Stock Island tree snail
(*Orthalicus reses* (not including *nesodryas*))

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
South Florida Ecological Services Office
Vero Beach, Florida

5-YEAR REVIEW
Stock Island tree snail/*Orthalicus reses* (not including *nesodryas*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: This review is based on monitoring reports, surveys, and other scientific and management information, augmented by conversations and comments from biologists familiar with the species. The review was conducted by the lead recovery biologist for this species with the South Florida Ecological Services Office. Literature and documents used for this review are on file at the South Florida Ecological Services Office. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the Stock Island tree snail (SITS). No part of the review was contracted to an outside party. Public notice of this review was given in the *Federal Register* on April 16, 2008, with a 60-day public comment period (73 FR 20702). Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A).

SITS was originally listed as *Orthalicus reses*. However, *O. reses* is comprised of two recognized taxa, *O. reses reses* (SITS) and *O. reses nesodryas* (Florida Keys tree snail) (Integrated Taxonomic Information System 2009). Accordingly, *Orthalicus reses* (not including *nesodryas*) equates to the recognized taxon, *O. reses reses*.

B. Reviewers

Lead Region: Southeast Region, Kelly Bibb, 404-679-7132, and Nikki Lamp, 404-679-7091

Lead Field Office: National Key Deer Refuge, Phillip Hughes, 305-872-2239, and South Florida Ecological Services Office, Paula Halupa, 772-562-3909

C. Background

1. FR Notice citation announcing initiation of this review: April 16, 2008, 73 FR 20702.

2. Species status: Uncertain (2008 Recovery Data Call). The primary threat to SITS at the time of listing was habitat loss due to development. Additional threats include pesticides, hurricanes, vegetation trimming along utility corridors, overutilization, and non-native predators. Trends in those threats are continuing at the same level, except for predation, the threat level for which is unknown. The population trend is unknown.

3. Recovery achieved: 2 (26-50 percent recovery objectives achieved) (2008 Recovery Data Call).

4. Listing history
Original Listing
FR notice: 43 FR 28932
Date listed: July 3, 1978
Entity listed: Subspecies
Classification: Threatened

5. Associated rulemakings: N/A

6. Review History: 5-year review, November 6, 1991 (56 FR 56882). In this review, different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors and threats as they pertained to the different species' recovery. The notices summarily listed these species and stated that no changes in the designation of these species were warranted at that time. In particular, no changes were proposed for the status of the SITS.

Final Recovery Plan: 1999
Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008

7. Species' Recovery Priority Number at start of review (48 FR 43098): 3 (3 = high degree of threat, low to moderate recovery potential).

8. Recovery Plan or Outline
Name of plan: South Florida Multi-Species Recovery Plan (MSRP)
Date issued: May 18, 1999
Dates of previous plans: Original plan approved March 9, 1983 (Stock Island Tree Snail Recovery Plan) (Service 1983)

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. Is the species under review listed as a DPS? No. The Endangered Species Act (ESA) defines species as including any subspecies of fish or wildlife or plants, and any distinct population of a species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? No. The recovery criteria largely pertain to habitat, in particular a minimum number of sites (four) and habitat stability for those sites in the Lower Keys. However, only one Lower Keys site is currently occupied by a persistent population, whereas more populations and larger numbers of SITS occur at various sites in the Upper Keys. Accordingly, the criteria do not reflect the best

available and most up-to-date information on the biology of the species because they treat the Lower Keys as the only area to conduct reintroductions and otherwise achieve recovery for SITS. Moreover, significant threats in addition to habitat loss have emerged, and these are not adequately addressed in the recovery criteria.

2. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the five listing factors are addressed by that criterion. If any of the five listing factors are not relevant to this species, please note that here. The criteria included in the approved recovery plan (Service 1999) to delist SITS are:

1) further loss, fragmentation, or degradation of suitable, occupied habitat in the Lower Keys has been prevented; (Factor A)
2) occupied habitat on priority acquisition lists for the Lower Keys is protected either through land acquisition or cooperative agreements; (Factors A and D)
3) potential habitat on these protected lands is managed, restored, or rehabilitated to provide habitat for the SITS; (Factors A and E)
4) four stable populations of the SITS are established throughout the Lower Keys; these populations will be considered demographically stable when they exhibit a stable age structure, have a rate of increase (*r*) equal to or greater than 0.0 as a 3-year running average for 14 years, and have at least a 95 percent probability of persistence for 100 years.

Although reduced, habitat loss and degradation continues. Acquisition of occupied habitat on priority lists has largely been achieved; however a substantial number of the sub-populations are in private subdivisions. Substantial progress has been made in managing, restoring, and rehabilitating potential habitat, but this has not been fully accomplished. In the Lower Keys, the No Name Key population is the only one that persists in natural surroundings and generally appears to be viable. Demographic data are lacking. In addition, other threats (e.g., non-native predators, inadequacy of existing regulatory mechanisms, and natural and manmade factors) continue to affect the species. In summary, none of the criteria have been fully met.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate), or demographic trends: SITS abundance and range declined throughout the 20th century (Service 1999). Limited information on SITS demographics is available, and little additional data exist since the MSRP was published (Service 1999). Few additional data are available on SITS abundance or population trends since the publication of the MSRP. Rigorous estimates of SITS numbers are not known for any

population. SITS status is currently assessed by the numbers of discrete populations that are known. Accordingly, potential trend information only includes observations of whether various populations continue to persist. However, for most populations, even the area occupied is poorly defined. As of 2006, a tabulation of all well-known and poorly documented sites indicated that SITS occupied approximately 25 sites in the Florida Keys (Monroe County) and two sites on the mainland (Miami-Dade County) (Service 2006a). However, for many of those sites, even confirmation as to whether SITS persists in recent years is lacking. Survey and monitoring efforts have been limited and highly variable, and methodologies are usually not reported in detail. Whereas SITS occupies more sites at present than in the recorded past, the total area occupied remains unknown, as are trends in abundance and demographics. Overall, however, the SITS population status appears to be more secure than when it was listed, due to the widespread translocations that occurred subsequently (Service 1999, 2006a).

