Status of the Ichetucknee Siltsnail (*Floridobia mica*) in Coffee Spring, Ichetucknee Springs State Park, Suwannee County, Florida, November 2015

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Introduction

The Ichetucknee Siltsnail (*Floridobia mica*, Figure 1) is one of eleven snails of the genus *Floridobia* endemic to single Florida spring systems and is the lone endemic siltsnail known to occur in the Suwannee River basin. *Floridobia mica* has been found only in Coffee Spring, a third magnitude spring that is one of several springs located within Ichetucknee Springs State Park, Columbia and Suwannee Counties, Florida. Since *F. mica* inhabits only one location, its population is vulnerable to extinction from any environmental perturbation that adversely affects habitat or water quality where it resides. *F. mica* has a global ranking of G1 (critically imperiled) in the Nature Serve ranking system and is categorized as S1 (critically imperiled) by the Florida Natural Areas Inventory. The snail is designated as a Species of Greatest Conservation Need by the Florida Fish and Wildlife Conservation Commission (FWC) and was one of ten Florida siltsnail species petitioned for federal listing as threatened or endangered by the Center for Biological Diversity, Tucson, Arizona, in their 2010 “megapetition” submitted to the U.S. Fish and Wildlife Service (Center for Biological Diversity 2010).

No quantitative assessments of the abundance, distribution, habitat preferences, or environmental requirements of the Ichetucknee Siltsnail have ever been conducted. Media accounts and gray literature reports “documenting” the stable or declining status of the *F. mica* population have no basis in quantitatively collected data. The research documented herein represents the first attempt to quantitatively characterize the abundance and distribution of the Ichetucknee Siltsnail in Coffee Spring and to establish a baseline for future comparisons. This work is the first step in implementing a long-term monitoring program designed to elucidate the population dynamics of the Ichetucknee Siltsnail and to determine the environmental conditions required to sustain its population into the future.

Figure 1. Specimens of the Ichetucknee Siltsnail (*Floridobia mica*) on eelgrass (*Sagittaria kurziana*) at Coffee Spring, 18 November 2015 (photograph by Jennifer Bernatis, FWC).

Background

The Ichetucknee Siltsnail was discovered in the early 1960s by Fred Thompson, a University of Miami Ph.D. student at the time, and now emeritus at the Florida Museum of Natural History. Thompson found *F. mica* associated with bryophytes (mosses) and cypress rootlets only in Coffee Spring (Thompson 1968). Dr. Thompson described the Ichetucknee Siltsnail as a new species, *Cincinnatia mica*, in his monograph on peninsular Florida Hydrobiidae (Thompson 1968). In 2002 *C. mica* was assigned to the newly erected genus *Floridobia* based upon female anatomy and phylogenetic relationships (Thompson and Hershler 2002).

The length of time that *F. mica*, and other siltsnail species, have been present on the Florida peninsula has been intensely debated. In his 1968 monograph, Thompson hypothesized that the current geographic distribution of hydrobiid snails in Florida implied that a peninsular connection with the North American continent had persisted since at least the late Pliocene Epoch (for at least 1.8 million years). Therefore, Thompson believed that hydrobiid snails lived and speciated above sea level in northern Florida through the sea level fluctuations that characterized the Pleistocene Epoch. Johnson (1973) disputed Thompson's contention and argued that northern Florida was separated from the North American continent during Pleistocene interglacials, with a few land areas existing as islands or archipelagos that were inaccessible to colonization by snails and other land bound animals from the mainland. Johnson argued that hydrobiids are much more recent in Florida and that, once the peninsula permanently emerged, it was invaded by hydrobiid species from the Apalachicolan and Southern Atlantic Slope regions (Johnson 1973).

Little is known regarding the life history attributes and environmental requirements of siltsnails, even though there are 15 genera and 185 species in the Family Hydrobiidae in North America north of Mexico (Johnson et al. 2013). Most Florida siltsnail species, including *F. mica*, are thought to have a one year lifespan (Thompson 1968). All *Floridobia* species are dioecious and recruitment can be continuous in warm spring systems such as Coffee Spring (Brown et al. 2008). Sexual dimorphism is pronounced with females usually being much larger than males. Sex ratios are skewed toward females (Thompson 1968).

