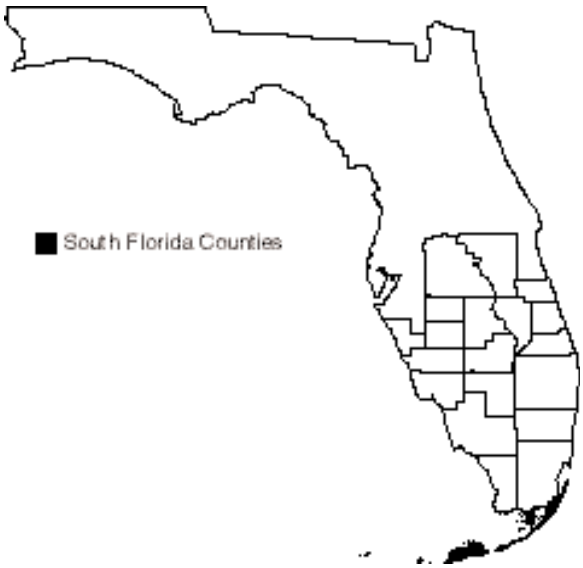
Stock Island Tree Snail

Orthalicus reses

Federal Status:	**Threatened (July 3, 1978)**
Critical Habitat:	**None Designated**
Florida Status:	**Endangered**
Recovery Plan Status:	**Revision (May 18, 1999)**
Geographic Coverage:	**Rangewide**

Figure 1. Distribution of the Stock Island tree snail; this species is endemic to only the Florida Keys portion of Monroe County.



The Stock Island tree snail *(Orthalicus reses,* not including *nesodryas)* is an arboreal snail inhabiting the hardwood hammocks of the Florida Keys. It was listed as threatened because of population declines, habitat destruction and modification, pesticide use, and over-collecting. Snail collecting in South Florida has been popular for many years, and although the Stock Island tree snail lacks the vibrance and radiance of some of the other intricately colored snails, it has not escaped intense collecting pressures. In addition, it has not escaped the pressures of destruction of its habitat due to residential and commercial construction activities. The Stock Island tree snail historically occurred on the islands of Stock Island and Key West, both from which it has been largely extirpated from its historic range. In response to the loss of habitat and decline in the number of snails on Stock Island, collectors have moved snails and introduced them to areas outside of their historic range. The few remaining populations have continued to decline as a result of further habitat loss and other threats.

This account represents a revision of the existing recovery plan for the Stock Island tree snail (FWS 1982).

Description

The Stock Island tree snail is a large, conical snail attaining approximately 45 to 55 mm in length. The external ground color is white to buff, with three poorly developed spiral bands and several flame-like purple-brown axial stripes that stop at the lower of the spiral bands (Deisler 1982). The thickness of the shell varies, but is usually more lightweight and translucent than other species of *Orthalicus* (Pilsbry 1946). The axial stripes are typically narrower than their whitish interspaces and do not fork near the upper suture. There are two to three white apical whorls. The last whorl contains two to four darker brown

growth-rest varices. The columella and parietal callus are white or faint chestnut brown. This species is distinguished from *O. r. nesodryas* by its lighter color pattern of the apical whorl, columella, and parietal callus. These characteristics are chestnut-brown or darker in *O. r. nesodryas*.

Taxonomy

The Stock Island tree snail is a subspecies of the genus *Orthalicus*, a group of large, arboreal pulmonate snails in the family Bulimulidae. *Orthalicus* occurs primarily in Central and South America. Two species occur in North America, *O. reses* and *O. floridensis* Pilsbry, both of which are restricted to South Florida. *Orthalicus reses* has two subspecies, *O. r. reses* and *O. r. nesodryas.* The Stock Island tree snail (*O. reses*) was first described by Say in 1830 based on a snail that was probably collected from Key West. That specimen was lost and the species was later described by Pilsbry (1946) using a snail collected from Stock Island.

Distribution

Pilsbry (1946) suggested the Stock Island tree snail arrived in Florida from Central America and the Caribbean shortly after the emergence of the Florida peninsula in the late Pleistocene. Snails that were sealed to floating tropical trees may have been cast ashore on the Florida peninsula by high winds and hurricanes. This form of dispersal has been suggested for both *Orthalicus* and *Liguus*, but the exact origin of these species is still in question. Craig (1972) suggested populations of *Orthalicus* arrived directly across the Gulf of Mexico from Central America, but the mode of transportation and whether dispersal occurred on a single or multiple occasions was not known. No one knows when the Stock Island tree snail arrived in the Lower Keys.

Historically, the Stock Island tree snail was believed to have a very limited distribution, being found only in tropical hardwood hammocks on Stock Island and Key West; although it may have been found in other hammock areas in the Lower Keys. Their distribution has since been artificially extended by collectors who have introduced them to Key Largo and the southernmost parts of the mainland. *Orthalicus reses nesodryas* has a broader range, distributed throughout the Keys from Sugarloaf Key north. *Orthalicus floridensis* is the only *Orthalicus* species to occur naturally on the mainland, and is also found in the Keys.

Habitat

Originally, the Stock Island tree snail occurred exclusively in hardwood hammocks of the Keys. The Stock Island tree snail survives best in hammocks with smooth-barked native trees that support relatively large amounts of lichens and algae. In the Keys, *Orthalicus* is limited to the higher portions of the islands that support hammock forests (minimum elevations of 5 to 11 feet).

Stock Island tree snail.
Original photograph by Beth Forys.

