level impacts that are scale-dependent and act synergistically to reduce available habitat and disrupt demographic connectivity within populations.

Habitat fragmentation also increases edge and may benefit bears and deer by creating conditions favorable for growth of early successional plant species; white-tailed deer are known to frequent power line and gas line corridors to forage on young-aged plants. However, the benefits of fragmentation may be more than offset by the range of other negative effects (e.g., increased ingress and poaching); the cost-benefit tradeoff likely dependent on the scale of operations. Habitat loss and fragmentation could be more influential on the smaller ranging fox squirrel and mink if activities extensively occurred in areas they occupied, particularly for mink if hydrological alterations reduced habitat or prey quality and quantity.

Contaminant run-off, leaks, and spills from oil exploration activities could contaminate habitat and lead to loss or reduced quality of forage or prey species, conditions that would most likely impact mink than the other threatened or endangered mammals.

Table 3.1: Potential impacts of oil development activities on cypress wetlands (modified from de la Cruz 1982 and Ko and Day 2004).

Stage	Activity	Impact
Exploration	Seismic surveys by explosive discharge methods. This involves clearing of a survey line, drilling the shot-lines, detonating the explosives, recording the shock waves, and removing of equipment.	<ul style="list-style-type: none"> ∞ Immediate loss of vegetation through crushing or clearing along shot lanes ∞ Changes in surface hydrology and runoff through creation of water courses by vehicle tracks ∞ Changes in plant growth and organic matter accumulation ∞ Hazard of fire from vehicles, people, and explosive materials ∞ Introduction of invasive species
Access to site	Construction of access routes and well sites which involves building up the roadbeds and sites to be above normal flooding heights.	<ul style="list-style-type: none"> ∞ Direct loss of vegetation due to construction of roads and production platform ∞ Blockage of natural water flows by roadways ∞ Changes to surface hydrology and drainage ∞ Changes in surface/subsurface hydrology ∞ Impact on plant growth
Drilling	During drilling, supply lines and utility lines are placed along edges of roads. All equipment, supplies, and people are transported along the access roads. Drilling may last for several months.	<ul style="list-style-type: none"> ∞ Release of nutrients and toxic/noxious substances into environment ∞ Reduction in water quality ∞ Increase in suspended solids ∞ Changes in soil/water chemistry ∞ Changes in plant growth. ∞ Changes in subsurface hydrology and drainage

Table 3.1: continued

Stage	Activity	Impact
Production	Conversion of drilling site to production involves pumps, regulators, separators, heater-treaters, filters, pipelines to bring all to one site, etc. Life of well could exceed 50 years? Requires daily checking and monitoring. Frequent maintenance activities.	<ul style="list-style-type: none"> ∞ Loss of wetland if drilling site expanded ∞ Release of nutrients and toxic/noxious substances during construction and operation ∞ Reduction in water quality ∞ Occurrence of minor oil spills ∞ Changes in surface and subsurface hydrology and drainage ∞ Introduction of invasive species ∞ Altered soil/water chemistry
Pipeline building	Laying of pipe from production pad to central collection/distribution site. Pipe will traverse wetland area and either be above-ground or belowground.	<ul style="list-style-type: none"> ∞ Loss of wetland habitat ∞ Changes in surface hydrology
Spill control/cleanup	Oil leaks and spills can occur with any of the above activities, but especially with pipeline breakage.	<ul style="list-style-type: none"> ∞ Coverage of soil surface and plants with oil ∞ Potential disruption of substrate during cleanup ∞ Negative impact on plant growth ∞ Loss of habitat ∞ Alteration of nutrient and soil characteristics
Restoration	Return of site to pre-oil conditions; removal of pads, roadways, etc.	<ul style="list-style-type: none"> ∞ Increased turbidity during removal of site material ∞ Accidental spillage of petroleum and other wastes ∞ Increase in vegetation through restoration efforts and natural regeneration



Figure 3.1: Image at the exit road for pad #5 at Collier Resources Company's Raccoon Point oil field. The image was take after a large rainfall event and shows significant water accumulation on the surface of the pad and a small breach in the levee (near the front flowline) that is draining turbid water into the adjacent cypress swamp. This image also shows flowlines coming into contact with surface water in the wetland (Photo by Jerome Jackson).