North American hydrobiid populations typically reside in spring systems where they can attain high densities grazing on periphyton and detritus (Brown et al. 2008). Springs provide uniform temperature and flow conditions and serve as refugia for species able to tolerate low dissolved oxygen concentrations, such as most Hydrobiidae. Hydrobiids typically withstand dissolved oxygen concentrations less than 2.0 milligrams per liter (FWC data), making them safe from most fish predators. Other abiotic factors that influence spring hydrobiid populations include substrate particle size, canopy cover, presence of submersed macrophytes and filamentous algae mats, and flood frequency (Brown et al. 2008, Thompson 1968).

The Ichetucknee Siltsnail is confined to an extremely small geographic area, or Extent of Occurrence (EOO) as defined by the International Union for the Conservation of Nature (IUCN 2010). At a high pool of 18 feet NGVD29, Coffee Spring has a maximum surface area of 364 square meters (SRWMD 2013). Average pool elevation (50% inundated) of Coffee Spring is 16.90 feet NGVD29, which corresponds to an EOO of 182.1 square meters for *F. mica*. HEC-RAS modelling by the Suwannee River Water Management District determined that Coffee Spring does not fall below a stage of 15.88 feet NGVD29; hence, at the lowest possible pool elevation *F. mica* is restricted to an EOO of only 18.8 square meters (SRWMD 2013). Dye tracer studies conducted within the Ichetucknee Springs complex watershed have failed to locate the source of groundwater for Coffee Spring. The extremely small surface area of Coffee Spring, in combination with the unknown source of its water, make the Ichetucknee Siltsnail especially vulnerable to extirpation from groundwater pollutants that originate from an unknown source.

Objectives

The overall goal of the research documented herein was to estimate the abundance and distribution of *Floridobia mica* in Coffee Spring and, hence, establish a baseline for future comparisons. This research was undertaken with the intent of developing and implementing a long-term monitoring program aimed at protecting the *F. mica* population into the future. To realize the goal of this program the following objectives were proposed:

1 Create a study design adequate for long-term monitoring of *Floridobia mica* distribution and abundance in Coffee Spring.

2. Determine areally dominant habitats suitable for inhabitance by *Floridobia mica* in Coffee Spring.

3. Sample the *Floridobia mica* population in Coffee Spring using habitat specific, quantitative, methods supplemented by qualitative sampling methods.

4. Create a long-term database containing *Floridobia mica* population abundance data and associated environmental parameter measurements obtained from Coffee Spring. Database to be maintained in a format suitable for storage and analyses using a variety of statistical packages including SAS, R, Systat, Primer, and PC_ORD.

Technical Approach

Study Site

Coffee Spring (29.9592. -82.7753) is a third magnitude spring (Hornsby and Ceryak 1998) that is one of nine named springs in the Ichetucknee Springs State Park springs complex. The spring and spring run total approximately 22 meters in length and the spring run is approximately 19 meters wide at its widest point near the confluence with the Ichetucknee River. Water flows from two sources beneath rock outcroppings in the spring - one at the head of the spring run and the other approximately 18 meters downstream from the head along the right descending bank. Water surface area of Coffee Spring ranges between 18.8 square meters (202.9 square feet) at a low pool elevation of 15.88 feet NGVD29 and 364 square meters (3,920.3 square feet) at a high pool elevation of 18.1 feet NGVD29 (SRWMD 2013). Average water surface area of the spring is 182 square meters at a pool elevation of 16.9 feet NGVD29 (SRWMD 2013). Average discharge of Coffee Spring is 2.83 cubic feet per second. The Florida Park Service has prevented disturbance of the *Floridobia mica* population from recreational users by erecting a steel mesh fence across the mouth of the Coffee Spring run at the confluence with the Ichetucknee River (Figure 2).

On the 18 November 2015 sampling date, water temperatures in Coffee Spring were stable at 21.8 °C at all locations and depths measured. Specific conductance was stable at 307 micro Siemens/cm and salinity was 0.15 ppt at all locations measured. Dissolved oxygen ranged from 1.88 mg/l at the upper-most spring boil to 2.92 mg/l measured in the riffle approximately 7 meters downstream from the uppermost spring boil. Dissolved oxygen at the downstream end of the spring run was 2.43 mg/l. Maximum depth measured in the spring run was 48.5 cm.