SITS no longer occupies the Key West Tropical Forest and Botanical Garden (KWTFBG) (discussed below). In contrast, many populations exist on Key Largo, well beyond SITS historic range, as a result of relocations by snail collectors (Service 1999, 2006a). The majority of relocations occurred by the late 1990s. These were largely carried out by private hobbyists who sought to thwart extinction. However, these actions were poorly documented and subsequently poorly monitored. One clear trend is that Key Largo has accumulated more populations than the Lower Keys.

SITS has two congeners (i.e., same genus) in the Florida Keys, the banded tree snail (*O. floridensis*) and the Florida Keys tree snail. Little information is available regarding the status of these taxa. However, Emmel and Perry (2004) believed there to be shifts in the relative abundances of the three *Orthalicus* taxa in the Keys. In the past, the banded tree snail was the most common and widespread of the three, whereas subsequent to 2000, Emmel and Perry (2004) considered the banded tree snail to be the rarest. This situation results partly from the translocations that bolstered SITS distribution and allowed them to avoid extinction, but probably also reflects actual declines in banded tree snail populations over time. SITS now occur in sympatry with their congeners in several locations (Emmel and Perry 2004). The observations of Emmel and Perry (2004) suggested that translocated SITS, all of which are outside the historic range, perform as well or better than congeners in those places where they overlap.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding): *Orthalicus* is comprised of three recognized taxa in Florida—SITS, Florida Keys tree snail, and banded tree snail—all of which currently overlap in portions of the Keys and Miami-Dade County. Emmel and Perry (2004) sequenced 681, 452, and 683 base pairs in the cytochrome oxidase, 16S ribosomal RNA, and Internal

Transcribed Spacer regions, respectively. The 16S ribosomal subunit is typically found to exhibit variation at the species level in a wide variety of organisms. Overall, however, the only marker found to exhibit variation among the *Orthalicus* taxa was the cytochrome oxidase region, which varied at only two positions. Both *Liguus* and *Orthalicus* taxa exhibit substantial morphological differences. Other researchers had found little genetic variation among populations of *Liguus fasciatus* despite the extreme color polymorphisms in this snail, which exhibit partial self-fertilization (Hillis et al. 1987, 1991; Hillis 1989 as cited in Emmel and Perry 2004). However, Emmel and Perry (2004) found a lack of variation more surprising in congeneric *Orthalicus*, which like most pulmonate land snails are hermaphroditic and obligate outcrossing species (reproduce through sexual matings).

Emmel and Perry (2004) considered the findings to be consistent with either of two explanations, neither of which could be confirmed from the available data. One explanation is that there has been recent gene flow among taxa, and the other is that divergence was so recent that sufficient time has not elapsed for the taxa to accumulate mutations. Emmel and Perry (2004) asserted that the taxa "should continue to be considered as independent units for management purposes."

The results of Emmel and Perry (2004) suggested that the taxa are morphological variants as opposed to subspecies. However, additional studies should be conducted to confirm this. For example, sample sizes were very small. From a total of 47 specimens for all three taxa, cytochrome oxidase, 16S ribosomal RNA, and Internal Transcribed Spacer region sequences for 6, 46, and 4 samples, respectively, were reported (Emmel and Perry 2004). Additionally, Emmel and Perry (2004) noted that an "extremely small percentage of the overall genome of these organisms has been sequenced" and may be a potentially confounding factor. However, the gene fragments used in this analysis are normally capable of delineating differences among species in a wide range of organisms including land snails, and Emmel and Perry (2004) considered it "very likely that these taxa are indeed much more closely related than has previously been suspected."

At field sites that were occupied by more than one taxon (e.g., Monkey Jungle, Miami-Dade County), observations suggested that the different taxa did not interbreed despite close contact (Emmel and Perry 2004). As noted above, morphological distinctiveness is evident. However, assortative mating has not been confirmed, mating experiments have not been conducted, and genes responsible for color traits and the heritability of polymorphisms have not been identified. Accordingly, relatedness among individuals within an area of sympatry, even individuals presenting color variation, cannot be inferred with certainty based on visual observations at present.

c. Taxonomic classification or changes in nomenclature: The Integrated Taxonomic Information System (2009) continues to recognize SITS as a valid subspecies, *O. reses reses*. However, Emmel and Perry (2004) recommended that if the two *O. reses* subspecies prove to be as genetically invariant as was observed in their study, the groups should be considered a single taxon or taxonomic unit. In that case, the nominate form, *O. reses reses*, would prevail and *O. reses nesodryas* would become a synonym instead of a valid subspecies.

d. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range): SITS was originally restricted to the far west end of the Keys, on Stock Island and Key West. It remains unknown whether the Key West Golf Course retains any habitat that is suitable. KWTFBG encompasses and protects a remnant of the original hardwood hammock to which SITS is endemic. However, SITS currently appear to be extirpated there and elsewhere on Stock Island. Currently, only one Lower Keys site is occupied by a self-sustaining population, whereas more populations and larger numbers of SITS occur in Upper Keys sites. In the Lower Keys, indigenous and introduced SITS have occupied Key West (urban settings), Stock Island (KWTFBG, Key West Golf Course), Big Pine Key (Watson Hammock), No Name Key (Service 1999), and Weapons Hammock (Naval Air Station Key West, Boca Chica Key). In the Lower Keys, the population on No Name Key is the only one that persists in natural surroundings and, based on persistence in the absence of direct intervention such as augmentations, generally appears to be viable. The historical SITS introduction sites on Big Pine Key and No Name Key are ensconced within the National Key Deer Refuge (NKDR), with Watson Hammock designated as an inviolate area (i.e., closed to the public year-round). These habitats are protected and managed by the Service. There is no additional information on urban Key West sites, which have historically been tenuous for SITS, or the Weapons Hammock site. Other than sites within urban Key West, previously and currently occupied habitats in the Lower Keys are owned by the City of Key West (KWTFBG), Service (NKDR), and Navy (Naval Air Station Key West). Acquisition of hardwood hammock parcels by Monroe County, the State of Florida, and the Service, both within and adjacent to the administrative boundaries of NKDR, has advanced substantially (see Section 2.a. below).