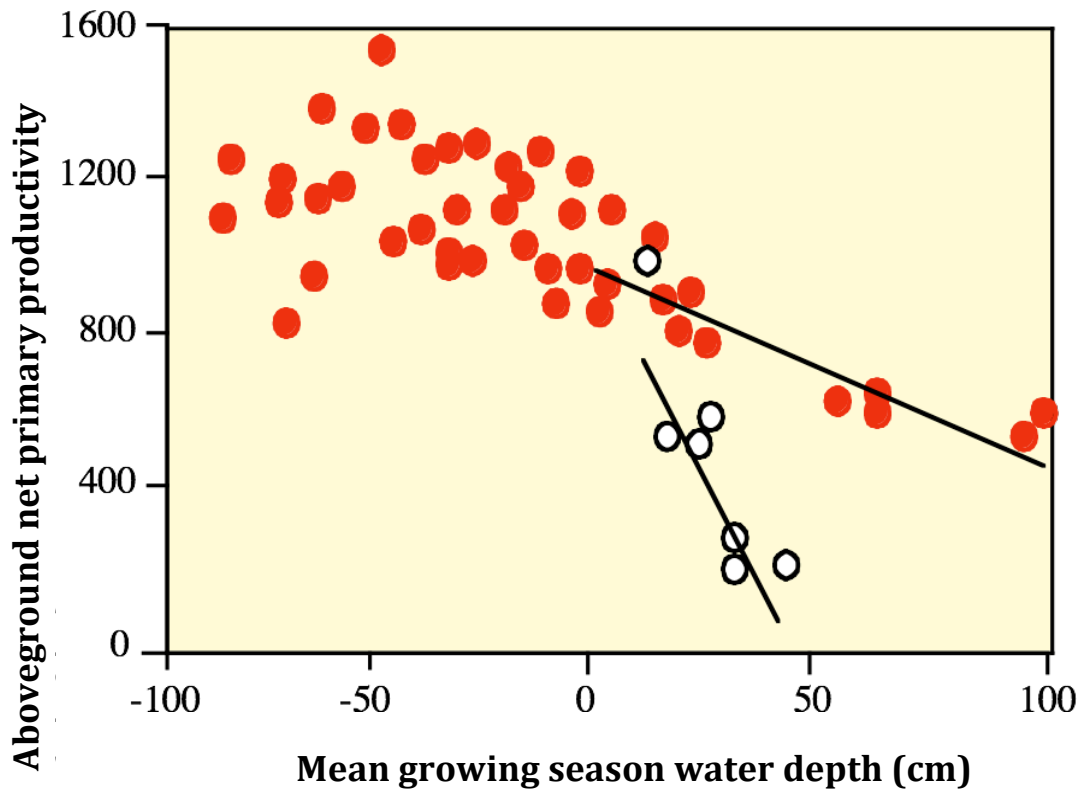


Figure 3.2: Relationship of aboveground net primary production to mean growing season water depth for baldcypress (Megonigal et al. 1997).

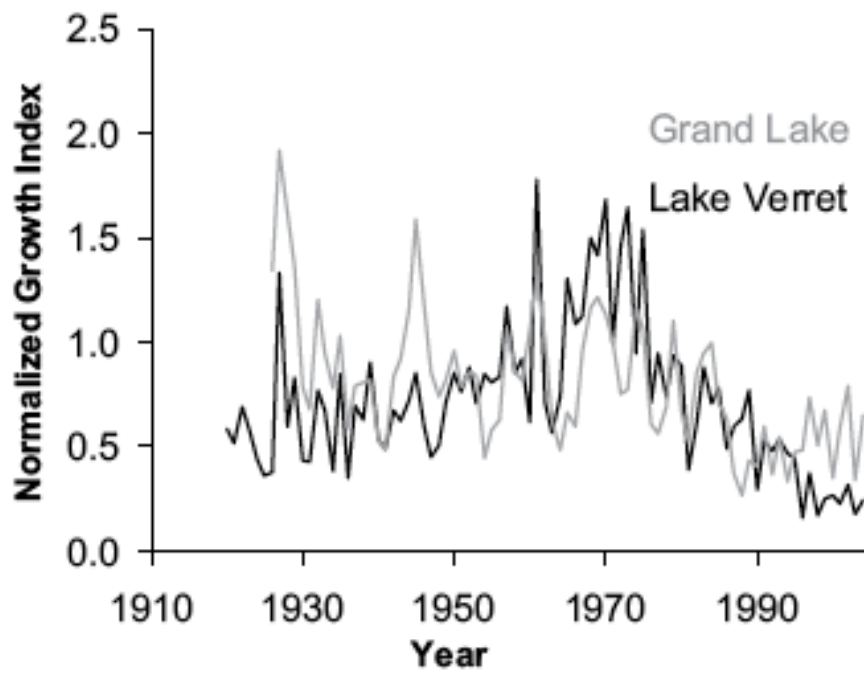


Figure 3.3: Tree ring growth indices (normalized to remove biological trends) for two baldcypress stands in Louisiana with increasing water levels (Keim et al. 2006).