Areally dominant habitats present in Coffee Spring on the 18 November 2015 sampling date were bryophytes (*Sphagnum* sp. and *Leptodictyum* sp.) on limestone bedrock and rocks, eelgrass (*Sagittaria kurziana*), and bottom sediments composed of gravel, sand, and shell fragments. Other important snail habitats present but limited to small areas included tree roots, wood debris, floating and benthic filamentous algae mats, and mud.

Field Methods

Initial field sampling of the Ichetucknee Siltsnail in Coffee Spring was conducted on 18 November 2015. The Coffee Spring boil area and spring run were divided into three study zones (Figure 2). Zone one extended from the head spring eight meters downstream to the end of a small limestone bedrock riffle. Zone 2 extended from the end of the riffle downstream for seven meters and included the small spring on the right descending bank. Zone three was the area extending from the downstream end of zone 2 to the fence separating Coffee Spring from the Ichetucknee River.

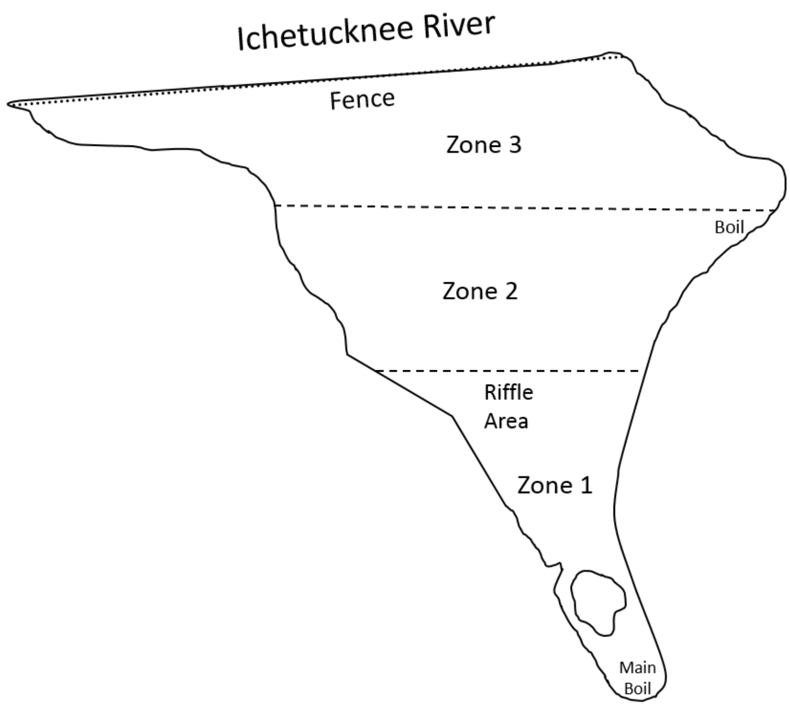

Figure 2. Photo of Coffee Spring (left) and illustration of sampling zones (right), for the 18 November 2015 sampling event (photograph by Jennifer Bernatis, FWC).

Areally dominant habitat types were determined in each zone. Four replicate samples were then obtained from each areally dominant habitat type in each zone. To minimize disturbance of habitat, the number of samples collected was kept to a minimum and only one biologist entered the spring to obtain samples. Sampling methods and gear were habitat-specific. Gravel/sand/shell and mud habitats were sampled using a 57 mm inner diameter dive corer fitted with 300 micron Nitex© mesh near one end. The corer was inserted into the sediments to a maximum depth of 10 cm. The bottom of the corer was then covered and the corer was inverted to drain water and the contents rinsed into a sample container. Surface area sampled by the corer was 25.5 cm^2. *Sagittaria kurziana* was sampled by inverting a zip-lock bag over the plants in the area to be sampled, cutting the plants just above the bottom sediment, then sealing the bag and rinsing the contents into a sample container. Surface area sampled by the bag was 183.8 cm^2. Bryophytes were sampled by scraping them from a rectangular area on bedrock or rock substrate into a zip-lock bag, then carefully measuring the surface area scraped. Surface area of bryophyte sampled varied by sample, but was usually approximately 100 cm^2. Qualitative samples were obtained from habitats with small areal coverage, including tree roots, filamentous algae, and flat stones, habitats using a 300 micron mesh dip net. Wood debris was qualitatively sampled by hand picking with forceps. All samples were transported live in coolers to the FWC freshwater invertebrate laboratory in Gainesville for processing.

