

**A Species Action Plan for the
Santa Fe Cave Crayfish
*Procambarus erythropus***

**Final Draft
November 1, 2013**



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EXECUTIVE SUMMARY

This plan was developed to guide conservation actions for the Santa Fe cave crayfish (*Procambarus erythrops*), a species endemic to Florida and known only from several caves and sinkholes in southern Suwannee and Columbia counties. This crayfish has only been known to science since 1975, and a great deal remains to be learned about its natural history and extent of distribution. A determination of how closely known sites are connected through the aquifer will provide information about the species' vulnerability, genetic variation, and population size. Working with subterranean fauna like the Santa Fe cave crayfish is a specialized and potentially dangerous endeavor (when it involves diving). It can be challenging to ascertain a species' presence or absence, and it may be impossible to directly assess population size. The discovery and protection of additional sites where Santa Fe cave crayfish occur should help ensure its long-term survival.

State-listed as a Species of Special Concern in 1989, the crayfish's status was reviewed in 2010. The review panel determined that the Santa Fe cave crayfish met the criteria for listing on the Florida Endangered and Threatened Species List. Given the restricted distribution of this species and the inherent vulnerability of the aquifer that supports it, it is unlikely that removal of the Santa Fe cave crayfish from the Florida Endangered and Threatened Species List would ever be warranted. Therefore, the goal of this plan is to improve the conservation status of the Santa Fe cave crayfish to a point that the species is secure within its historical range. Objectives proposed to achieve this goal include: 1) maintaining or increasing habitat quality at occupied sites, 2) mapping the aquifer and determining the connectedness of known sites, and 3) finding and protecting additional sites occupied by Santa Fe cave crayfish. Major proposed conservation actions for the Santa Fe cave crayfish include: 1) coordination with landowners to manage, protect, and monitor the known sites; 2) assessment of threats to known sites and how to address them; 3) research to locate new sites and determine whether and how sites may be connected; and 4) coordination with the regulators of resource extraction interests to ensure consideration of the crayfish in future activities.

Effective partnerships among Florida Fish and Wildlife Conservation Commission staff and other agencies, organizations, companies, counties, municipalities, and the public are critical to moving forward with initiatives that will achieve the conservation goal and objectives in this plan. The Santa Fe cave crayfish is an example of a species dependent on the integrity of the aquifer and the karst windows that expose it to habitats above ground. Ensuring the long-term survival of the crayfish will require communication and coordination among the multiple entities on the state, local, and private level. These entities can help regulate, ameliorate, or avoid potential threats, and their responsibilities, policies, and actions directly or indirectly impact the Santa Fe cave crayfish and its subterranean habitat.

This plan details the actions necessary to improve the conservation status of the Santa Fe cave crayfish. A summary of this plan will be included in the Imperiled Species Management Plan (ISMP), in satisfaction of the management plan requirements in Chapter 68A-27, Florida Administrative Code, Rules Relating to Endangered or Threatened Species. The ISMP will address comprehensive management needs for 60 of Florida's imperiled species and will include an implementation plan; rule recommendations; permitting standards and exempt activities;

anticipated economic, ecological, and social impacts; projected costs of implementation and identification of funding sources; and a revision schedule. The imperiled species management planning process relies heavily on stakeholder input and partner support. This level of involvement and support is also critical to the successful implementation of the ISMP. Any significant changes to this plan will be made with the continued involvement of stakeholders.

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GLOSSARY OF TERMS AND ACRONYMS

Aquatic Cave: A Florida Natural Areas Inventory classification, defined as underground cavities that contain permanent standing water ranging from shallow pools to completely inundated caverns. Caves are found statewide and develop as water moves through underlying limestone, dissolving it, and creating fissures and caverns. They often support troglobitic crustaceans and salamanders.

Aquifer: An underground layer of water-bearing permeable rock or unconsolidated materials (e.g., gravel, sand, or silt) from which groundwater can be extracted using a well.

BMP: Best Management Practice(s): Generally, BMPs represent methods, measures or practices that are developed, selected, or approved by various agencies to protect, enhance, and preserve natural resources including wildlife habitat. They include, but are not limited to, engineering, conservation, and management practices for mining, agriculture, silviculture, and other land uses, that are designed to conserve water quality and quantity, soil and associated nutrients, and to simultaneously control nonpoint and point-source pollution and other impacts to natural resources including aquatic and terrestrial wildlife habitat.

BRG: Biological review group, a group of taxa experts convened to assess the biological status of taxa using criteria specified in Rule 68A-27.001, Florida Administrative Code, and following the protocols in the Guidelines for Application of the International Union for Conservation of Nature (IUCN) Red List Criteria at Regional Levels (Version 3.0) and Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1).

Biological Status Review Report: The summary of the biological review group's findings. Includes a Florida Fish and Wildlife Conservation Commission staff recommendation on whether or not the species' status meets the criteria for listing as a State-designated Threatened species based on the IUCN guidelines and criteria in Rule 68A-27-001, Florida Administrative Code. These criteria, based on IUCN criteria and guidelines, are used to help decide if a species should be added or removed from the Florida Endangered and Threatened Species List. In addition, FWC staff may provide within the report a biologically justified opinion that differs from the criteria-based finding.

Conservation Easement: A power invested in a qualified private land conservation organization or government (municipal, county, state, or federal) to constrain, as to a specified land area, the exercise of rights otherwise held by a landowner so as to achieve certain conservation purposes.

Debris Cone: Accumulation of organic and inorganic material that falls or is washed into a sinkhole and mounds up beneath the surface opening, and may serve as a focal point for feeding by cave crayfish and other troglobites.

DEP: Florida Department of Environmental Protection

GLOSSARY OF TERMS AND ACRONYMS

Detritus: Non-living particulate organic material (as opposed to dissolved organic material) that typically includes the bodies or fragments of dead organisms as well as fecal material, and is colonized and decomposed by communities of microorganisms. Detritus is the major food source in subterranean systems, often entering through sinkholes.

Dolomite: A mineral consisting of a calcium magnesium carbonate found in crystals and in extensive beds as a compact limestone; used in the formation of concrete.

Extent of Occurrence: The geographic area encompassing all observations of individuals of a species, including intervening areas of unoccupied habitat; synonymous with range (as defined by International Union for Conservation of Nature).

F.A.C.: Florida Administrative Code. The Department of State's Administrative Code, Register and Laws Section is the filing point for rules promulgated by state regulatory agencies. Agency rulemaking is governed by Chapter 120, Florida Statutes, the Administrative Procedures Act. Rules are published in the Florida Administrative Code.

Florida Geological Survey: A division of DEP specializing in geoscience research and assessments to provide objective quality data and interpretations. Its mission statement is to "Collect, interpret and provide objective quality geologic information about Florida."

Florida Natural Areas Inventory: A non-profit organization, founded in 1981, that is administered by Florida State University and dedicated to gathering, interpreting, and disseminating information critical to the conservation of Florida's biological diversity.