Deflection of wind upward resulting in swirling turbulence just above forest

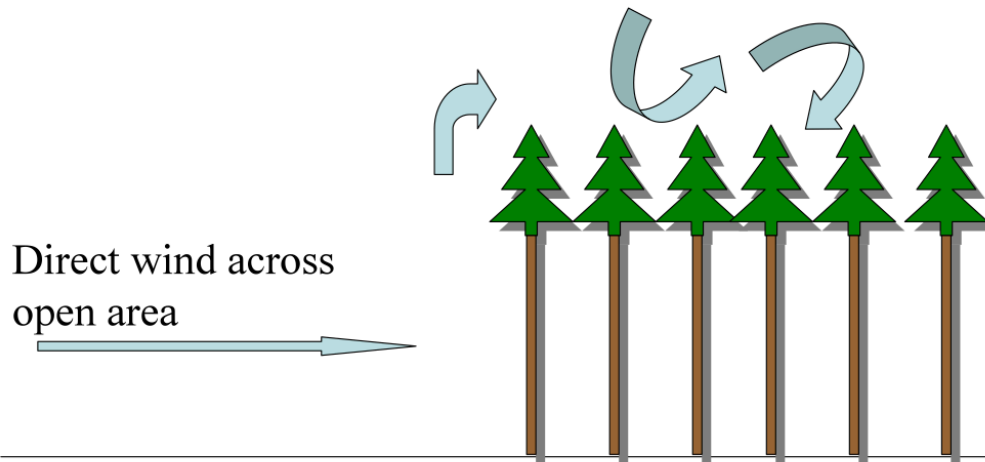


Figure 3.4: Schematic illustration of wind striking the edge of a forest, being deflected upward, where it interacts with higher horizontal wind to generate turbulence, resulting in damage or loss of red-cockaded woodpecker cavity trees and foraging habitat both at forest edge and in the forest interior. (Redrawn and modified from Conner and Rudolph 1995).

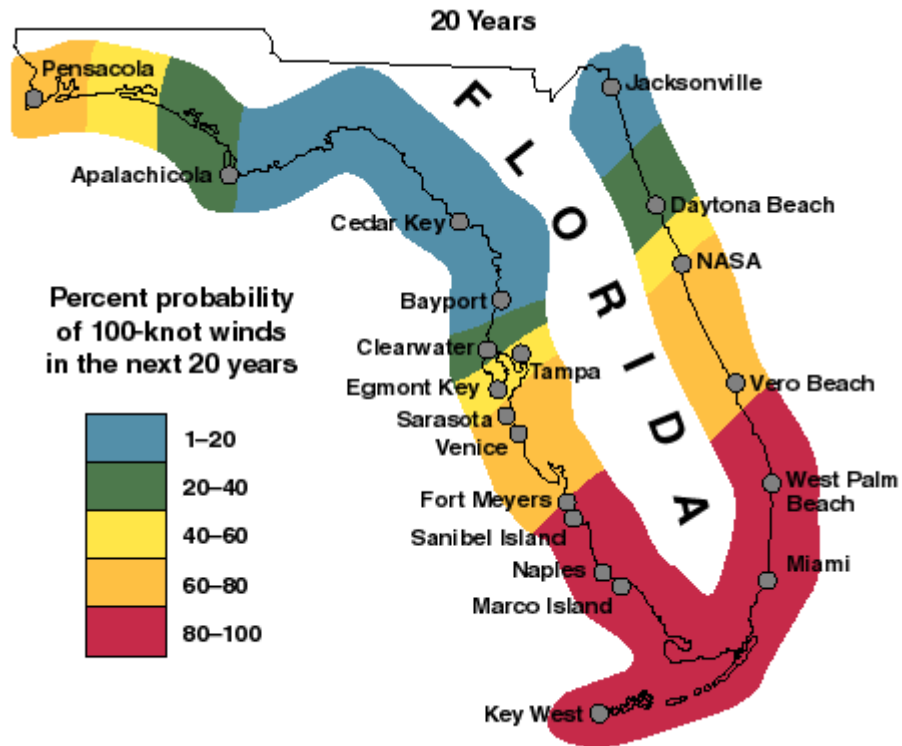


Figure 3.5: The probable frequency of category 2 hurricanes (based on Saffir-Simpson scale; wind speeds ≥ 100 knots [115 mph]) striking Florida within the next 20 years. These probability estimates are based on 106 years of observation. (From Barton and Nishenko 2003).