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): In many portions of the SITS range, habitats that are either suitable or occupied are only loosely delineated on maps, otherwise quantified, or monitored. SITS occupy tropical hardwood hammock communities and ecotones on private and public lands in Monroe and Miami-Dade counties. The extent, distribution, and suitability of the habitat and ecosystem components have not been fully described or

monitored. We have no new data on the relationships between tree species composition or forest stand structure and food availability or fitness, nor information on trends in any of these factors. There are no new data that describe particular aspects of hardwood hammock with respect to SITS selection, preference, or fitness. Overall, important habitat components for SITS are not fully identified and understood. Accordingly, the extent of suitable habitat is only loosely delineated (as hardwood hammock in general). In most areas, the extent of occupied area, and the acreage of hardwood hammock itself, is poorly delineated. However, SITS occupy hardwood hammocks with a range of characteristics, and the status and trends of hardwood hammock in general remains a reasonable proxy for the status and trends of SITS habitat.

As of 2006, there was a total of approximately 3,371 hectares (ha) (8,327 acres) of potential SITS habitat in Monroe County. Of those, approximately 2,419 ha (5,976 acres) were located on conservation lands not subject to development (Service 2006a). The area of potential SITS habitat in Miami-Dade County is unknown. On public conservation lands occupied by SITS, habitat conditions have generally improved due to ongoing acquisitions (i.e., increased habitat continuity) and the various management efforts carried out on such properties (e.g., invasive exotic plant [IEP] control, restoration projects). Regulatory constraints have substantially reduced the occurrence of hammock destruction for development projects. However, in both the Lower and Upper Keys, further fragmentation and loss of privately owned hammock occurs following the issuance of limited building permits by Monroe County.

f. Other: None.

2. Five-Factor Analysis

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Development—As a result of natural occurrences and introductions, the previous range of the SITS included natural and developed areas on Stock Island (KWTFBG, Key West Golf Course, Key West), Key Largo (Dagny Johnson Key Largo Hammock Botanical State Park [DJKLBSP], Crocodile Lake National Wildlife Refuge [CLNWR], John Pennekamp Coral Reef State Park, Curry Tract of Florida Keys Wildlife and Environmental Area, Key Largo Subdivisions, Calusa Cove Campground), Lower Matecumbe Key (Klopp Tract of Florida Keys Wildlife and Environmental Area, Lignumvitae Key Botanical State Park), Miami (Monkey Jungle), Weapons Hammock (Naval Air Station Key West), Everglades National Park, and Big Cypress National Preserve. The largest land management units with persistent SITS populations are DJKLBSP and CLNWR, which encompass approximately 2,316 acres (937 ha) and 6,050 acres (2,448 ha), respectively, excluding open water.

The SITS current range consists of disjunct populations, concentrated on No Name Key in the Lower Keys and Key Largo in the Upper Keys. Past habitat destruction and fragmentation eliminated some habitat patches and may have caused others to be too small to support persistent SITS populations (Service 1999, 2006a). In the last 20 years, loss or fragmentation of SITS habitat due to development has been greatly slowed. Extensive land acquisitions and regulations such as Monroe County's Rate of Growth Ordinance (ROGO) have contributed substantially to this outcome. Additionally, the State's Florida Forever program continues to acquire land for conservation purposes within the range of SITS in both the Lower and Upper Keys.

Florida Forever is administered by Florida Department of Environmental Protection (FDEP) on behalf of the Board of Trustees of the Internal Improvement Trust Fund (Trustees). Fee-simple title for purchased lands resides with the Trustees. In the Lower Keys, the program includes the Coupon Bight / Key Deer and the Florida Keys Ecosystem projects. These projects seek to protect the remaining undeveloped land, including virtually all natural hammock throughout identified project areas. Together, considering all habitat types, the Coupon Bight / Key Deer and Florida Keys Ecosystem projects include approximately 5,942 ha (14,684 acres) targeted for acquisition by willing sellers (FDEP 2006). Of this target, about 2,793 ha (6,901 acres) had been acquired as of 2005. The full complement of acquisitions, if realized, could encompass much of the remaining undeveloped habitat on private and county land. These efforts consolidate habitat and expand potential corridors and allow for management over a larger portion of the landscape. Accordingly, these acquisitions should benefit SITS indirectly by reducing the expansion and overall impact of secondary threats from development.

In the Upper Keys, areas targeted in the Florida Forever Project's North Key Largo Hammocks accession area encompass the entire remaining privately owned SITS habitat (hardwood hammock) in north Key Largo. As of February 2008, 1,604 ha (3,964 acres) out of 1,870 ha (4,621 acres) had been acquired, leaving about 266 ha (657 acres) to be acquired (FDEP 2008). Most of those acquisitions included hardwood hammock. CLNWR and DJKLBSP manage those lands acquired on north Key Largo. In the rest of the Upper Keys (below north Key Largo), potential SITS habitat in private ownership remains at risk of being developed. Miami-Dade County has far less natural areas, except for portions of Everglades National Park that occur in the county. Remaining habitat fragments in Miami-Dade outside of the Park include public and private parcels (proportions unknown), the latter being susceptible to development. Overall, both the magnitude and imminence of this threat are moderate.