FWC: Florida Fish and Wildlife Conservation Commission, the state agency constitutionally mandated to conserve and manage Florida's native wildlife resources.

ISMP: Imperiled Species Management Plan.

IUCN: International Union for Conservation of Nature, a professional global conservation network.

IUCN Red List: International Union for Conservation of Nature Red List of Threatened Species, an objective, global approach for evaluating the conservation status of plant and animal species to identify and document species most in need of conservation attention and to provide a global index of the state of change of biodiversity.

Karst: A term adopted by geologists to describe a terrain or area of the landscape where readily dissolved rock like limestone occurs at or close to the surface of the ground. Karst areas are characterized by the presence of features such as sinkholes, caves, and springs. Karst features typically form over long periods of time as rain or groundwater drains through the rock, dissolving some parts of the rock as it does so.

GLOSSARY OF TERMS AND ACRONYMS

Limestone: A rock that is formed chiefly by accumulation of organic remains (as shells or coral), consisting mainly of calcium carbonate, is extensively used in building, and yields lime when burned.

Location: A geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present (as defined by IUCN).

Population: The total number of individuals of the taxon. Population numbers are expressed as numbers of mature individuals only (as defined by IUCN).

Sinkhole: A Florida Natural Areas Inventory classification, defined as a “karst feature with steep walls; mesic-hydric; statewide; variable vegetation structure”; also referred to as a “sink.”

SMZ: Special Management Zone(s), a best management practice for a specific area associated with a stream, lake, wetland or other water body that is designated and maintained during silviculture operations. SMZs protect water quality by reducing or eliminating inputs of sediment, nutrients, debris, chemicals, and water temperature changes that can adversely affect aquatic communities.

Species of Special Concern: a species protected under Rule 68A-27.005, F.A.C., which declares that "no person shall take, possess, transport, or sell any species of special concern included in this subsection or parts thereof or their nests or eggs except as authorized by permit from the executive director, permits being issued upon reasonable conclusion that the permitted activity will not be detrimental to the survival potential of the species. For purposes of this section, the definition of the word take in Rule 68A-1.004, F.A.C., applies."

Subterranean: A Florida Natural Areas Inventory category that includes aquatic and terrestrial cave classifications. Subterranean is defined as the twilight, middle, and deep zones of natural chambers overlain by the earth's crust. This area is characterized by climatic stability and assemblages of troglobitic organisms.

SRWMD: Suwannee River Water Management District

Threatened: Refers to a listing status of Threatened on the Florida Endangered and Threatened Species List. As designated by the FWC, species of fish or wild animal life, subspecies, or isolated population of a species or subspecies, whether vertebrate or invertebrate, that are native to Florida and are classified as Threatened as determined by criteria in accordance with Rule 68A-27.0012, F.A.C. No person shall take, possess, or sell any Threatened species or parts thereof or their nests or eggs except as authorized by Commission rule or by permit from the FWC.

TNC: The Nature Conservancy

Troglobite: A descriptive term for organisms that live permanently underground and cannot survive naturally outside the cave environment. Adaptations and characteristics may

GLOSSARY OF TERMS AND ACRONYMS

include a heightened sense of hearing, touch, and smell, as well as a reduction of pigmentation and eyesight.

Type Locality: Site where the original or “type” specimen (or series of specimens) was collected that provided the basis for the formal taxonomic description of the organism (e.g., species or subspecies).

INTRODUCTION

Biological Background

Species Description

The Santa Fe cave crayfish was first described in 1975 and named *Procambarus (Ortmannicus) erythroops*, with no recognized subspecies (Relyea and Sutton 1975). *Procambarus* is the largest genus of the North American crayfishes and was subdivided into subgenera by Hobbs (1972). The subgenus *Ortmannicus* aligns this crayfish with more than 3 dozen other taxa, including both surface-dwelling and cave forms (Hobbs 1972). The Santa Fe cave crayfish is also a member of the *lucifugus* complex, a group of 5 taxa of cave crayfish (with the name of the nominate species *P. lucifugus* deriving from the Latin for “light fleeing”) that appear to be closely related to the surface-dwelling stream species *P. pictus*, the Black Creek crayfish (Franz and Lee 1982).

The specific epithet *erythroops* refers to the red pigment spot on the eye of many specimens (Relyea and Sutton 1975) and accounts for another species common name, the red-eyed crayfish. It is also known as the Sims Sink crayfish in reference to the type locality designated by Relyea and Sutton (1975). The Santa Fe cave crayfish is a medium-sized (body length to 8.9 cm [3.5 in]) species that has an unpigmented body and reduced eyes, each of which has a reddish or brown pigment spot (Franz 1982, 1994; P. Moler, Florida Fish and Wildlife Conservation Commission [FWC], personal communication; [Figure 1](#)).



Figure 1. Santa Fe cave crayfish, *Procambarus erythroops*. Photograph copyright Barry Mansell.

The Santa Fe part of the common name refers to the Santa Fe River, which flows to the south of the known crayfish sites and is a major tributary to the Suwannee River, which it joins to the southwest.

Habitat and Range

The Santa Fe cave crayfish is endemic to a small portion of north-central Florida and currently is known only from several flooded sinkholes and caves in southeastern Suwannee and southwestern Columbia counties (Franz 1994, Franz et al. 1994, NatureServe 2010; T. Morris, Karst Environmental Services, Inc., personal communication; [Figure 2](#)). In the type locality, Sims Sink, the water temperature is approximately 21 °C (69 °F) throughout the year, with water depths ranging down to 12.5 m (41 ft), and no discernible water flow (Streever 1996). Specific associations of water quality characteristics and the presence of Santa Fe cave crayfish have not been reported.