Ancillary measurements obtained concurrently with sampling included depth, water temperature, conductivity, salinity, percent dissolved oxygen concentration, dissolved oxygen mg/l, and current velocity.

Lab Methods

In the laboratory samples were placed separately into small holding tanks containing Coffee Spring water and maintained in these tanks prior to processing. Room temperature was maintained at 22°C to simulate water temperature in Coffee Spring. Samples were processed separately by a biologist who placed samples in white processing pans and, using a magnifying lamp, removed snails from sample debris using forceps. The biologist then identified and enumerated all snail species. All identifications were verified by FWC experts in gastropod taxonomy.

Results

Numbers of *Floridobia mica* obtained in samples ranged from zero in all four Zone 3 mud replicates to 435 in one Zone 2 bryophyte sample. The second highest number of *F. mica* occurring in one sample, 217 in one Zone 1 bryophyte replicate, was half that obtained in the sample with the highest numbers. Raw counts of *F. mica* from all Coffee Spring quantitative samples were converted to number of snails per square meter for comparison purposes. Mean habitat type densities of *F. mica* and associated coefficients of variation are presented in Table 1. Overall, coefficients of variation associated with mean density estimates were high, most being 100 percent of the mean or greater, indicating that *F. mica* densities are extremely variable, even within habitat types, and that the snail has an extremely aggregated (clumped) distribution in Coffee Spring. Usually coefficients of variation of 0.50 or lower are necessary to perform statistically legitimate comparisons between mean density estimates, hence, no such estimates were performed with the Coffee Spring *F. mica* data.

Bryophytes were by far the most productive Coffee Spring habitat sampled, with the Zone 2 mean of 27,265 snails per square meter being the highest density estimate of all habitat/zone means (Table 1). The Zone 1 bryophyte mean of 7,714 snails per square meter was second greatest of all zone/habitat density estimates (Table 1). No bryophytes were present in Zone 3. Eelgrass (*Sagittaria kurziana*) was the second-most productive habitat sampled. Zone means of *F. mica* in eelgrass were 1,360 per square meter in Zone 2 and 353 per square meter in Zone 3. No eelgrass was present in Zone 1. Bottom sediments were the least productive of all habitat types sampled. The gravel/sand/shell bottom habitat supported Zone 1 and Zone 3 means of 98 per square meter and a high of 490 per square meter in Zone 2. However, most gravel/sand/shell samples contained zero *F. mica*. No *F. mica* were found in the mud habitat, which was present only in a small area of Zone 3 along the left descending bank. Another hydrobiid snail, *Notogillia wetherbyi* was found in low densities in the mud habitat.

Table 1. Mean (no. m^{-2}) and coefficient of variation (c.v.) of *Floridobia mica* in the three sampling zones of Coffee Spring, Ichetucknee Springs State Park, Suwannee County, FL. Coefficient of variation expressed as a proportion of mean (not as %).

Habitat	Zone 1 $\bar{x}$ no. m^{-2} (c.v.)	Zone 2 $\bar{x}$ no. m^{-2} (c.v.)	Zone 3 $\bar{x}$ no. m^{-2} (c.v.)	All Zones $\bar{x}$ no. m^{-2} (c.v.)
Gravel/sand/shell	98 (2.00)	490 (2.00)	98 (2.00)	229 (2.47)
Bryophytes	7,714 (1.20)	27,265 (1.06)	---	17,489 (1.28)
Eelgrass	---	1,360 (0.92)	353 (0.93)	857 (1.17)
Mud	---	---	0	0

--- denotes habitat not present.

Several habitats having small areal coverages in Coffee Spring, including tree roots, wood debris, filamentous algae mats, and small flat stones, were sampled on 18 November 2015 using qualitative methods, Low numbers of *F. mica* were found in tree roots, algae mats, and wood debris. No *F. mica* were found in the flat stone habitat.