The amount and variety of potential resource damage is reduced by closures

of sensitive areas that occur on KWTFBG and various State and Federal conservation lands and State and Federal law enforcement officer patrol of public lands throughout the range of SITS. The KWTFBG has increasingly pursued and attained active protection, management, and restoration of the original hammock and adjacent areas (Service 1999, Keys Environmental Restoration Fund [KERF] 2006). Accordingly, the site's suitability for SITS reintroductions has increased substantially. SITS sites on Service properties (NKDR and CLNWR) are strictly managed for the protection of SITS and other listed species. However, specific knowledge about how to best manage such protected habitats for SITS is limited and management is essentially passive in that regard. On protected lands on Key Largo, approximately 65 percent of hardwood hammocks and acquired areas that were hardwood hammock prior to historical disturbances have been restored or rehabilitated. Details regarding these rehabilitated areas are provided in KERF (2006) and Service (2006b). Where restoration or rehabilitation occurs, IEP control is a routine component of efforts.

IEPs—IEPs supplant the native flora on which SITS reside. Significant resources have been applied to IEP control in the Keys. Active management, restoration, and rehabilitation (including IEP control) occurs on KWTFBG as well as State and Federal conservation lands in the Lower and Upper Keys (KERF 2006, Service 2006b, FDEP 2008). The Service and State, with assistance of the Florida Keys Invasive Exotics Task Force, carry out IEP control programs throughout CLNWR, NKDR, and State lands. Consistent records of control efforts and outcomes have not been produced for each of the IEP species. Accordingly, available data do not allow for quantifying acreages of IEP-infected areas or that of areas that have been treated, and specific risk or cost trajectories cannot be projected. However, undisturbed hardwood hammock has relatively limited susceptibility to current IEP threats. IEPs currently do not appear to be an imminent threat, and the magnitude of this threat to the SITS is low.

b. Overutilization for commercial, recreational, scientific, or educational purposes: Extensive SITS poaching occurred in the past and remains a potentially significant threat (Service 1999). Some SITS populations occur on protected Federal and State lands, which may help protect it from collectors. However, patrols by law enforcement personnel are limited and variable, and those populations not on public lands are particularly vulnerable in this regard. The potential for unauthorized or illegal collection of SITS exists despite Federal and State provisions for protection. Individual populations are localized, and many lie close to road access points. We do not have evidence of recent collection of SITS, nor of further relocations by enthusiasts. We do not have any information to conclude that the species is currently threatened by overutilization for commercial, recreational, scientific, or educational purposes at this time.

c. Disease or predation: Disease is not known to be a threat in the wild. Predation is a natural part of the species' life history, but impacts are more devastating when habitat composition and native and non-native predator abundance and composition patterns are altered. Historical studies indicate that substantial predation on SITS may occur and may vary significantly according to location. Deisler (1987) concluded that predation by "vertebrates and invertebrates must be a very important factor in controlling populations of *Orthalicus*" (including SITS). More recent studies focusing on the red imported fire ant (*Solenopsis invicta*), a non-native species, suggest the same patterns (Wojcik et al. 2001, Forys et al. 2001a, 2002; Forys and Allen 2005).

Forys et al. (2001a) used Florida tree snails (*Liguus fasciatus*) as a surrogate for SITS to assess vulnerability to fire ant predation. In laboratory trials, 19 out of 22 tree snails were killed by the fire ants within 3 days, some while foraging and others while aestivating. Forys et al. (2001a) argued that the likely cause of the 1992 SITS extirpation on Stock Island (KWTFBG and vicinity) was fire ant predation. Fire ants were first recorded in Monroe County and Stock Island in the 1970s and 1980s, respectively. Forys et al. (2001a) summarized the SITS decline on Stock Island and concluded that the fastest and terminal phase of the decline occurred after the advent of fire ants.

Forys et al. (2001b) concluded that "habitat restoration that decreases red imported fire ant abundance may be the most cost effective and long-term method of decreasing impacts from red imported fire ants." They suggested that "the removal and restoration of abandoned roads and access paths, and limiting disturbance of road shoulders, will probably lower fire ant populations in the area." Fire ants were found to be abundant in the protected hammocks on north Key Largo where translocated SITS occur (Forys et al. 2001b).

Forys and Allen (2005) reported on the entire assemblage of ants detected on bait transects. They found "the native ant fauna of the Florida Keys does not appear to be dramatically influenced by sprawl, however, if development increases, the number of non-native ants may increase, and many of these species have been documented as decreasing native ant diversity. If development plateaus, there is evidence that the native ant fauna could persist and could decrease non-native species richness through competition or predation" (Forys and Allen 2005). Accordingly, precluding or reversing the effects of disturbance may not only help to protect SITS from fire ants, but may also preclude the advent of additional non-native species and help to restore ant community composition.

At CLNWR, the Service acquires in-holdings, restores and protects habitat from disturbances that may facilitate fire ants, and treats 9 miles of County Road 905 twice per year using long-lasting broadcast baits (Service 2006b). The Service plans to expand effectiveness monitoring and control efforts to

the Port Bougainville, Keystone/Whiskey Bottle area, county auto salvage, and Nike missile sites, as appropriate.

Overall, the magnitude and imminence of predation threats due to fire ants appears to remain moderate.

Other known invertebrate predators of *Orthalicus* in Florida include the rosy wolf snail (*Euglandina rosea*) and click beetle (*Aleus* sp.) larva (Voss 1976, Deisler 1987, Forys et al. 2001a). Forys et al. (2001a) asserted that, unlike fire ants, these other invertebrate predators are not known to increase in fragmented or disturbed habitats. Voss (1976) indicated that certain crabs may prey on Florida tree snails. Deisler (1987) outlined a variety of additional, potential invertebrate predators and parasites of *Orthalicus*. The imminence and magnitudes of threats from these predators remains unknown. None of these predators are known to be a substantial threat to SITS at present.