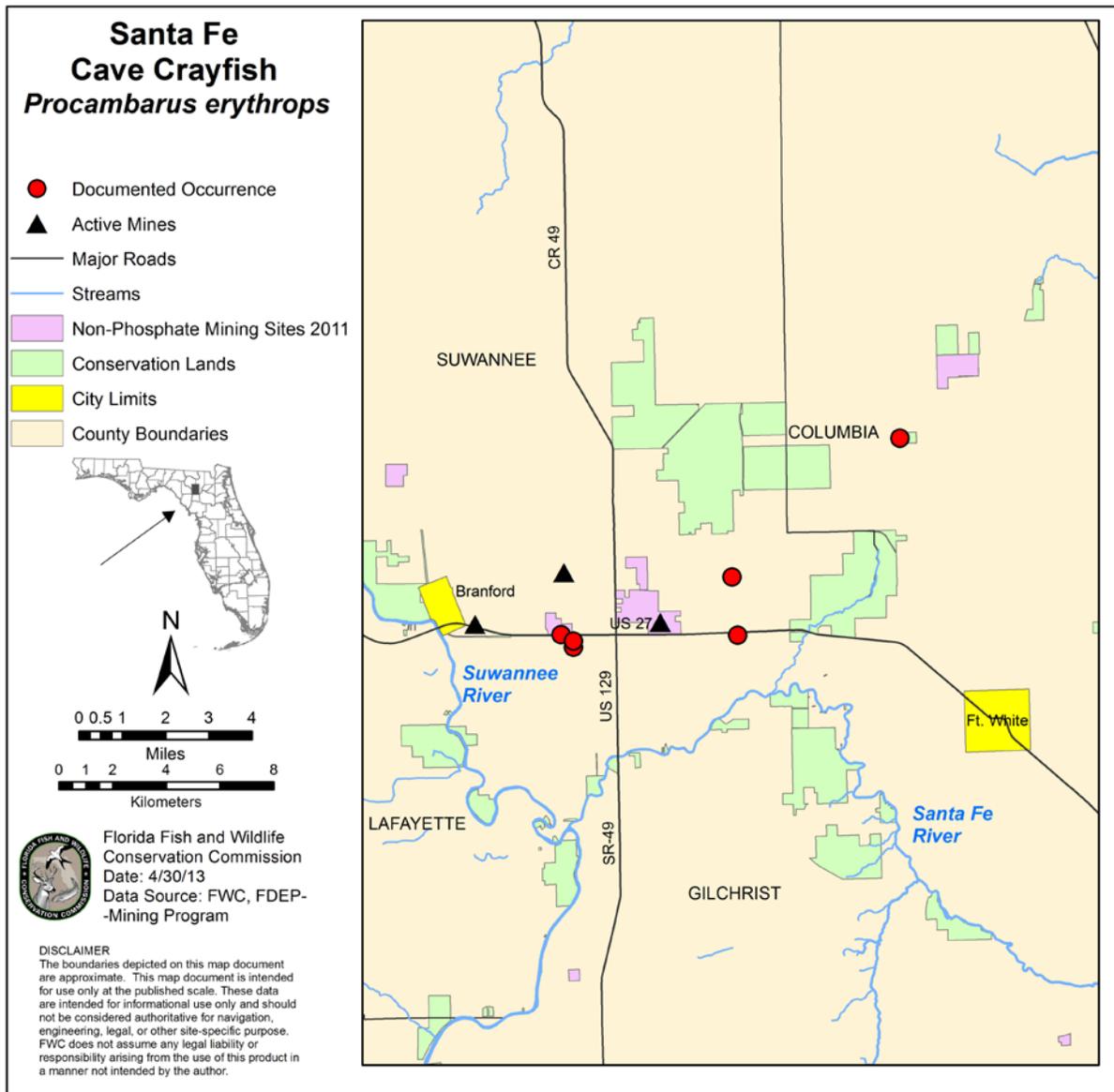


Figure 2. Distribution of occurrences of Santa Fe cave crayfish, *Procambarus erythropus*, plus non-phosphate mining sites and active mines in the vicinity.

This species is known historically from 6 sites (Table 1), although it may have been extirpated at 1 site due to garbage dumping (Franz 1994, Franz et al. 1994; T. Morris, personal communication). Only 2 sites have been known to contain significant subpopulations. One is the type locality, Sims Sink (*sink* is another term for sinkhole), which is owned and managed by The Nature Conservancy (TNC). The other site, Azure Blue Sink, is on private land and may need protection (Franz 1994, NatureServe 2010). The subpopulation at Sims Sink was estimated to number 400 to 500 mostly mature individuals in the 1970s (Franz and Lee 1982), but on a more recent visit only about 200 were counted (T. Morris, personal communication). No subpopulation is estimated to contain more than 1,000 individuals (a threshold in listing Criterion C; see [Threats and Recommended Listing Status](#) section below), although the range-wide

population may be >1,000 (Franz 1982, Streever 1996, FWC 2011a). It seems probable that most or all of the known sites are connected by subterranean passages; these would allow some genetic exchange among the populations (Streever 1996).

Table 1. Site information for Santa Fe cave crayfish, *Procambarus erythrops*. Sink is another term for sinkhole.

Site Name(s)	County	Owner	Population Size	Site Status/Comments
Azure Blue Sink	Suwannee	Private	“significant” ^{1,4} , ~10 per visit ⁶	May need protection ^{1,4} ; known to be affected by rising river levels, which have forced stained water into the cave on at least 1 occasion ⁶
Bufo Sink (or Pit)	Suwannee	Private	Unknown	0.3 km (0.2 mi) south of Sims Sink, and may connect with Sims Sink ^{2,5}
Hildreth Cave	Suwannee	Private	Possibly extirpated ¹	Current status unknown; used as garbage dump in early 1970s ^{1,2,6}
Quarry Sink	Suwannee	Private	Unknown	Documented, but status not reported ²
Sims Sink	Suwannee	TNC	400-500 ³ ; ~200 ⁶	Protected, but may still be threatened by upland contamination ⁴ ; type locality ⁵
Saylor Sink (or Boy Scout Sink)	Columbia	DEP	~5-6 per visit ⁶	Protected; outlying parcel of Ichetucknee State Park ⁶

References: ¹ Franz 1994, ² Franz et al. 1994, ³ Franz and Lee 1982, ⁴ NatureServe 2010, ⁵ Relyea and Sutton 1975, ⁶ T. Morris, personal communication.

Life History

Working with subterranean fauna like the Santa Fe cave crayfish is a specialized and potentially dangerous endeavor (when it involves diving). It can be challenging to ascertain a species' presence or absence, and it may be impossible to directly assess population size. The study of these crayfish depends on the few karst “windows” (sinkholes and caves) that can be accessed by researchers, so a complete picture of their life history is difficult to piece together. As with crayfish that live above ground, male Santa Fe cave crayfish periodically alternate between a reproductively ready form (Form I) and a form that is not reproductive (Form II). Although reproductive males have been reported most months of the year, egg-bearing and young-bearing females have not yet been reported (Franz 1994, Streever 1996). Streever (1996) reported copulating pairs of crayfish in July, August, and September 1994, and in January 1995.

With regard to food habits, Santa Fe cave crayfish appear to behave similarly to surface crayfish, by feeding on whatever organic matter is readily available. Streever (1996) reported crayfish in Sims Sink feeding on detritus, nuts, insects, fungi, and leaves and described crayfish consuming 75% of a mouse carcass in less than 1 hour. Within large flooded sinkholes with little or no water flow, such as Sims Sink, Santa Fe cave crayfish are typically seen occupying the “debris cones” beneath the sinkhole opening (Franz 1994). This species has not been associated with bat

colonies (Franz 1994). Streever (1996) also reported 8 dead crayfish observed during his year-long study; no specific information about causes of mortality has been reported. In its type locality, Sims Sink (Figure 3), this species has been found in association with 2 other troglobitic crustaceans, the spider cave crayfish, *Troglocambarus maclanei*, and Hobb's cave amphipod, *Crangonyx hobbsi* (Franz 1994).



Figure 3. Sims Sink, type locality for Santa Fe cave crayfish, *Procambarus erythropus*, showing wooden platform partly covering the sink. Photograph by Paul Moler.