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Appendix A

Panelists and Panel Staff for Everglades Foundation-based study of Oil and Gas
Impacts on the Big Cypress Ecosystem

List of panelists and panel staff

Wildlife Biology/Ecology

1. **Dr. John J. Cox** (University of Kentucky): large mammal (i.e. panther and black bear) and herpetofaunal ecology, 859-229-7200, jjcox@uky.edu
2. **Dr. Jerome A. Jackson** (Florida Gulf Coast University): Ecology, behavior, and habitat use of red-cockaded woodpecker and wildlife ecology, 239-590-7193, jjackson@fgcu.edu
3. **Dr. Dale E. Gawlik** (Florida Atlantic University): Ecology of wading birds, prey density effects on wading birds, hydrologic effects on wading birds; 561-297-3333, dgawlik@fau.edu

Plant Ecology/Cypress Ecosystem

4. **Dr. Jennifer H. Richards** (Florida International University): wetland plant ecology and hydrologic control over wetland plant growth; 305-348-3102, richards@fiu.edu
5. **Dr. William H. Conner** (Clemson University, Baruch Institute of Coastal Ecology and Forest Science): forested wetlands and water quality, forested wetland restoration, influence of hydrology on forested wetland productivity; 843-546-6323, wconner@clmson.edu

Hydrology/Geology/Oil & Gas Exploration

6. **Dr. Fernando Miralles-Wilhelm** (Florida International University): spatial analysis, integrated surface-ground water modeling in wetlands: 305-348-3653, miralles@fiu.edu
7. **Mr. James O. Jones** (SWCA, Austin): expert in oil and gas exploration tools and environmental assessment, wetland ecosystems: 832-722-5464, jjones@swca.com

Panel Staff

1. Panel Chair and Project leader: **Dr. Stephen E. Davis, III** (Everglades Foundation): wetland ecosystem ecology: 305-251-0001, sdavis@evergladesfoundation.org
2. Panel Assistant: **Ms. Kirsten N. Hines** (Everglades Foundation): M.S. and research background in herpetology: 305-251-0001, khines@evergladesfoundation.org

Appendix B

Agenda/Schedule for Panel Meetings for study of Oil and Gas Impacts on the Big Cypress Ecosystem

Agenda for Big Cypress Ecosystem (partial) Panel meeting

Dates: June 29-30, 2009

Location: conference room at Barron Collier Companies, 2600 Golden Gate Parkway, Naples, FL 34105 (see map)

Attendees: Stephen Davis (Everglades Foundation), Jennifer Richards (Professor, Florida International University), and Jerome Jackson (Professor Florida Gulf Coast University)

Collier Participants: Bob Duncan (President, Collier Resources Company), Christian Spilker (VP Environmental Planning & Permitting, Collier Enterprises), and Tom Jones (VP Governmental Relations, Barron Collier)

June 28: Davis and Richards to arrive in Naples on evening of June 28. Jackson will join Davis and Richards for dinner on evening of June 28.

June 29: begin at 8:30AM

- Introductions
- Discuss broad agenda and goals/expectations for panel
- Brief overview of Big Cypress
- Introduce/meet CRC representatives
- History of oil exploration and development in south Florida
- Permitting for Oil & Gas activity at State and Federal level
- Details of CRC's plans for exploration
- Questions
- Working Lunch: approx. 12:30PM
- Partial Panel Discussion
 - Issues with regard to new exploration in Big Cypress
 - ∞ Plant community
 - ∞ Red-cockaded woodpecker habitat
 - ∞ Links or interactions to consider
 - New questions/issues to consider
 - Options/alternatives to consider
- Outline of exploration component of report related to panelist area
 - Compile notes to deliver to July panel (mainly for Jackson)
 - Individual schedule for deliverables
- Wrap-up at 5:00PM

June 30: depart Naples at 8:30 AM

- ∞ Meet at 11-mile Rd. at 9AM
- ∞ Tour Raccoon Point Oil Field (till approximately 12:00 PM)

Agenda for 1st Big Cypress Ecosystem Panel meeting

Meeting Dates: July 29-31, 2009

Contact: Dr. Stephen Davis; Everglades Foundation; 305-251-0001 ext 234 (office) or 979-571-4739 (mobile)