Green iguanas (*Iguana iguana*) are among the most popular reptiles in the pet trade and comprise a major portion of imports. By the 1960s, they became established as part of the non-native fauna of southern Florida (Townsend et al. 2003). Green iguanas may occur at high densities; greater than 242 individuals per square mile (627 per square km) were found at a Bill Baggs Cape Florida State Park on Key Biscayne in 2003 (Smith et al. 2007). The extent to which SITS may have capacities to resist predation by green iguanas is unknown. At Bill Baggs Cape Florida State Park, the stomachs of two green iguana (out of 18 assessed) were found to contain lined tree snails (*Drymaeus multilineatus*) (Townsend et al. 2005). Like *Orthalicus* and *Liguus*, *Drymaeus* snails are members of the Family Bulimulidae. The stomach of one iguana (a juvenile) contained 12 individual snails, indicating that predation occurred as opposed to incidental consumption (Townsend et al. 2005). Townsend et al. (2005) stated that "The large and rapidly growing *I. iguana* populations in southern Florida may have the potential to devastate some highly localized native species of tree snails" (*Orthalicus* and *Liguus*). Iguana populations throughout the range of SITS and other *Orthalicus* constitute a potential new threat, and the magnitude is moderate. The imminence of this threat is unknown.

Opossums (*Didelphis virginiana*) and raccoons (*Procyon lotor*) prey upon both *Orthalicus* and *Liguus* snails (Voss 1976, Deisler 1987). Deisler (1987) noted that the opossum "is more numerous in the mainland range of *Orthalicus* than in the Keys," but added that they have been reported from Key Largo, Key Vaca, Big Pine Key, and Key West. Throughout 2008, opossum presence has been observed and reported with increasing prevalence on Big Pine Key (P. Hughes, Service, personal observation, 2008). They now appear to be widespread and relatively abundant on Big Pine Key. Opossums frequently exhibit opportunistic foraging and diverse, omnivorous diets

(McManus 1974), which include terrestrial snails in various portions of North America (Sandidge 1953, Hopkins and Forbes 1980). Opossums may constitute a predation threat to SITS on No Name Key and elsewhere within the range, depending on the distribution of habitats and interacting species. Raccoons, particularly where overabundant due to anthropogenic and/or natural influences, similarly constitute a potential threat.

Black rats (*Rattus rattus*), Norwegian rats (*R. norvegicus*), grey squirrels (*Sciurus carolinensis*), and birds are reported predators of *Orthalicus* and *Liguus* tree snails in portions of the respective ranges (Deisler 1987). We have no additional information on these potential threats to SITS.

d. Inadequacy of existing regulatory mechanisms: On August 25, 1994, the United States District Court for the Southern District of Florida directed the Federal Emergency Management Agency (FEMA) to consult with the Service to determine whether implementation of the National Flood Insurance Program in Monroe County was likely to jeopardize the continued existence of federally listed species (Case No. 90-10037-CIV-MOORE). In 2003, the Service issued a jeopardy biological opinion with reasonable and prudent alternatives that required Monroe County to consult with the Service before issuing building permits in suitable habitat for listed species. Thus, in recent years, the Service provided technical assistance on pertinent projects (virtually all building applications on private parcels throughout the range of SITS, excluding Coastal Barrier Resource Act zones). On September 9, 2005, the Court ordered an injunction against FEMA issuing flood insurance on any new developments in suitable habitat of federally listed species, and required the Service to submit a revised biological opinion within nine months (deadline later extended to August 9, 2006). Because the Court ruled that the 2003 reasonable and prudent alternatives were invalid, Monroe County was no longer required to consult with the Service before issuing building permits in suitable habitat, and the Service suspended technical assistance on building permit applications.

The Service finalized its reanalysis of the National Flood Insurance Program in Monroe County and provided a biological opinion to the Court on August 8, 2006 (Service 2006a). The biological opinion provides a revised strategy for implementing regulatory actions pertaining to threatened and endangered species. This strategy includes clarification of FEMA's oversight role and a more comprehensive strategy of evaluating potential impacts. The latter incorporates a lot-by-lot assessment of potential impacts that takes into account the limitations on development imposed by Monroe County's ROGO. In the biological opinion, the Service concluded that continued administration of the National Flood Insurance Program in Monroe County was not likely to jeopardize the continued existence of the SITS. The Court has not made a determination on whether to accept the biological opinion and whether to lift the prohibition on FEMA's issuance of flood insurance in Monroe County.

The Service's (2006a) assessment of FEMA's proposed action indicated there were approximately 3,321 ha (8,327 acres) of hardwood hammock (potential SITS habitat) throughout the Keys. Approximately 72 percent were in public ownership, significantly more than was the case in 1996 (Service 2006a). The remainder occurs on 3,825 parcels in private ownership that are susceptible to development and may be affected by the action. A portion of the lots may not accurately represent suitable habitat due to isolation, disturbance, location in well-developed subdivisions, lack of suitable plant species, and/or infestation by IEPs.

The SITS is listed by the Florida Fish and Wildlife Conservation Commission (FWC) as endangered (Chapter 68A-27, Florida Administrative Code). This legislation prohibits take, except under permit, but does not provide any direct habitat protection. Wildlife habitat is protected on FWC wildlife management and wildlife environmental areas according to Florida Administrative Code 68A-15.004.