The Hyacinth Siltsnail (*Floridobia floridana*) is one of two Florida siltsnail species not endemic to a single spring system. *F. floridana* occurs throughout the northern half of the Florida peninsula (Thompson 1999) and was documented from the mainstem of the Ichetucknee River near Coffee Spring by Thompson (1968). Given the potential for *F. floridana* to be found in Coffee Spring, all *Floridobia* specimens collected on 18 November 2015 were closely examined and verified as *F. mica*. No *F. floridana* were found in Coffee Spring.

Two nonindigenous and invasive snails of the family Thiaridae are known to occur in the Ichetucknee River. The Red-rimmed Melania (*Melanoides tuberculata*) is ubiquitously distributed across the Florida peninsula and was observed alive in Coffee Spring during the November 18 sampling event. However, *M. tuberculata* was not collected in any samples obtained during the November 18 sampling event. The Quilted Melania (*Tarebia granifera*) has been observed in the Ichetucknee River approximately 400 meters upstream from Coffee Spring, but was not observed or collected in samples from Coffee Spring on November 18. Both of these thiarid snails are native to Southeast Asia, are extremely prolific, and are known to replace native snails in areas they have invaded (Thompson 1999).

Discussion

Status of the *Floridobia mica* Population

Results of the 18 November 2015 sampling event demonstrate that the *Floridobia mica* population is distributed throughout Coffee Spring, from the headwaters downstream to the eelgrass bed near the fence separating the spring run from the Ichetucknee River mainstem. Although we found the population to be moderately abundant in two habitat types (bryophytes and eelgrass), we consider the population to be, overall, small, given the extremely limited EOO and low siltsnail abundances in bottom sediment habitats. The greatest densities of *F. mica* were encountered in the bryophyte habitat in Zone 2 (Figure 2) near the middle of the spring run. *F. mica* was substantially less abundant in gravel/sand/shell, tree root, wood debris, and stone habitats and was completely absent from mud sediments. Anecdotal reports reviewed during the course of our research claimed that *F. mica* occurs only in bryophytes near the headspring, but we found the snail to be present along the entire length of the spring run in several habitat types.

While processing and identifying samples we noted a substantial range of maturity of *F. mica* specimens, as reflected by the number of whorls present on shells. Both adult and juvenile specimens were present at the time of the sampling event, but most specimens were probably juveniles, being characterized by only one to one and one-half whorls. The presence of both adults and juveniles in the population is indicative of active recruitment. Given the overall moderate abundance of siltsnails in the spring run and the presumed level of recruitment, we believe that the *F. mica* population in Coffee Spring is healthy.

Significant Threats to the *F. mica* Population

Although the *F. mica* population appeared to be moderately abundant in certain Coffee Spring habitats at the time of the 18 November 2015 sampling event, a number of significant threats to the population place it in peril. These threats are presented below in the context of Section 4 of the Endangered Species Act and its implementing regulations (50 CFR part 424). As per the Act, a species can be federally listed as threatened or endangered based upon any of the five factors listed below:

1. Present or threatened destruction, modification, or curtailment of habitat or range.

One of the greatest threats to the *F. mica* population is loss of habitat area due to declining spring flows and water levels in the Ichetucknee River basin. Since the habitat area of *F. mica* is only 364 square meters at high pool, small reductions in the flow of Coffee Spring can cause significant reductions in habitat area. Declining groundwater levels and flow reductions in the Suwannee River basin are an artifact of the pumping of groundwater for human use (Toroc et al. 2010). In the period 1965 to 2010 total groundwater withdrawals in the Suwannee River Water Management District have increased by approximately 150 percent, from 100 million gallons per day (MGD) to over 250 MGD (Marella 2013, SRWMD 2013). The declines in groundwater levels in the lower Santa Fe, Ichetucknee, and priority springs watersheds has contributed to reductions in stream and spring flows to levels below the minimum flow levels established by the SRWMD (2013), forcing the District to produce a recovery plan. (SRWMD 2014),