July 28: Marriott Dadeland hotel check-in (5 people; see directions and map); Cox, Conner, Jones arrive to MIA via air, Gawlik drive to Miami, and Duever (guest speaker) drive to Miami

July 29: conference room Everglades Foundation, 18001 Old Cutler Road, Suite 625, Palmetto Bay, FL 33157 (see directions and map)

- ∞ begin at 8:30 AM
 - Introductions (Davis; EF)
 - Discuss broad agenda and goals/expectations for panel (Davis; EF)
 - Overview of Big Cypress Ecosystem (Dr. Michael Duever; SFWMD)
 - Working Lunch: approx. 12:30 PM
 - Collier Resources Company (CRC) Presentation (Bob Duncan President, CRC; other Collier reps.)
 - History of oil exploration and development in south Florida
 - Permitting for Oil & Gas activity at State and Federal level
 - Details of CRC's plans for exploration
 - Questions
 - Panel Discussion (closed to all but panel and panel staff)
 - Issues with regard to new exploration in Big Cypress
 - ∞ Individual components
 - ∞ Links or interactions to consider
 - New questions/issues to consider
 - Options/alternatives to consider
 - Wrap up discussion around 5:30-6:00 PM
- ∞ Panel dinner (TBD): voluntary

July 30: visit to Big Cypress (panel and representatives from CRC)

- ∞ Will meet out front of Marriott Dadeland at 7:15 AM with van.
- ∞ For those driving separately, we will meet at 11-mile Rd. at 9:00-9:15 AM
- ∞ Tour Raccoon Point Oil Field with CRC (till approximately 12:00 PM)
- ∞ Lunch (12:00-12:30 PM)
- ∞ Meet at Oasis Conference Center at around 1:00PM
 - Presentations by Big Cypress staff and scientists
 - James Snyder, Fire Ecology, USGS Florida Integrated Science Center
 - Darrell Land, Panther Team Leader, Florida Fish and Wildlife Conservation Commission

- Don Hargrove, oil & gas permitting, Big Cypress National Preserve
 - James Burch, exotic plants, Big Cypress National Preserve
- ∞ Return to Miami and Marriott Dadeland
- ∞ Dinner on own

July 31: conference room Everglades Foundation, 18001 Old Cutler Road, Suite 625, Palmetto Bay, FL 33157 (see directions and map)

- ∞ begin at 8:30 AM
 - 9:00 AM: presentation by Jimi Sadle (Botanist, Everglades National Park) on habitats and distribution of rare plants of Big Cypress and Addition Lands
 - Comments/questions
 - Topical area development
 - Break-out groups (tbd)
 - Issues with regard to new exploration in Big Cypress
 - ∞ Individual components
 - ∞ Links or interactions to consider
 - New questions/issues to consider
 - Options/alternatives to consider
 - Formulation of conceptual model for topical area
 - Working Lunch: approx. 12:00 PM
 - Group reports
 - Outline of exploration component of report related to panelist area
 - Individual schedule for deliverables
 - Expectations for August panel
 - Wrap up discussion around 4:00-4:30 PM

Agenda for 2nd Big Cypress Ecosystem Panel meeting

Meeting Dates: August 29-31, 2009

Contact: Dr. Stephen Davis; Everglades Foundation; 305-251-0001 ext 234 (office) or 979-571-4739 (mobile)

Friday August 28: Marriott Dadeland hotel check-in (4 people; see directions and map); Cox, Conner, Jones arrive to MIA via air, Jackson drive to Miami. Gawlik will drive down morning of August 29 and check-in that evening.

Saturday August 29: conference room Everglades Foundation, 18001 Old Cutler Road, Suite 625, Palmetto Bay, FL 33157 (see directions and map). Meeting is open to all.

- ∞ Begin at 9:00 AM
 - Welcome and introductions (Davis; EF)
 - Presentation: Red cockaded woodpeckers in Big Cypress (Ross Scott; FWC)
 - Presentation: Deer, Panthers, and other large mammals in Big Cypress (Deb Jansen; BCNP)
 - Working Lunch: approx. 12:00 PM
 - Collier Resources Company (CRC) Presentation (Bob Duncan President, CRC; other Collier reps.): Hypothetical plan for drilling and long-term oil development of Nobles Grade area including
 - Questions
 - Initial panel discussion on long-term development impacts (closed to all but panel and panel staff)
- ∞ End at 5:00 PM

Sunday August 30: conference room Everglades Foundation, panel and panel staff only.