To date, there have been 2 major efforts to study Santa Fe cave crayfish. Between September 1974 and July 1978, Richard Franz marked individuals from Sims Sink by injecting red ink through the crayfish exoskeleton, leaving dye patterns that were still visible following molts. Unfortunately, the dye patterns specific to individuals shifted and became indistinguishable over time, so the fate of individuals could not be tracked, although the general marks could still be seen (Streever 1996). When W. J. Streever began a study of the Santa Fe cave crayfish in Sims Sink in 1994, he recaptured 5 individuals that were recognized as having been previously dye-marked at least 16 years earlier (Streever 1996). This indicates considerable longevity for the Santa Fe cave crayfish, and this finding led to the Biological Review Group (BRG) using an estimated lifespan of 15 years for the species' status review (FWC 2011a). Streever's study investigated the energy economy hypothesis, testing whether reduced pigmentation in troglobitic crayfish was consistent with adaptation to a low-energy environment. Steever (1996) collected size-frequency data of crayfish encountered, used sediment traps beneath the sinkhole opening to

measure the influx of organic carbon to the cave system, and used radiochemical dating of vertical sediment cores to establish a chronology spanning about 150 years. Streever (1996) concluded that, although his results did not provide completely consistent evidence supporting the energy economy hypothesis, they did suggest that energy limitation may have been important in the evolution of the Santa Fe cave crayfish.

A great deal remains to be learned about this species' natural history and extent of distribution. Discovering additional sites where Santa Fe cave crayfish occurs and determining how closely connected known sites are will provide more information about the species' vulnerability to threats that could impact its long-term survival.

Conservation History

The Santa Fe cave crayfish was listed by the State of Florida as a Species of Special Concern in 1989 (Florida Game and Fresh Water Fish Commission [predecessor to the FWC] 1989, Wood 1991). This status makes it illegal to take, possess, transport, or sell Santa Fe cave crayfish except as authorized by permit from the FWC executive director, permits being issued upon reasonable conclusion that the permitted activity will not be detrimental to the survival potential of the species. The Santa Fe cave crayfish is also among those invertebrates considered Species of Greatest Conservation Need according to FWC's State Wildlife Action Plan (FWC 2011*b*).

The International Union for Conservation of Nature (IUCN) Red List (Crandall 2010) assessed the Santa Fe cave crayfish as Endangered, referencing its small extent of occurrence; low number of locations; and continuing decline in the quality of its habitat as a result of pesticide and herbicide use in surrounding areas, mining pollution, and groundwater abstraction. Another assessment was provided by the American Fisheries Society (Taylor et al. 2007), which gave the Santa Fe cave crayfish a status of Endangered, based on 2 factors: 1) existing or potential destruction, modification, or reduction of the species' habitat or range; and 2) restricted range. The Florida Natural Areas Inventory, the state's natural heritage program, assesses this species' status as G1/S1–Critically Imperiled (NatureServe 2010). The U.S. Fish and Wildlife Service has been petitioned to federally list the Santa Fe cave crayfish, along with several hundred other aquatic species from the southeastern U.S. (Center for Biological Diversity 2010). The timetable for a federal review and listing determination for this species has not been determined.



Figure 4. View of entrance gate and surrounding chain link fence from within TNC property that protects Sims Sink, type locality for the Santa Fe cave crayfish, *Procambarus erythrops*. Photograph by Paul Moler.

Sims Sink is the most significant site known for the Santa Fe cave crayfish, since surveys there have historically recorded the greatest number (at least 200) of individuals (Franz and Lee 1982; T. Morris, personal communication). TNC owns and manages the site and restricts human access to the property with a chain link fence (P. Moler, personal communication; [Figure 4](#)). The sink is partially covered by a wooden platform, which helps facilitate access by divers (P. Moler, personal communication; [Figure 3](#)). Another known site, Saylor (or Boy Scout) Sink is on land protected by the Florida Department of Environmental Protection (DEP).

Threats and Recommended Listing Status

Threats

The key to the long-term survival of the Santa Fe cave crayfish is the protection of the aquifer and the karst features that are exposed to land-borne threats. It is presumed that this species is dependent on groundwater of adequate quantity and quality, and that it requires a relatively predictable source of food. Potential threats include changes in hydrology and in the input of detritus and other organic material to the subterranean ecosystem (Franz 1982, Franz 1994, NatureServe 2010). Garbage dumping was implicated as the cause for possible extirpation of the crayfish from Hildreth Cave (Franz 1994), and the mining of limestone in the vicinity of this species (Florida Natural Areas Inventory 2001) would appear to be an obvious source of direct and indirect impacts. Streever (1992, 1995, as cited in Walsh 2001) reported on the population recovery of a related cave crayfish, *P. pallidus*, in a Suwannee County cave following a kill apparently due to physical and chemical changes associated with the flushing either of contaminants or of Suwannee River water during a flood event. Climate change is a potential threat that could impact the Santa Fe cave crayfish by lengthening drought periods, thereby altering hydrology and lowering groundwater levels.

The near-surface limestone located in southern Suwannee and Columbia counties provides the karst features where Santa Fe cave crayfish have been found, but it has also been a resource for stone-extraction operations. As of 1992, there were 5 active limestone mines (and 9 inactive limestone mines) and 1 active dolomite mine in the vicinity of the Santa Fe cave crayfish sites (Macesich et al. 1992). As of 2011, there were at least 5 mining sites and 3 active mines in the vicinity of known crayfish occurrences (DEP 2011; [Figure 2](#)). More information is needed about ongoing mining operations and their impact on water quality and flow.

Recommended Listing Status

In 2010, the FWC directed staff to evaluate the status of all species listed as Threatened or Species of Special Concern that had not undergone a status review in the past decade. To address this charge, staff conducted a literature review and solicited information from the public on the status of the Santa Fe cave crayfish. The FWC convened a BRG to assess the biological status of the species using criteria specified in Rule 68A-27.001, Florida Administrative Code (F.A.C.), following the protocols in the Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0) and Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1). FWC staff developed an initial draft of a biological status review report, which included the BRG's findings and a preliminary listing recommendation from staff. FWC distributed the draft for peer review and the reviewers' input was incorporated into a [final report](#) (FWC 2011a).

The Santa Fe cave crayfish BRG concluded from the biological assessment that the Santa Fe cave crayfish met criteria necessary to warrant listing it as a State Threatened species.

The Santa Fe cave crayfish met the following 3 criteria for listing:

- Criterion B, Geographic Range: the extent of occurrence $<20,000 \text{ km}^2$ ($7,722 \text{ mi}^2$) and/or area of occupancy $<2,000 \text{ km}^2$ (772 mi^2), the population is severely fragmented and may exist in fewer than 10 locations, and a continuing decline is observed or projected in area of occupancy, quality of habitat, and number of individuals based on ongoing mining activity.
- Criterion C, Population Size and Trend: the population size is estimated to number fewer than 10,000 mature individuals and a continuing decline in the number of individuals is inferred based on continuing decline in area of occupancy and quality of habitat, and no subpopulation is estimated to contain more than 1,000 mature individuals.
- Criterion D, Population Very Small or Restricted: the population has a very restricted area of occupancy (typically less than 20 km^2 [8 mi^2]) and/or occupies a very small number (typically 5 or fewer) locations, such that it is prone to the effects of human activities or stochastic events within a short time period in an uncertain future.