Only a minimal number of flow records are available from individual springs in the Ichetucknee River. Spring flows have been measured infrequently and the timing of measurements has been highly biased toward more recent time periods (SRWMD 2013), hence, there is an inadequate period of record to determine the magnitude of flow reductions that have occurred or to quantify the amount of reduced flows that constitute significant harm to spring-associated aquatic biota. However, data and analyses presented by Heffernan (2010) and the H.T. Odum Florida Springs Institute (2012) indicate that flows from the Ichetucknee Springs complex constitute nearly 100 percent of the Ichetucknee River flow measured at the U.S. 27 gage. Hence, the period of record discharge at the U.S. 27 gage can be used as a surrogate for the flow trend of the combined Ichetucknee Spring complex. Grubbs (2011) presented data that are indicative of a 60 cfs decline in Ichetucknee River flow for the period 1900 to 1980 and a 32 cfs decline from 1980 – 2009. Using U.S. Geological Survey data, the Odum Florida Springs Institute demonstrated a 90 cfs flow reduction over a 1917 – 2011 period of record, with a significant trend of decline beginning in the 1970s. The 90 cfs value represents a 25 percent flow reduction from the 355 cfs average period of record flow measured at the U.S. 27 gage.

Flow of Coffee Spring has been measured only on rare occasions. However, SRWMD (2013) documented a relationship between discharge measured at the U.S. Route 27 gage on the Ichetucknee River and Coffee Spring pool elevation (and, hence, habitat area). Using this relationship the District determined that an Ichetucknee River discharge of 351.42 cubic feet per second (cfs) at the U.S. 27 gage resulted in a Coffee Spring stage of 16.90 feet NGVD29. This 16.90 feet stage corresponds to a 50 percent inundation of Coffee Spring and a habitat area of 183.96 square meters. The SRWMD further established that a 15 percent loss of inundation area from the 50 percent inundation value would equate to a Coffee Spring area of 154.79 square meters at an Ichetucknee River stage of 16.74 feet NGVD29 at the U.S. Route 27 gage. The 15 percent habitat loss (or greater) metric has been used as the standard to indicate significant ecological harm to stream systems (Bovee 1986, Gore 1987). Using this metric, discharges below 325 cfs and stage measurements below 16.74 feet NGVD29 measured at the U.S. Route 27 stream gage would result in significant ecological harm to Coffee Spring and the *F. mica* population. The observed exceedance probability for these flows and levels in the 2002 – 2011 time period was 0.33 (33 % of the time).

An additional threat to *F. mica* habitat is increasing groundwater nitrate levels in the Ichetucknee River watershed. Elevated nitrates expressed in spring flows can result in benthic filamentous algae blooms that cause overall degradation of habitat. Filamentous algae blooms in Coffee Spring would have the potential to shade-out the bryophyte and eelgrass habitats where *F. mica* flourishes, thus reducing amount of available habitat. Nitrate has not been measured on a regular basis in Coffee Spring, but measurements in the Ichetucknee head spring may be considered as generally representative of springs in the Ichetucknee basin. It should be noted that the groundwater source for Coffee Spring is unknown, while the water sources for other springs in the Ichetucknee River complex have been verified. Nitrate concentrations in the Ichetucknee head spring increased from less than 0.05 mg/l in the 1960s to 0.77 mg/l in the 2000s (Odum Springs Institute 2012). The Florida Department of Environmental Protection has established a total nitrate + nitrite criterion of 0.35 mg/l for Florida groundwater. Ichetucknee basin groundwater levels are chronically above this standard.

2. Overutilization for commercial, recreational, scientific, or educational purposes.

Floridobia mica is not currently utilized for commercial, recreational, or educational purposes. The Florida Park Service, Florida Department of Environmental Protection, has erected a fence in the Ichetucknee River across the mouth of the Coffee Spring run, effectively preventing recreational users of the Ichetucknee River (snorkelers, canoers, kayakers) from entering Coffee spring and, thus, disturbing the Ichetucknee Siltsnail population.

3. Disease or predation.

There is currently no evidence or data that suggests the Coffee Spring *F. mica* population is affected by disease or could potentially be affected by disease. Snail predators (fish and aquatic insects) were observed in Coffee Spring during the 18 November 2015 sampling event, however, there is no current evidence or data that suggests that predation is affecting the population status of *F. mica*.