The State of Florida has compelled the Monroe County Board of Commissioners to strengthen controls on land use since at least 1975 when the Keys were designated an Area of Critical State Concern. A critical regulatory factor is the level of service on U.S. Highway 1 as it relates to hurricane evacuation time. The County developed a ROGO that, as of March 2006, incorporated a land tier system that specifically designates areas of native habitat for listed species, including the SITS. The process made it more costly to destroy habitat and now discourages development in unfragmented habitat, steers available permit allocations to disturbed areas that are poor habitat for native fauna, and implements a land acquisition program for areas with native vegetation, including SITS habitat.

Throughout the Keys, development is subject to regulatory oversight by Monroe County (e.g., the ROGO), the State (e.g., designated an Area of Critical State Concern), and the Service (e.g., ESA consultation, presumably including continued consultation with Monroe County regarding administration of the FEMA National Flood Insurance Program). Regulatory mechanisms have significantly reduced habitat loss in the Keys, including SITS habitat. However, pressure to develop remaining residential and commercial land within the range of the SITS continues.

For scientific research on SITS, a permit is required from the Service and FWC. Although most of the range occupied by SITS occurs on State and Federal lands, which offers protection, these areas are large and open to the public. Signage prohibiting collection is largely lacking, and efforts to patrol or monitor activities are variable. Therefore, illegal collection could occur without being detected, as discussed under Factor B above.

The City of Key West Code of Ordinances (Chapter 108, Article VI), which generally deals with landscaping, provide very strict and detailed provisions regarding trees and other aspects of landscaping, including the preservation and promotion of native trees.

Currently, regulatory mechanisms provide significant protections to SITS. However, some of the potential and suitable habitat remains vulnerable to development pressure. SITS may be vulnerable to fire ants in any area where management on adjacent lands does not include fire ant control. Additionally, regulatory mechanisms have not eliminated potential threats from mosquito control (e.g., spray drift) (Factor E below). Therefore, we conclude that existing regulatory mechanisms are inadequate to fully protect SITS and its habitat.

e. Other natural or manmade factors affecting its continued existence: *Mosquito control (pesticides)*—As human activity and population size increased in south Florida, so has the control of mosquitoes such as the salt marsh mosquitoes, *Aedes sollicitans* (Walker) and *A. taeniorhynchus* (Wiedemann). To suppress mosquitoes, second-generation organophosphate (naled) and pyrethroid (permethrin) adulticides may be used year-round (particularly May to November in the Keys) by Mosquito Control Districts (Hennessey et al. 1992, Salvato 2001, Zhong 2008). Despite improved mosquito control practices, the use of adulticides applied using both aerial and ground-based methods may result in collateral effects on a variety of non-target invertebrates (Service 1999, Walker 2001), although much of the evidence is strictly correlative. Florida Keys Mosquito Control District and the Mosquito Control Division of Miami-Dade Public Works Department conduct aerial and/or ground spraying of mosquito adulticides over most of Miami-Dade and Monroe Counties. Additionally, the Ocean Reef Club (a residential and golf resort) may conduct or contract ground-based adulticide spraying within their borders. The Service currently does not have specific insecticide application records from those entities for the majority of the SITS range.

Occupied habitat on NKDR, DJKLBSP, and CLNWR are excluded from direct applications of pesticides to control mosquitoes. However, on NKDR (Big Pine Key and No Name Key) as well as DJKLBSP and CLNWR (northern Key Largo), adjacent or interspersed subdivisions are treated with both ground and aerial pesticide spraying to control mosquitoes. On northern Key Largo, residues of these adulticide applications were shown to drift onto DJKLBSP and CLNWR (Hennessey et al. 1992, Zhong 2008). We have no new information that directly assesses impacts or a lack of impacts to SITS.

Climate change—The Intergovernmental Panel on Climate Change (IPCC) reports that the warming of the world's climate system is unequivocal, based on documented increases in global average air and ocean temperatures,

unprecedented melting of snow and ice, and rising average sea level (IPCC 2007). IPCC (2008) found that rising sea level is consistent with warming. They emphasized that it is very likely that anthropogenic forces contributed to sea-level rise during the latter half of the 20th century, but indicate that "the observational uncertainties, combined with a lack of suitable studies, mean that it is difficult to quantify the anthropogenic contribution."

The long-term record at Key West shows that sea level rose on average 0.224 centimeters (cm) (0.088 inches) annually between 1913 and 2006. This equates to approximately 22.4 cm (8.76 inches) over the last 100 years (National Oceanographic and Atmospheric Administration 2008). Sea-level rise in the 20th century has been shown to affect conversions of upland communities (i.e., hardwood hammock, pine rockland) with low soil and moisture salinities to communities comprised of more salt tolerant plant species and higher soil and groundwater salinities in the Keys (Ross et al. 1994). This phenomenon may result in loss of suitable SITS habitat. Over time, the ultimate effect of sea-level rise may be total inundation in some areas. The general effects of sea-level rise within the range of the SITS will depend upon the rate of rise and landform topography. However, the specific effects across the landscape will be affected by complex interactions among geomorphology, tides, and fluctuations in energy and matter. These effects have yet to be simulated and projected for the range of the SITS. Sea-level rise enhances the potential impacts of salt-water storm surges associated with hurricanes. Storm surges may directly flood SITS eggs and neonates that are at or near ground level, as well as alter salinity levels and plant composition over longer time-frames. Storm surges associated with Hurricane Andrew influenced the distribution of leaf litter and storm debris on Elliott Key and other areas within the SITS range (Loope et al. 1994). Data on the long-term effects of storm surges are not available. The magnitude of this threat is potentially very high, but imminence is low.