Discussion of "Location"

It is important to recognize that with regard to listing criteria, the term *location* has a specific meaning. According to IUCN guidelines, "The term *location* defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of 1 or many subpopulations. Where a taxon is affected by more than 1 threatening event, location should be defined by considering the most serious plausible threat."

Therefore, in this document, places where Santa Fe cave crayfish are found may be referred to as *sites* or *occurrences*, whereas the term *location* (or *threat-defined location*) is reserved to designate an area within the species' range that is subject to a common threat. Determining the number of locations represented by the distribution of Santa Fe cave crayfish is not straightforward, since it requires an understanding of the connectedness of the known sites through the subterranean aquifer. Research is needed to determine the threats to the crayfish and its habitat, and whether the known sites represent 1 or several threat-defined locations.

CONSERVATION GOAL AND OBJECTIVES

The BRG found that the Santa Fe cave crayfish met the criteria for listing as Threatened on the Florida Endangered and Threatened Species List. The conservation goal and objectives for the Santa Fe cave crayfish are:

Goal

The conservation status of the Santa Fe cave crayfish is improved to a point that the species is secure within its historical range.

Rationale

The objectives supporting this goal are designed to help maintain current known occurrences and determine the population status of the Santa Fe cave crayfish in Florida. They also address information needs required to assess the vulnerability of this species to extinction. Additional survey efforts may lead to revised estimates of its population size or area of occupancy. However, given the restricted distribution of this species and the inherent vulnerability of the aquifer, it is unlikely that removal of the Santa Fe cave crayfish from the Florida Endangered and Threatened Species List will ever be warranted.

Objectives

I. Maintain or increase habitat quality at occupied sites within 10 years of plan implementation.

Rationale

Because this species is historically known to occur in only 6 sites, it is critical that each site receives maximum protection and appropriate management to ensure the crayfish's long-term survival. It will be important to establish a schedule for periodic monitoring at each site for crayfish presence. Safeguarding known sites for the Santa Fe cave crayfish will entail determining habitat quality needs, identifying specific threats, and working with landowners to draft site-specific management plans to reduce threats and periodically monitor the sites. The BRG identified limestone mining as an ongoing threat to the Santa Fe cave crayfish. More information is needed regarding how protection of the species should be considered in future mining activities. Associated actions will address decline in quality of habitat (Criterion B) and the decline in number of individuals (Criterion B).

II. Map the aquifer and determine connectedness of known sites within 10 years of plan implementation.

Rationale

Developing a clear understanding of the subterranean ecosystem will enable us to determine the number of threat-defined locations and better estimate the population size and its genetic variation. A genetic analysis that demonstrates restricted genetic exchange will help determine how many locations are represented by the 6 known sites. Associated actions will address the low number of locations (Criteria B and D) and the size and distribution of the population (Criterion C).

CONSERVATION GOAL AND OBJECTIVES

III. Find and secure additional sites occupied by Santa Fe cave crayfish within 10 years of plan implementation.

Rationale

Canvassing the region to identify additional karst openings and working with Suwannee River Water Management District (SRWMD), DEP, and mining interests to sample wells may lead to the discovery of more Santa Fe cave crayfish sites for which protective measures could be implemented. Associated actions would increase the species' known area of occupancy and perhaps our understanding of the extent of occurrence (Criteria B and D).

CONSERVATION ACTIONS

The following sections describe the conservation actions that will make the greatest contribution toward achieving the conservation objectives. Actions are grouped by category (e.g., Habitat Conservation and Management, Population Management). The Conservation Action Table ([Table 2](#)) provides information on action priority, urgency, potential funding sources, likely effectiveness, identified partners, and leads for implementation.

These actions emphasize protection and management of known sites, searches to discover new sites, and identification and reduction of threats to the aquifer and karst features that support the crayfish. Some actions are specifically geared to establishing the connectedness and relatedness of crayfish from different sites, which will provide insight on the species' overall vulnerability to threats. Completing these actions will allow us to measure progress toward the conservation goal and objectives for the Santa Fe cave crayfish.

Habitat Conservation and Management

The Santa Fe cave crayfish is currently known from only 6 sites ([Table 1](#)), 2 of which are on protected land. Proactive partnerships with public and private landowners and land managers will be critical to ensure that the few sensitive karst features known to harbor Santa Fe cave crayfish remain suitable and as undisturbed as possible. Habitat conservation and management actions are focused on protecting the known sites and maintaining the water quality of the aquifer with which they are connected. The [establishment](#) of conservation easements ([Action 14](#)) and use of best management practices ([Action 15](#)) would be important ways to help safeguard these sites.

Action 1 Develop a long-term habitat protection and management plan in coordination with DEP and TNC for Santa Fe cave crayfish sites under their jurisdiction.

It is fortunate that 2 of the known sites, Sims Sink and Saylor Sink (or Boy Scout Sink), are owned by TNC and DEP, respectively. This action is a high priority since it is critical to work with these landowners to develop a plan for the long-term protection and management of these sites. Protection and management efforts would focus on identification and reduction of potential threats, periodic monitoring of water quality, and at least annual assessment of crayfish presence.

Action 2 Coordinate with the landowners of other identified sites to develop and implement site-specific habitat protection and management plans to ensure long-term suitability of those sites to Santa Fe cave crayfish.

The owners and managers of private lands with the 4 other sites where Santa Fe cave crayfish are known to occur may be unaware of the significance of protecting those sites and reducing their potential exposure to threats. This action is a high priority since it is urgent to establish a working relationship with these private landowners to help them recognize the importance of the sites and the steps they can take to protect the species and the aquifer. It is important to develop site-specific plans that preserve the integrity of the sinkholes, caves, and the aquifer without unreasonably limiting landowner activities. Additional landowner incentives may also be pursued ([Actions 14](#) and [15](#)).

Action 3 Develop and implement habitat management recommendations that safeguard the integrity of the habitat at aquatic caves and sinkholes (and springs) within the range of the Santa Fe cave crayfish.

Conduct research to understand optimal habitat parameters ([Action 10](#)) and develop a set of recommended management strategies to achieve those conditions. Management strategies outlined for the protection of springs (Florida Springs Task Force 2000) are generally pertinent to the management of upland habitats surrounding caves and sinkholes. Such strategies may already be used for the protected sites. Because it is not clear how useful and effective it would be to formally draft recommendations for the small suite of target sites, as compared to site-specific plans ([Actions 1](#) and [2](#)), this action would have moderate priority.

Action 4 Assess ongoing and planned mining and other resource extraction activities and evaluate their potential impact on Santa Fe cave crayfish.