4. Inadequacy of existing regulatory mechanisms.

Despite the fact that the *F. mica* population is endemic to a single spring system and its Extent of Occurrence is only 364 square meters at high pool, there are no existing regulatory mechanisms in place to ensure its protection. The species is not listed as endangered or threatened by the USFWS or the State of Florida. *F. mica* is listed as a Species of Greatest Conservation Need by the Florida Fish and Wildlife Conservation Commission, but this status carries no regulatory protection.

The Florida Department of Environmental Protection, in cooperation with the Suwannee River Water Management District and the St. Johns River Water Management District, adopted minimum flows and levels (MFLs) for the lower Santa Fe River, the Ichetucknee River, and associated “priority” springs in 2013 (SRWMD 2013). These MFLs are regulatory tools established to ensure that water bodies are protected and do not experience “significant harm” resulting from water withdrawals. The MFLs are specific discharges set at specific gages in the lower Santa Fe River basin. The MFL set at the U.S. 27 gage on the Ichetucknee River is not currently being met due to groundwater withdrawals, despite a recovery plan developed by the SRWMD. Overall, the MFL is an inadequate mechanism in that it allows groundwater withdrawals that may cause significant harm. Continued low flows resulting from violation of the Ichetucknee River and priority springs MFL pose a substantial threat to *F. mica*.

5. Other natural or manmade factors affecting continued existence.

Two nonindigenous, invasive, aquatic snail species are known to occur in the Ichetucknee River – the Quilted Melania (*Tarebia granifera*) and the Red-rimmed Melania (*Melanoides tuberculata*). Both species are reproductively prolific (Abbott 1952, Thompson 1999, Appleton et al. 2009), both become very abundant given adequate habitat conditions (Abbott 1952, Thompson 1999), and both are known to displace native snail species (Abbott 1952, Prentice

1983, Thompson 1999, Appleton et al. 2009, Raw et al. 2013). Both have been reported from multiple locations in Ichetucknee Springs State Park (Dormsjo 2008, Florida Museum of Natural History Molluca Database, Gary Warren personal observation). Of the two invasive snail species, *T. granifera* poses the greatest threat to the Coffee Spring *F. mica* population. Dormsjo (2008) reported *T. granifera* from an undisclosed location in the river mainstem. A Florida Museum of Natural History database record documents *T. granifera* from Mill Pond Spring in 1996. An additional observation was made in the river mainstem at Dampier's Landing in 2005 (G. Warren, FWC). *T. granifera* was introduced into Florida in the Tampa area in the late 1930s (Abbott 1952) and has slowly spread from Lithia Springs north to the Hillsborough, south Withlacoochee, St. Johns, and Suwannee River basins. The presence of *T. granifera* in the Ichetucknee River system is significant because this invasive snail has displaced and extirpated native snails in several locations, including Lithia Springs and Alexander Springs, in Florida (Abbott 1952, Prentice 1983, Samadi et al. 1997, Appleton et al. 2009, Karatayev et al. 2009, Raw et al. 2013, G. Warren, FWC, personal observations). Based upon our personal observations in south and central Florida spring systems, the fact that *T. granifera* occurs 300 – 400 meters upstream from Coffee Spring at Dampier's Landing represents a significant threat to the Coffee Spring *F. mica* population. During the sampling event of 18 November 2015, FWC biologists searched Coffee Spring for *T. granifera* but found no living specimens or dead shells of the species. FWC plans to continue monitoring the Ichetucknee River and Coffee Spring for *T. granifera*. *Melanoides tuberculata* was observed in Coffee Spring during the November 18, 2015 sampling event, but did not occur in any quantitative samples. The presence of *M. tuberculata* in Coffee Spring should be considered a threat to the *F. mica* population.

A second natural/manmade factor threatening the *F. mica* population is the unknown source of water for Coffee Spring. Dye tracer studies conducted by Florida DEP and several consultants from 1991 through 2005 identified the sources of groundwater for all springs in the Ichetucknee Springs complex except Coffee Spring. Since it is unknown if the source of the springshed is on protected or unprotected lands, the *F. mica* population is vulnerable to toxic spills and groundwater pollutants. Agricultural and petroleum-based chemicals are spill constituents that could potentially extirpate the *F. mica* population. Further tracer studies are needed in areas not previously dye-injected to identify the source of Coffee Spring.