Hurricane winds—Hurricanes may impact SITS populations and habitat due to high wind velocities. Detachment of tree branches and tree falls due to wind may result in SITS mortalities (Forys et al. 2001a). In August 1992, Hurricane Andrew impacted extreme south Florida. Winds associated with Hurricane Andrew downed approximately 20 to 30 percent of large trees, and sheared large branches off almost all large trees in hardwood hammocks on Elliott Key (Loope et al. 1994). The woody structure of smaller trees was impacted less radically. However, for trees of all sizes, "… defoliation was virtually complete, even near ground level" (Loope et al. 1994). Hurricane Andrew provided some of the impetus to conduct a SITS captive propagation that was unsuccessful (Service 1999). In contrast, post-hurricane responses by SITS populations were not studied *in situ*. According to the National Oceanographic and Atmospheric Administration, Miami-Dade County, the Keys, and western Cuba are the most storm-prone areas in the Caribbean so this threat is expected to continue. Depending on the location and intensity of

catastrophic winds, it is possible that SITS populations could be extirpated. Accordingly, we consider the magnitude and imminence of this threat to be moderate.

The magnitude of threats from stochastic events such as hurricanes is exacerbated by small population sizes and the limited range of SITS. Given these factors, catastrophic loss of adults (arboreal) or eggs and neonates (terrestrial) is a potential threat of high magnitude. Because catastrophic events affect further reductions in abundance over time, they increase the probability that detrimental impacts may subsequently arise due to demographic or genetic stochasticity, or from additional, adverse environmental conditions. For example, Emmel and Daniels (2005) reported that drought conditions prevailed from 1998 through 2002. Natural fluctuations in rainfall, forage volume, or predation may weaken a population to such an extent that recovery to a viable level would be impossible.

Right-of-way maintenance—The Florida Keys Electric Cooperative Association, Inc. (FKECA) and Monroe County regularly conduct vegetation maintenance activities along power line and road rights-of-way in SITS-occupied habitat along Card Sound Road and elsewhere in Key Largo. This results in habitat loss and injury and death to individual SITS. FKECA has routinely searched for affected SITS and placed them into adjacent unimpacted portions of the occupied hammocks. FKECA (2004) reported that other crews failed to take similar measures in 2004. The magnitude of this threat appears to be low, and the imminence is high.

Key deer (Odocoileus virginianus clavium) browsing—Plant community alteration associated with excessive browsing by locally abundant Key deer is a concern on No Name Key. Barrett et al. (2006) compared baseline vegetation data from the 1990s (Folk 1992) to data collected in 2002 within NKDR and found pronounced browsing impacts in mangrove, buttonwood, and hardwood hammock communities on keys where deer densities have been relatively high (Big Pine Key, No Name Key, Big Munson Key). Because deer are selective browsers, densities of preferred plant species decreased and non-preferred plant species increased on islands with high deer density. Many highly preferred species present in the hardwood hammock understory in the 1990s were virtually absent in 2002. These results indicate that, within a 12-year period, heavy deer herbivory in the understory can influence mid-story composition (Barrett et al. 2006). More generally, available information (Wilmers 1995, Barrett et al. 2006) suggests that, within areas of high deer density, browsing has already driven some plant communities to alternate (i.e., overbrowsed) states (Hobbs 1996, Côté et al. 2004, Wisdom et al. 2006).

Without intervention, such conditions can result in altered species richness in canopy trees (Hobbs 1996, Côté et al. 2004). Replacement of canopy trees by seedlings will be precluded by continued browsing, at least for preferred

browse species, which will result in long-term alterations to canopy composition and structure. Specific long-term effects on community dynamics in affected areas are difficult to predict. However, the relative abundance of preferred and non-preferred browse species will continue to change (Barrett et al. 2006). How these phenomena relate to SITS habitat relationships and trends in stand structure and composition important to SITS have not been assessed. However, they will likely alter SITS habitat conditions over the medium- and long-term. Overbrowsing by deer is currently a threat of low magnitude and imminence.

D. Synthesis

The predominant threat described at the time SITS was listed was habitat destruction. Additional threats include: non-native predators, inadequacy of existing regulatory mechanisms, climate change, hurricane winds, right-of-way maintenance, Key deer browsing, and IEPs. None of these threats has been eliminated, although many have been reduced. Threats relating to climate change and predation have increased. Associated with climate change is sea-level rise and enhanced impacts due to storm surges. These factors not only serve to alter plant communities over different time-frames, but may increase the probability that entire cohorts of young SITS are eliminated due to catastrophic storm surges. The threat of sea-level rise is potentially very high, but effects have yet to be simulated and projected for the range of the SITS. Hurricane winds pose additional risks. Relatively recent or expanded predatory threats potentially include green iguanas and opossums. Threats from fire ants persist. IEPs are largely controlled and do not appear to be an imminent threat. Poaching and mosquito control practices remain as potential threats.

Due to translocations, SITS are now roughly as widespread as any time in the past. Additionally, a substantial portion of SITS populations occur on public lands managed for conservation purposes. Threats of habitat destruction due to human population growth and associated development have been significantly reduced. In addition to acquisition efforts, regulatory mechanisms have provided for substantial reductions in the rate of habitat loss. However, detrimental habitat impacts associated with earlier development, including fragmentation and proliferation of fire ants (and likely other predators), persists over much of the historic range. Significant areas of suitable and occupied habitat remain vulnerable to development pressure. Vegetation clearing along utility corridors results in localized threats, but requires further investigation to determine the full extent of impact on SITS. In addition to remaining threats, none of the four recovery criteria for delisting have been fully met. Therefore, SITS continues to meet the definition of threatened.