Assessing the potential impact on the species from resource extraction will require research to determine the configuration of the aquifer associated with Santa Fe cave crayfish sites ([Action 9](#)) and research to determine suitable physical and chemical properties of groundwater ([Action 10](#)). The mining of limestone and dolomite by private companies and Suwannee County may have both direct and indirect impacts on populations of subterranean fauna and the groundwater on which they depend. Potential threats include physical removal of cavern system habitat, water contamination due to the mining processes, and lowering of the groundwater level. DEP's Bureau of Mine Reclamation has provided information on active mines within the species' range (DEP 2011; [Figure 2](#)), which serves to update similar data provided in Macesich et al. (1992).

In addition to stone mining, the extraction of groundwater for industrial, agricultural, and residential uses is a potential threat to the stability of subterranean ecosystems. The volume and extent of ongoing and proposed water extraction activities should also be assessed and its impact evaluated. Such assessments of resource extraction activities may be difficult and would require becoming familiar with mining techniques, equipment, and protocol. The results of this action may be indirect and subject to interpretation, but achieving a better understanding of the relationship of resource extraction to the crayfish and its habitat is critical and a high priority.

Action 5 Coordinate with private and public mining operations and SRWMD to access monitoring wells and other potential new sampling sites in the aquifer for Santa Fe cave crayfish.

The Santa Fe cave crayfish is currently known from typical sinkhole features ([Table 1](#)), but any other places that provide access to the aquifer could become potential sampling sites. For example, bottle traps could be lowered into wells used for water testing, if such wells are at least 10 cm (4 in) in diameter (P. Moler, personal communication). It is a high priority to collaborate with the extraction industries and SRWMD to access monitoring wells or similar sites that may lead to the discovery of additional occurrences of Santa Fe cave crayfish.

Population Management

The concept of population management is difficult to apply to a subterranean species whose ability to be sampled is restricted by the size and shape of karst windows into the aquifer (e.g.,

[Figure 5](#)). These caves and sinkholes have an unknown number of conduits to adjoining underground systems, and at least a few conduits may serve as travel corridors for crayfish and other troglobitic fauna.



Figure 5. Example of a karst window into the aquifer, as seen at Sims Sink, type locality for the Santa Fe cave crayfish, *Procambarus erythrops*, photographed through the wooden platform partly covering the sink. Photograph by Paul Moler.

Action 6 Conduct a genetic assessment to determine the effective population size of the Santa Fe cave crayfish in Sims Sink, Azure Blue Sink, and other sites.

It is difficult enough to estimate the population size of aboveground species of crayfish; to estimate the population numbers of cave crayfish one must rely on indirect deductive techniques. One such technique assesses genetic differences within and between subpopulations to estimate amount of interchange, and deduce the effective population size (Buhay and Crandall 2005, Buhay et al. 2007). This action has a high priority and could be accomplished through a contract with a research university, although the results may be subject to interpretation. If it were determined that the total, albeit mostly unseen, Santa Fe cave crayfish population contains more than 10,000 mature individuals, the species would no longer meet listing Criterion C. However, it should be cautioned that accurate effective population size inference through genetic analyses

can be very inaccurate at times, and that listing or delisting decisions made from it should be made very carefully (M. Rowe, FWC, personal communication).

Monitoring and Research

The Santa Fe cave crayfish has only been known to science since 1975 (Relyea and Sutton 1975), and a great deal remains to be learned about its natural history and extent of distribution. The discovery of new sites where Santa Fe cave crayfish occur will provide more information about the species' vulnerability to threats and how many threat-defined locations it occupies. Additionally, determining the connection of known sites through the aquifer will also help to define the species' population distribution. The following actions include gaining a clearer picture of what constitutes the Santa Fe cave crayfish "population," in both genetic and geographic terms, assessing water quality and potential threats, and determining effective and repeatable methods for monitoring.

Action 7 Conduct intensive surveys for additional sites, including canvassing landowners for access to sinkholes, identifying sites with access for diving, and gaining access to SRWMD and private mines and monitoring wells to look for occupied caverns and to obtain trap samples.

It is a high priority to launch a comprehensive search for more potential sites for Santa Fe cave crayfish, using a variety of methods and involving all stakeholders. Information on the subterranean connectedness of sites ([Actions 8](#) and [9](#)) is needed to assess the impact of potential threats. The identification of more sites could indicate that the species is less vulnerable to extinction.

Action 8 Determine how to define a "location," conduct a genetic assessment to identify restricted genetic exchange and separate locations, and use microsatellites to determine genetic isolation.

Besides providing information on effective population size ([Action 6](#)), genetic investigation of Santa Fe cave crayfish samples from different sites should yield clues to the relatedness of subpopulations. This is a high-priority action that addresses [Objective I](#), and could be accomplished through a contract with a research university. However, because it involves an indirect assessment, its results may be subject to interpretation.

Action 9 Work with DEP's Florida Geological Survey, SRWMD, and university geology departments to map the configuration of the aquifer and determine subterranean connectedness among Santa Fe cave crayfish sites.

Alternative, and perhaps complementary, methods to using genetics ([Action 8](#)) for investigating the extent of underground connections among portions of the aquifer would involve identifying subterranean physical connections via dye studies or other available tools. Florida Geological Survey, SRWMD, and university geology departments may have expertise with such methods, and access to sites would need to be arranged with landowners and land managers. Results could help determine potential impacts from mines and other threats ([Action 4](#)), and information on connectedness among Santa Fe cave crayfish sites would help delineate threat-defined locations. This action is a high priority, but its results may be subject to interpretation.

Action 10 Determine the habitat parameters that characterize Santa Fe cave crayfish life history needs and their occupied sites, including physical and chemical properties of the groundwater.

Careful description should be made of the habitat attributes of occupied sites, and these data could be used to compare with information from sites where Santa Fe cave crayfish are not found. This action represents an expansion on information already collected from some sites (Streever 1996) and could be coordinated by FWC staff with TNC, DEP, and private landowners. This may provide additional baseline biological information and is a moderate priority.

Action 11 Coordinate with DEP and SRWMD to assess the water quality monitoring processes that may already be in place (e.g., testing for pesticides, other agrichemicals, and nutrient levels) and evaluate the potential for introduction of contaminants.

Determination of what constitutes suitable habitat, especially with respect to characteristics of water quality, is critical to any efforts to ensure the long-term survival of Santa Fe cave crayfish. The proximity of known sites to potential threats from limestone mining operations and agricultural land uses lends immediacy to this research, and these actions are a high priority. Besides collaboration with DEP and SRWMD on water monitoring capabilities and scope, landowner access to target testing sites would be required.

Action 12 Determine effective monitoring techniques, and regularly monitor crayfish presence at each site.

Working with subterranean fauna like the Santa Fe cave crayfish is a specialized and potentially dangerous endeavor (especially when it involves diving). It can be challenging to ascertain a species' presence or absence, and it may be impossible to directly assess population size. Although monitoring techniques ideally would be standardized across all sites, this is not realistic given the variation in site access. Effective monitoring at a given site would entail carefully recording the sampling techniques used so that they could be repeated as closely as possible on future visits, conducted at least every 5 years. This action is a high priority, and represents an expansion on previous efforts.