Listing of Other Hydrobiid Species

Eight species of hydrobiid snails have been federally listed as endangered as of 2015. The locations and reasons for listing each of these eight species is presented in Appendix 1. Like the Ichetucknee Siltsnail, some of these endangered snails are endemic to single spring systems and are common within their ranges; however, each was listed due to substantial threats affecting or potentially affecting their habitats. A case very similar to that of the Ichetucknee Siltsnail is the Phantom Springsnail (*Pyrgulopsis texana*), which was listed as an endangered species by the USFWS in 2013 (Appendix 1). The Phantom Springsnail occurs in only one Texas spring system, but can attain very high densities. The threats responsible for the listing of *P. texana* included reduction of spring flows, inadequate regulatory mechanisms, and the presence of two invasive snail species, *T. granifera* and *M. tuberculata* (Federal Register 2013).

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Appendix 1. Listing information for eight *Pyrgulopsis* (Gastropoda: Hydrobiidae) species listed as endangered by the U.S. Fish and Wildlife Service.

Species	Listing citation	Location	Threats
Pyrgulopsis pachyta	Federal Register. 2000. 65(38):10033-10039	Occurs only in Piney and Limestone Creeks, Limestone County, Alabama	Confined to small range - restricted to a few isolated sites along two or three short river reaches. Poor water quality - siltation and other pollutants from poor land-use practices and waste discharges are contributing to the general deterioration of water quality
Pyrgulopsis bruneauensis	Federal Register. 1993. 58(14): 5938-5946	Complex of related thermal springs and immediate outflows along the Bruneau River in Owyhee County, ID	Reduction thermal spring habitats due to agricultural-related ground water withdrawls.
Pyrgulopsis chupaderae	Federal Register. 2012. 77(134): 41088-41106	Willow Spring and an unnamed spring of similar size 0.5 kilometers north of Willow Spring at the southeast end of the Chupadera Mountains in Socorro County, New Mexico	Habitat loss and degradation. Decreased spring flow due to drought and ongoing and future groundwater pumping. Habitat degradation from livestock grazing. Springhead modification.
Pyrgulopsis neomexicana	Federal Register. 1991. 56(189): 49646-49649	Thermal spring in Socorro County, NM	Declining flows. Potential introduction of nonnative competing or predaceous organisms into springs. Loss of organic film or other natural elements from habitat.
Pyrgulopsis ogmorhaphe	Federal Register. 1994. 59(73): 17994-17998	Two spring runs on public lands in the Sequatchie River system, Marion County, TN	Water quality deterioration that has resulted from siltation and other pollutants contributed by coal mining, poor land use practices, and waste discharge.

Appendix 1 (cont.)

Species	**Listing Citation**	**Location**	**Threats**
Pygrulopsis roswellensis	Federal Register. 2005. 70(152): 46304-46333	Bitter Lake National Wildlife Refuge in Roswell basin, southeastern New Mexico. Core population in the Sago Springs Complex and Bitter Creek. The Sago Springs complex is approximately 0.3 km long (1,000 linear feet). Bitter Creek has a total length of 1.8 km (1.1 miles).	Extremely limited Distribution. Low mobility. Fragmented habitat. Introduced species. Surface and groundwater contamination. Oil and gas extraction activities within the supporting aquifer and watershed. Local and regional groundwater depletion. Severe drought. Direct loss of habitat due to burning, marsh vegetation removal, or flooding).
Pygryulopsis texana	Federal Register. 2013. 78(131): 41228-41258	Spring outflows in the San Solomon Springs system near Balmorhea in Reeves and Jeff Davis Counties, Texas.	Small range. Habitat loss and degradation. Current and ongoing decline in spring flows. Presence of two nonindigenous, invasive, snail species.
Pyrgulopsis trivialis	Federal Register. 2012 77(74): 23060-23092	Two springs complexes in Apache Co., AZ: Boneyard Bog Springs and Boneyard Creek Springs. These spring complexes are constituted by few to many spring vents in shallow canyon drainages or open mountain meadows at 8,200 feet elevation. The springs are spread across 3.7 miles of perennial flowing stream.	"Threats of sufficient imminence, intensity, or magnitude to cause a substantial decrease in distribution or loss of viability."