- ∞ Begin at 9:00 AM
 - Thoughts from previous day
 - Panelist (and panel staff) presentations on 3-d seismic impacts with initial thoughts on long-term development impacts
 - John Cox
 - Jerome Jackson
 - Dale Gawlik
 - Kirsten Hines
 - Break for lunch (catered): approx. 12:00 PM
 - Panelist (and panel staff) presentations on 3-d seismic impacts with initial thoughts on long-term development impacts (continued)
 - Jennifer Richards
 - William Conner
 - Stephen Davis

- Fernando Miralles-Wilhelm
 - James Jones
- Discussion and final thoughts concerning 3-D seismic impacts
- ∞ End at 5:00 PM
- ∞ Panel Dinner (approx. 7:00 PM): to be determined

Monday August 31: conference room Everglades Foundation, panel and panel staff only

- ∞ Begin at 9:00 AM
 - Comments/questions on 3-d seismic text (each panelist should be prepared to submit draft text to panel staff)
 - Thoughts from each topical area regarding long-term development component. (How similar to or different from impacts associated with 3-d seismic surveying?). Things to consider.
 - Severity and duration of impacts
 - Areas to avoid
 - Ways to minimize impacts
 - Mitigation requirements
 - Monitoring recommendations
 - Outline of long-term development component of report related to panelist area.
 - Other report material? (TOC, executive summary, references, data, figures, diagrams, appendices, etc.)
 - Re-visit schedule for deliverables (i.e., expectations from now till December) and deadline for long-term development impact text.
 - Any more discussion of review process?
 - Peer review recommendations
 - Begin internal review of 3-d seismic text from other panelists
 - Break for lunch (catered): approx. 12:00 PM
 - Writing/work time (if available)
 - Wrap up around 4:00-4:30 PM

Appendix C

List of attendees and presenters for each of the panel meetings

June 29, 2009 – Big Cypress Panel Attendees

Name	Email	Affiliation
Bob Duncan	bduncan@collierresources.com	Collier Resources Co.
Tom Jones	tjones@barroncollier.com	Barron Collier Co.
Christian Spilker	cspilker@collierenterprises.com	Collier Enterprises
Bruce Layman	BruceLayman@wilsonmiller.com	Wilson Miller
Tim Durham	timdurham@wilsonmiller.com	Wilson Miller
Stephen Davis*	sdavis@evergladesfoundation.org	Everglades Foundation
Jennifer Richards*	richards@fiu.edu	Florida International University
Jerome Jackson*	jjackson@fgcu.edu	Florida Gulf Coast University

* *Panelist or panel staff*

¹ *Invited speaker*

July 29, 2009 – Big Cypress Panel Attendees

Name	Email	Affiliation
Ana Blanco	ablanco@evergladesfoundation.org	Everglades Foundation
Kirsten Hines*	hineski@yahoo.com	Everglades Foundation
John Cox*	jjcox@uky.edu	University of Kentucky
Melodie Naja	mnaja@evergladesfoundation.org	Everglades Foundation
Rosanna Rivero	rrivero@evergladesfoundation.org	Everglades Foundation
Kevin Whelan	Kevin_R_Whelan@nps.gov	National Park Service/SFCN
Bob Duncan ¹	bduncan@collierresources.com	Collier Resources Co.
Fred Griggs	fgriggs@lakeronel.com	Lake Ronel Oil Co.
Jim Mazzu	jmazzu@lakeronel.com	Lake Ronel Oil Co.
Pete Lake	plake@lakeronel.com	Lake Ronel Oil Co.
Dale Gawlik*	dgawlik@fau.edu	Florida Atlantic University
William Conner*	wconner@clemson.edu	Baruch Institute at Clemson University
Mark Kraus	mkraus@evergladesfoundation.org	Everglades Foundation
Vic Engel	vic_engel@nps.gov	Everglades National Park
Matt Patterson	matt_patterson@wps.gov	National Park Service/SFCN
Tom Jones	tjones@barroncollier.com	Barron Collier Co.
Tim Durham	timdurham@wilsonmiller.com	Wilson Miller
Tom Van Lent	tvanlent@evergladesfoundation.org	Everglades Foundation
Stephen Davis*	sdavis@evergladesfoundation.org	Everglades Foundation
Fernando Miralles-Wilhelm*	miralles@fiu.edu	Florida International University
Jim Jones*	jjones@swca.com	SWCA
Michael Duever ¹	mduever@sfwmd.gov	SFWMD