III. RESULTS

A. Recommended Classification:

__X__ **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Expand analyses of genetic relationships between populations of *O. reses*, presumably using microsatellite markers, and confirm whether the two subspecies should be lumped taxonomically.
- Assess the current distribution and abundance of SITS and its congeners.
- Assess the status of *O. reses nesodryus*, and whether it should be listed, either due to similarity of appearance or level of imperilment.
- Assess the current distribution of fire ants and their impacts, and respond accordingly.
- Continue to establish appropriate hardwood hammock species in disturbed areas in order to increase habitat area and continuity and thwart advances by fire ants.
- Work with all right-of-way maintenance entities to ensure that best practices are implemented.
- Determine whether green iguana or opossum predation occurs and poses a threat to SITS.
- Continue to work with partners and take measures to limit or prohibit mosquito control pesticide drift on protected State and Federal lands, avoid the use of broad spectrum mosquito control pesticides in other conservation areas, and seek cooperative ways to reduce application levels throughout the remainder of the SITS range.
- Routinely obtain, monitor, and assess temporally and spatially explicit data regarding mosquito control applications throughout the SITS range.
- Further assess the habitat values and importance of particular tree species to SITS, and the land use and ecological characteristics that affect the abundance and distribution of the various trees.
- Identify and implement a viable means to obtain a representative, annual sample of SITS distribution and abundance throughout the range.
- Assess and conduct translocations of SITS within the Lower Keys. [Note: Current recovery criteria indicate that reintroductions should be undertaken in the Lower Keys, and requires the assumption that the Lower Keys are the only place to achieve recovery for SITS. This assumption should be assessed and the recovery criteria revised accordingly.]

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of STOCK ISLAND TREE SNAIL

Current Classification: Threatened
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__X__ **No change is needed**

Appropriate Listing/Reclassification Priority Number, if applicable _____

Review Conducted By: Phillip Hughes

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 2/20/09

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 9-11-09

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

Appendix A. Summary of peer review for the 5-year review of Stock Island tree snail (*Orthalicus reses* (not incl. *nesodryas*))

A. Peer Review Method: The Service conducted peer review. Recommendations for peer reviewers were solicited from Florida Fish and Wildlife Conservation Commission, The Nature Conservancy, and Monroe County. Additionally, peer reviewers were selected by the Service. Three peer reviewers were asked to participate in this review. Individual responses were requested and received from all three.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: Two reviewers specifically noted that the information presented was consistent with the review's conclusions.

Two reviewers commented about the genetics information and taxonomic ramifications derived from Emmel and Perry (2004). Gene fragments totaling 1816 base pairs were sequenced in the study. One reviewer stated that the selected genes are generally polymorphic and rapidly evolving, so that 1816 base pairs should be sufficient to demonstrate a difference (between congeneric *Orthalicus* taxa) if there were differences (i.e., if the taxa were distinct). The reviewer saw the evidence as sufficient to indicate that subspecific status should not be bestowed on the taxa. The reviewer stated that instead, the taxa appear to be morphs of a single species, and stated that some additional sampling should be conducted and a "simple systematic revision should be published in a peer reviewed scientific journal". However, the reviewer noted one concern about the results of the report, specifically the very small sample sizes for each taxon. The reviewer stated that "perhaps the results of Emmel and Perry should be repeated for confirmation."

The reviewer reiterated Emmel and Perry's (2004) belief that their observations at a field site that was occupied by more than one taxon suggested that the different taxa did not interbreed despite close contact (sympatry). One reviewer noted that mating experiments have not been conducted and the genetics of banding polymorphism are not known for the *Orthalicus* taxa. The reviewer stated that: "If species identification is based on these color differences and color differences are based on potentially very few alleles how do you know the individual with the darker aperture and apex is not conspecific or perhaps even a sibling of an individual with light apex and aperture?"

D. Response to Peer Review:

Regarding the taxonomic ramifications of Emmel and Perry (2004), the Service concurs with the reviewer's conclusions that the available data indicate the taxa may not be genetically distinct. However, Emmel and Perry (2004) articulated, and the review reiterated, those same conclusions. Neither Emmel and Perry (2004), the review, nor any reviewer suggested that the results from the study alone were sufficient to publish a taxonomic revision lumping the two *Orthalicus reses* taxa. While the current subspecies designation may be in error, additional work is needed to confirm this. This assertion was already included in the review. In addition, the Service added language describing the limited sample sizes used in the study.

Regarding the sympatric snail populations, the Service concurs that relatedness among individuals within an area of sympatry, even individuals presenting color variation, cannot currently be inferred with certainty based on visual observations, for the reasons given by the reviewer. The Service added language to the review to reflect that assertion.

Guidance for Peer Reviewers of Five-Year Status Reviews

U.S. Fish and Wildlife Service, South Florida Ecological Services Office

March 27, 2009

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with U.S. Fish and Wildlife Service (Service) policy.

Peer reviewers should:

1. Review all materials provided by the Service.

2. Identify, review, and provide other relevant data apparently not used by the Service.

3. Not provide recommendations on the Endangered Species Act classification (e.g., endangered, threatened) of the species.

4. Provide written comments on:
   - Validity of any models, data, or analyses used or relied on in the review.
   - Adequacy of the data (e.g., are the data sufficient to support the biological conclusions reached). If data are inadequate, identify additional data or studies that are needed to adequately justify biological conclusions.
   - Oversights, omissions, and inconsistencies.
   - Reasonableness of judgments made from the scientific evidence.
   - Scientific uncertainties by ensuring that they are clearly identified and characterized, and that potential implications of uncertainties for the technical conclusions drawn are clear.
   - Strengths and limitation of the overall product.

5. Keep in mind the requirement that the Service must use the best available scientific data in determining the species' status. This does not mean the Service must have statistically significant data on population trends or data from all known populations.

All peer reviews and comments will be public documents and portions may be incorporated verbatim into the Service's final decision document with appropriate credit given to the author of the review.

Questions regarding this guidance, the peer review process, or other aspects of the Service's recovery planning process should be referred to Paula Halupa, Acting Endangered Species Supervisor, South Florida Ecological Services Office, at 772-562-3909, extension 257, email: Paula_Halupa@fws.gov.