Rule and Permitting Intent

As a Threatened species, the Santa Fe cave crayfish is protected under [Chapter 68A-27, F.A.C.](#) The protective measures contained in Chapter 68A-27, F.A.C., should provide adequate protections for the species. These rules prohibit harm and harassment of Threatened species. The permit requirements and exemptions as currently provided in Rule 68A-27.007(2), F.A.C., are applicable to the Santa Fe cave crayfish.

This is an interesting crayfish, but it is not particularly easy to acquire. As such, there does not appear to be any pressure on the population due to collection. More serious threats to the crayfish involve disturbances that could impact sinkhole structures and water quality of the aquifer. Actions that reduce these threats and result in protection of the karst features have a high priority and are discussed in other sections of this plan.

Action 13 Maintain current protections granted by the species' listing status.

As stated above, the key to the long-term survival of the Santa Fe cave crayfish is the protection of the aquifer and the karst features that are exposed to land-borne threats. However, the protections afforded to Threatened species, including the prohibition against direct take, should lend support to the habitat protections. It is a high priority to maintain these. Encouragement for private landowners to follow water quality best management practices (BMPs; [Action 17](#)) should decrease the chances of incidental take.

Law Enforcement

FWC staff are not aware of particular law enforcement issues concerning the Santa Fe cave crayfish. The possible extirpation of the species from Hildreth Cave due to garbage dumping in the 1970s (Franz 1994, Franz et al. 1994; T. Morris personal communication) has not been recently verified. If such dumping were to occur today, and if it could be proven to be a deliberate attempt to impact a listed species, it might constitute an actionable law enforcement issue. However, at present no specific actions related to law enforcement are identified.

Incentives and Influence

FWC staff should investigate specific incentive programs that may help achieve conservation objectives for the Santa Fe cave crayfish. Additionally, FWC staff may seek out opportunities to work with stakeholders to ensure that their activities have low potential to directly or indirectly impact the aquifer and karst features that constitute crayfish habitat.

Action 14 Explore options for land purchase, establishment of conservation easements, and use of buffer zones for sites with Santa Fe cave crayfish on private land.

More formal protection of the Santa Fe cave crayfish sites on private land may increase the long-term survival of the species at those sites. As relationships with private landowners are developed, it may be productive to explore the purchase of occupied sites or establishment of conservation easements on them (although this is a lower priority than other actions). These could be an extension of site-specific management plans that are developed ([Action 2](#)).

Action 15 Encourage landowners and land managers engaged in agricultural or silvicultural land uses to follow BMPs for water quality and establish special management zones (SMZs) to protect karst features on their property.

In support of the development and implementation of site-specific habitat protection and management plans ([Action 2](#)), it would be appropriate and important for agricultural and silvicultural stakeholders to follow BMPs, including the establishment of SMZs. These voluntary actions help protect the water quality of the focal aquatic communities by reducing or eliminating negative impacts from agricultural and silvicultural land uses.

Proactive partnerships with public and private landowners and land managers will be critical to ensure that the few sensitive karst features known to harbor Santa Fe cave crayfish remain suitable and as undisturbed as possible. We also hope additional sites will be discovered and similarly protected.

Education and Outreach

It is desirable for the public to become informed about the importance of protecting the aquifer, springs, sinkholes, and other karst features. Targeted educational and outreach efforts specifically for the Santa Fe cave crayfish may have a relatively small audience due to the species' limited distribution, but its conservation needs could be included in existing programs.

Action 16 Promote existing education and outreach initiatives and develop new initiatives to advocate the conservation of karst habitats and their fauna.

Existing information on the importance of springs (e.g., Florida Springs Task Force 2000) could be adapted to emphasize the value of sinkholes, caves, and other karst habitats and the unique animals that inhabit them. Outreach efforts could target private landowners and encourage those with karst features to protect them and permit access for surveying and monitoring troglobites. Information specific to the Santa Fe cave crayfish could be included with the outreach efforts of SRWMD and DEP to promote water conservation and water quality.

Coordination with Other Entities

Effective partnerships among FWC staff and other agencies, organizations, companies, counties, municipalities, and the public are critical to moving forward with initiatives that will achieve the conservation goal and objectives in this species action plan. The Santa Fe cave crayfish is an example of a species dependent on the integrity of the aquifer and the karst windows that expose it to aboveground habitats. Ensuring the long-term survival of the crayfish will require communication and coordination with the multiple entities at the state, local, and private level. These are entities that can help regulate, ameliorate, or avoid potential threats, and whose responsibilities, policies, and actions directly or indirectly impact the Santa Fe cave crayfish and its subterranean habitat. Other actions will address coordinating the protection and management of known sites ([Actions 1](#) and [2](#)), accessing potential new sampling sites ([Action 5](#)), and coordinating water quality monitoring ([Action 11](#)).

Action 17 Work with DEP, SRWMD, and other agencies as appropriate, to consider the Santa Fe cave crayfish in the regulation of ongoing and future resource-extraction activities.

Collaboration with the agencies that permit and oversee limerock mining and other resource extraction interests should help reduce or minimize impacts to the aquifer, groundwater quality, and habitat quality needs of the Santa Fe cave crayfish. The specific impacts to this species from mining activities and groundwater extraction should be investigated ([Action 5](#)). Additionally, working with DEP, SRWMD, and the U.S. Army Corps of Engineers to consider the Santa Fe cave crayfish in permitting processes is a moderate priority that could be significant to the species' long-term survival.

Table 2. Santa Fe Cave Crayfish (*Procambarus erythroptus*) Conservation Action Table

NOTE: An explanation of acronyms used is below the table.