July 31, 2009 – Big Cypress Panel (Late/New) Attendees

Name	Email	Affiliation
Jennifer Richards*	richards@fiu.edu	Florida International University
Jimi Sadle ¹	Jimi_Sadle@nps.gov	Everglades National Park

* Panelist or panel staff

¹ Invited speaker

August 29, 2009 – Big Cypress Panel Attendees

Name	Email	Affiliation
Kirsten Hines*	hineski@yahoo.com	Everglades Foundation
John Cox*	jjcox@uky.edu	University of Kentucky
Melodie Naja	mnaja@evergladesfoundation.org	Everglades Foundation
Bob Duncan ¹	bduncan@collierresources.com	Collier Resources Co.
Jim Mazzu	jmazzu@lakeronel.com	Lake Ronel Oil Co.
Larry Hayes	lhayes@lakeronel.com	Lake Ronel Oil Co.
David Younger	dyounger@lakeronel.com	Lake Ronel Oil Co.
Dale Gawlik*	dgawlik@fau.edu	Florida Atlantic University
William Conner*	wconner@clemson.edu	Baruch Institute at Clemson University
Stephen Davis*	sdavis@evergladesfoundation.org	Everglades Foundation
Fernando Miralles-Wilhelm*	miralles@fiu.edu	Florida International University
Jim Jones*	jjones@swca.com	SWCA
Tom Jones	tjones@barroncollier.com	Barron Collier Co.
Christian Spilker	cspilker@collierenterprises.com	Collier Enterprises
Jennifer Richards*	richards@fiu.edu	Florida International University
Jerome Jackson*	jjackson@fgcu.edu	Florida Gulf Coast University
Deborah Jansen ¹	deborah_jansen@nps.gov	NPS/Big Cypress National Preserve
Ross Scott ¹	ross.scott@myfwc.com	FWC

* *Panelist or panel staff*

¹ *Invited speaker*

Appendix D

List of public presentations for panel meetings

June 29, 2009

Name	Presentation title
Bob Duncan (CRC)	"3-D Seismic Exploration for Oil & Gas in Big Cypress National Preserve"

July 29-31, 2009

Name	Presentation title
Dr. Michael Duever (SFWMD)	"Ecological Characteristics and Processes in the Big Cypress Swamp"
Bob Duncan (CRC)	"3-D Seismic Exploration for Oil & Gas in Big Cypress National Preserve"
Dr. James Snyder (USGS)	"Restoration of Disturbed Pond-Cypress Savannas, Big Cypress National Preserve"
Don Hargrove (NPS, BCNP)	"Calumet 3-D Seismic in Big Cypress" and "NPS Oil & Gas Permitting Process"
Dr. James Burch (NPS, BCNP)	"Invasive Species in BCNP"
Darrell Land (FWC)	"Challenges and Opportunities Facing Florida Panther Conservation—Can we increase the size of the box?"
Jimi Sadle (NPS, ENP)	"Big Cypress Flora"

August 29-31, 2009

Name	Presentation title
Dr. Deborah Jansen (NPS, BCNP)	“Big Cypress Wildlife in the Proposed Nobles Grade 3-D Seismic Project Area”
Ross Scott (FWC)	“Red Cockaded Woodpecker Management in Big Cypress National Preserve”
Bob Duncan (CRC)	“Drilling, Development and Production of Oil & Gas in the Big Cypress National Preserve”

Appendix E
Exotic and Rare Plant Ranking Systems

A. Plant Invasive Exotics

Florida Exotic Pest Plant Council (FL EPPC)

Source: <http://www.fleppc.org/list/07list.htm>

FL EPPC Category I. These are invasive exotics that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives. *This definition does not rely on the economic severity or geographic range of the problem, but on the documented ecological damage caused.*

FL EPPC Category II. These are invasive exotics that have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species.

B. Plant Species at Risk

1. Institute for Regional Conservation (IRC) Ranking System:

Source: Gann et al. 2002 and <http://regionalconservation.org/ircs/pdf/Chapter1.pdf>

SFX Extirpated or Extinct. Believed to be extirpated or extinct in South Florida. The IRC rank requires that botanists have searched for the taxon without success within appropriate habitats in its historical range, or that there is some documented reason that the species is thought to be extirpated or extinct. In most cases, a plant is not considered to be extirpated or extinct unless at least 20 years has passed since it was last observed in South Florida.

SFH Historical. Occurred historically in South Florida, but has not been observed for many years. The IRC rank is used when the species has not been observed for ten or more years, and there is a basis for believing that the species may not be present, although there is a reasonable possibility that additional searches could locate plants.

SF1 Critically imperiled. Critically imperiled in South Florida because of extreme rarity (five or fewer occurrences, or fewer than 1,000 individuals), or because of extreme vulnerability to extinction due to some natural or human factor. For taxa with two to five occurrences, IRC ranks as critically imperiled those taxa with 3,000 or fewer individuals. For taxa with a single occurrence, IRC ranks as critically imperiled those taxa with 10,000 or fewer individuals.

SF2 Imperiled. Imperiled in South Florida because of rarity (6-20 occurrences, or less than 3,000 individuals) or because of vulnerability to extinction due to some natural or human factor. IRC only ranks as imperiled those taxa with fewer than 10,000 individuals.

SF3 Rare. Either very rare and local throughout its range in South Florida (21-100 occurrences, or less than 10,000 individuals), or found locally in a restricted range. IRC only ranks as rare those taxa with fewer than 100,000 individuals.

SF4 Apparently secure. Apparently secure in South Florida (may be rare in parts of range). IRC ranks all taxa with more than 100,000 individuals as apparently secure.

SF5 Demonstrably secure. Demonstrably secure in South Florida. IRC ranks all taxa with more than 1,000,000 individuals as demonstrably secure.

2. Florida Natural Areas Inventory (FNAI) Ranking System:

Source: <http://www.fnai.org/ranks.cfm>

Using a ranking system developed by The Nature Conservancy and the Natural Heritage Program Network, the FNAI assigns two ranks to each element. The **global rank** is based on an element's worldwide status; the **state rank** is based on the status of the element in Florida. Element ranks are based on many factors, the most important ones being estimated number of element occurrences, estimated abundance (number of individuals for species; area for natural communities), range, estimated adequately protected element occurrences, relative threat of destruction, and ecological fragility.

Global Rank Definitions

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.

G2 = Imperiled globally because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some natural or man-made factor.

G3 = Either very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction from other factors.

G4 = Apparently secure globally (may be rare in parts of range).

GH = Of historical occurrence throughout its range, may be rediscovered (e.g., ivory-billed woodpecker).

GX = Believed to be extinct throughout range.

GXC = Extirpated from the wild but still known from captivity or cultivation.

G#? = Tentative rank (e.g., G2?).

G#G# = Range of rank; insufficient data to assign specific global rank (e.g., G2G3).

G#T# = Rank of a taxonomic subgroup such as a subspecies or variety; the G portion of the rank refers to the entire species and the T portion refers to the specific subgroup; numbers have same definition as above (e.g., G3T1).

G#Q = Rank of questionable species - ranked as species but questionable whether it is species or subspecies; numbers have same definition as above (e.g., G2Q).

G#T#Q = Same as above, but validity as subspecies or variety is questioned.

GU = Unrankable; due to a lack of information no rank or range can be assigned (e.g., GUT2).

GNA = Ranking is not applicable because the element is not a suitable target for conservation (e.g., a hybrid species).

GNR = Element not yet ranked (temporary).

GNRTNR = Neither the element nor the taxonomic subgroup has yet been ranked.

State Rank Definitions:

S1 = Critically imperiled in Florida because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.

S2 = Imperiled in Florida because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some natural or man-made factor.

S3 = Either very rare and local in Florida (21-100 occurrences or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction from other factors.

S4 = Apparently secure in Florida (may be rare in parts of range).

S5 = Demonstrably secure in Florida.

SH = Of historical occurrence in Florida, possibly extirpated, but may be rediscovered (e.g., ivory-billed woodpecker).

SX = Believed to be extirpated throughout Florida.

SU = Unrankable; due to a lack of information no rank or range can be assigned.

SNA = State ranking is not applicable because the element is not a suitable target for conservation (e.g., a hybrid species).

SNR = Element not yet ranked (temporary).

3. State of Florida Legal Status

Source: information provided by FNAI website (<http://www.fnai.org/ranks.cfm>) and available at Florida Department of Agriculture and Consumer Services website (<http://www.doacs.state.fl.us/pi/>).

Plants: Definitions derived from Sections 581.011 and 581.185(2), Florida Statutes, and the Preservation of Native Flora of Florida Act, 5B-40.001.

LE Endangered: species of plants native to Florida that are in imminent danger of extinction within the state, the survival of which is unlikely if the causes of a decline in the number of plants continue; includes all species determined to be endangered or threatened pursuant to the U.S. Endangered Species Act.

LT Threatened: species native to the state that are in rapid decline in the number of plants within the state, but which have not so decreased in number as to cause them to be Endangered.