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
I	1	1	Develop a long-term habitat protection and management plan in coordination with DEP and TNC for Santa Fe cave crayfish sites under their jurisdiction.	Habitat Conservation & Mgmt, Coordination with Other Entities	NEW	NO	YES	\$0-25k	Existing	HSC, FWRI	DEP, TNC	Likely.	It can be done; practical; some relationships already exist.	Urgent. Given the small number of known sites, it is critical to ensure appropriate site protection and management.
I	1	2	Coordinate with the landowners of other identified sites to develop and implement site-specific habitat protection and management plans to ensure long-term suitability of those sites to Santa Fe cave crayfish.	Habitat Conservation & Mgmt	NEW	NO	YES	\$0-25k	Existing	HSC	Private landowners	The high priority of this action makes it critical to pursue and achieve.	Relationships with private landowners would need to be developed.	Urgent. Given the small number of known sites, it is critical to ensure appropriate site protection and management.
I, III	3	3	Develop and implement habitat management recommendations that safeguard the integrity of the habitat at aquatic caves and sinkholes (and springs) within the range of the Santa Fe cave crayfish.	Habitat Conservation & Mgmt, Incentives & Influencing	NEW	YES	YES	\$0-25k	Existing	HSC, FWRI	DEP, TNC, private landowners, perhaps SRWMD	Moderate priority; not clear how useful and effective formal recommendations will be with small number of sites.	It can be done; practicality needs to be assessed; relationships with private landowners would need to be developed.	Not urgent.
I	2	4	Assess ongoing and planned mining and other resource extraction activities and evaluate their potential impact to Santa Fe cave crayfish.	Habitat Conservation & Mgmt, Monitoring & Research	NEW	YES		\$0-25k	Unknown; possible grant?	HSC, FWRI	County and private mining interests, perhaps SRWMD	Although the effectiveness could be somewhat indirect and might be difficult to assess, the high priority of this action makes it critical to pursue and achieve.	It can be done; practicality needs to be assessed; relationships with private landowners would need to be developed.	Urgent. Resource extraction implicated as important threat.
III	1	5	Coordinate with private and public mining operations and SRWMD to access monitoring wells and other potential new sampling sites in the aquifer for Santa Fe cave crayfish.	Habitat Conservation & Mgmt, Coordination with Other Entities	NEW	YES	YES	\$0-25k	Unknown	HSC, FWRI	County and private mining interests, SRWMD	Likely. Discovery of new sites for this species is critical to assessing its long-term survival.	It can be done; practicality needs to be assessed; relationships with private landowners would need to be developed.	Urgent. Given the small number of known sites, it is critical to identify additional sites for potential protection and management.
II	2	6	Conduct a genetic assessment to determine the effective population size of the Santa Fe cave crayfish in Sims Sink, Azure Blue Sink, and other sites.	Population Mgmt, Monitoring & Research	NEW	YES	YES	\$0-25k	Possibly existing; or grant	HSC, FWRI	Contract with research university	Likely, although results may be subject to interpretation.	It can be done; practical; some relationships already exist.	Not urgent.
III	1	7	Conduct intensive surveys for additional sites, including canvassing landowners for access to sinkholes, identifying sites with access for diving, and gaining access to SRWMD and private mines and monitoring wells to look for occupied caverns and to obtain trap samples.	Monitoring & Research	NEW	NO		TBD	Some existing; possible grant	HSC, FWRI	County and private landowners and mining interests, SRWMD	Likely.	It can be done; practicality will be determined on site by site basis; relationships with private landowners would need to be developed.	Urgent. Given the small number of known sites, it is critical to identify additional sites for potential protection and management.
II	1	8	Determine how to define a "location," conduct a genetic assessment to identify restricted genetic exchange and separate locations, and use microsatellites to determine genetic isolation.	Monitoring & Research	NEW	YES	YES	TBD	Possibly existing; or grant	HSC, FWRI	Contract with research university	Likely, although results may be subject to interpretation.	It can be done; practical; some relationships already exist.	Not urgent.
II	2	9	Work with DEP's Florida Geological Survey, SRWMD, and university geology departments to map the configuration of the aquifer and determine subterranean connectedness among Santa Fe cave crayfish sites.	Monitoring & Research	NEW	NO	YES	TBD	Unknown; possible grant	HSC, FWRI	university geology depts., SRWMD, DEP, TNC, private landowners	Likely, although results may be subject to interpretation.	It can be done; practicality needs to be assessed; relationships with private landowners would need to be developed.	Urgent. Should yield information on vulnerability to threats, and possible leads to additional occupied sites.
I	2	10	Determine the habitat parameters that characterize Santa Fe cave crayfish life history needs and their occupied sites, including physical and chemical properties of the groundwater.	Monitoring & Research	EXPANDED	YES	YES	\$0-25k	Possibly existing	HSC, FWRI	DEP, TNC, private landowners	Likely.	It can be done; practical; some relationships already exist.	Not urgent.
I	2	11	Coordinate with DEP and SRWMD to assess the water quality monitoring processes that may already be in place (e.g., testing for pesticides, other agrichemicals, and nutrient levels) and evaluate the potential for introduction of contaminants.	Monitoring & Research, Coordination with Other Entities	NEW	NO	YES	\$0-25k	Unknown	HSC, FWRI	DEP, SRWMD	Likely.	It can be done; practical; some relationships already exist.	Not urgent.

Table 2. Santa Fe Cave Crayfish (*Procambarus erythroptus*) Conservation Action Table

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
I, III	1	12	Determine effective monitoring techniques, and regularly monitor crayfish presence at each site.	Monitoring & Research	EXPANDED	YES	YES	\$0-25k	Possibly existing	HSC, FWRI	DEP, TNC, private landowners	Likely.	It can be done; practical; some relationships already exist; must gain access to private properties.	Urgent. Effective monitoring techniques critical to assessing species' status.
I, III	1	13	Maintain current protections granted by the species' listing status.	Protections & Permitting	ONGOING	YES	YES	\$0-25k	Existing	HSC, FWRI, possibly Law Enforcement	DEP, TNC, private landowners	Likely.	It can be done; practical; some relationships already exist.	Urgent. Given the small number of known sites and small population, it is critical to maintain legal protections for the species.
I, III	3	14	Explore options for purchase, establishment of conservation easements, and use of buffer zones for sites with Santa Fe cave crayfish on private land.	Habitat Conservation & Mgmt, Incentives & Influencing	NEW	NO	YES	\$0-25k	Existing	HSC, Legal	private landowners, possibly TNC	More formal protection of sites may increase long-term survival of species.	Relationships with private landowners would need to be developed, and incentives developed.	Not urgent.
I, III	2	15	Encourage landowners and land managers engaged in agricultural or silvicultural land uses to follow BMPs for water quality and establish special management zones (SMZs) to protect karst features on their property.	Habitat Conservation & Mgmt, Incentives & Influencing	NEW	YES	YES	\$0-25k	Existing	HSC	private landowners	Likely, but might not be pertinent in all cases.	Relationships with private landowners would need to be developed, and incentives developed.	Not urgent.
I, III	3	16	Promote existing education and outreach initiatives and develop new initiatives to advocate the conservation of karst habitats and their fauna.	Education & Outreach	NEW	YES	YES	\$0-25k	Possibly existing; or grant	HSC	DEP, Florida Springs Task Force, SRWMD, TNC, schools	Likely, although impact would be indirect.	It can be done; practical; some relationships already exist.	Not urgent.
I, III	3	17	Work with DEP, SRWMD, and other agencies as appropriate, to consider the Santa Fe cave crayfish in the regulation of ongoing and future resource-extraction activities.	Coordination with Other Entities	NEW	NO	YES	\$0-25k	Existing	HSC	DEP, possibly USACE, SRWMD	Likely. Discovery of new sites for the	It can be done; practical; some relationships already exist.	Not urgent.

Acronyms used in this table:

BMP: Best Management Practices
 DEP: Florida Department of Environmental Protection
 FWC: Florida Fish and Wildlife Conservation Commission
 FWRI: Fish and Wildlife Research Institute, the research branch of the Florida Fish and Wildlife Conservation Commission
 HSC: Habitat and Species Conservation, a Division of the Florida Fish and Wildlife Conservation Commission
 SMZ: Special Management Zone
 SRWMD: Suwannee River Water Management District
 TBD: To be determined
 TNC: The Nature Conservancy

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