Lower Keys hammocks consist of thick forests of tropical trees and shrubs which grow in limestone, marl, and calcareous sand soils. Canopy trees include black ironwood (*Krugiodendron ferreum*), gumbo limbo (*Bursera simaruba*) Jamaican dogwood (*Piscidia piscipula*), mahogany (*Swietenia mahagoni*), pigeon plum (*Coccoloba diversifolia*), poisonwood (*Metopium toxiferum*), and strangler fig (*Ficus aurea*). Hammock understory contains torchwood (*Amyris elemifera*), milkbark (*Drypetes diversifolia*), wild coffee (*Psychotria nervosa*), marlberry (*Ardisia escallonioides*), stoppers (*Eugenia* sp.), soldierwood (*Colubrina elliptica*), crabwood (*Gymnanthes lucida*), and velvetseed (*Guettarda scabra*).

Larger trees are more likely to support more Stock Island tree snails than smaller trees probably because they provide the snails with an increased surface area for foraging (Deisler 1987). It is not known if Stock Island tree snails prefer certain tree types or species (Deisler 1987); however, Voss (1976) suggested tree snails generally prefer trees with smooth bark over trees with rough bark, because it would require less energy to crawl over smooth bark. Voss also believed Stock Island tree snails would prefer smooth bark because it would make it easier for them to form a secure mucous seal when they were aestivating, resulting in lower mortalities from dehydration or accidental dislodgement.

Stock Island tree snails are entirely arboreal except when they move to the forest floor for nesting or traveling. Hammocks that contain well-developed soils or leaf litter are important for nesting activity and dispersal. Essential factors affecting food availability are the light intensity and moisture content of the hammock habitat.

No data are available on minimal hammock size needed to support a viable population of tree snails. Suitable habitat would have to include an area large

enough to provide for foraging and nesting requirements, as well as provide for the microclimate (air temperature and humidity) needed by the Stock Island tree snail. Preferences for edge or interior hammock have been observed in *Liguus* populations on Lignumvitae Key (Tuskes 1981). Age-class differences were seen where older individuals were found in the central mature hammock, while younger individuals were found more often along the edges of the hammock. Tuskes (1981) suggested this may be an adaptation of younger snails to move to the edge to escape competition from older snails. It is not known whether Stock Island tree snails prefer interior or edge hammock areas. Recent surveys of snails in Key Largo populations have shown higher numbers of snails along the edge of the hammock than in the interior, but this result may be affected by the differences in visibility during surveying.

Behavior

Stock Island tree snails are active mainly during the May through November wet season when breeding, feeding, and dispersion takes place. Dry periods (December through April) are spent in aestivation, in which the snail forms a tight sealed barrier between the aperture and a tree trunk or branch. Snails secrete a mucus seal that cements their shell to a tree to protect them from desiccation in the dry period. Snails may come out of aestivation briefly to feed during dry-season rains or go into aestivation during summer dry spells.

Reproduction

Stock Island tree snails are hermaphroditic and cross-fertilization is common. *Liguus* individuals are able to locate each other by following mucus trails (Voss 1976), and Stock Island tree snails likely do the same. They mate and nest in late summer and early fall during the wettest part of the rainy season. They lay approximately 15 eggs per clutch in a cavity that is dug into the soil humus layer, usually at the base of a tree, and take anywhere from 24 to 105 hours to deposit their eggs (Deisler 1987, McNeese 1989). The presence of this humus layer is essential for egg laying. The eggs hatch during the onset of the rains the following spring. Upon hatching the snails immediately proceed to climb adjacent trees. Most nesting snails appear to be approximately 2 to 3 years old and are estimated to live for up to 6 years, with 2.11 years being the mean age for the Stock Island population at the time of Deisler's study (1987). Tree snail age can be estimated by counting the number of dark "suture-like" lines resulting from pigment deposition during long dry spells (the dry season).

Foraging

The rate at which Stock Island tree snails grow is dependent upon the availability of food and how quickly their food is replenished after being grazed. Food regrowth is affected by the light intensity and moisture (canopy density and climate) of the hammock habitat. They feed on epiphytic growth on hardwood tree trunks, branches, and leaves. Little is known about the feeding habits or food preferences of the Stock Island tree snail. Probable food

items include a variety of fungi, algae, and lichens found on many of the native hammock trees. Mixobacteria and some small mites may serve as a secondary food source. Feeding can occur anytime during the day or night with peak feeding activity occurring from late afternoon through the night to mid-morning and during or immediately after rainfall. Stock Island tree snails often follow a random twisting path that covers the entire bark surface, but will move in a straight line if surface moisture is abundant.

Relationship to Other Species

There are two other species of *Orthalicus* in the Florida Keys: *O. floridensis* and *O. reses nesodryas*. *O. floridensis*, the Florida tree snail, is the most widespread of the *Orthalicus* and has occurred historically throughout the Keys. *Orthalicus reses nesodryas* also apparently occurs throughout the Keys, being seen most often in the Lower and Middle Keys, from Sugarloaf Key north.

It is generally thought that the two subspecies of *O. reses* do not interbreed due to differences in their anatomy (Pilsbry 1946, FWS 1982, 1996). As discussed below, individuals of *O. reses* have been introduced to other areas of the Keys and the mainland, including areas where the other species of *Orthalicus* and *Liguus* are present.

Historically, the Stock Island tree snail did not have overlapping ranges with any of the current federally listed species. Due to their introduction into other habitats, Stock Island tree snails now share habitat with other listed species. Some snails have been introduced into habitat on Key Largo that contains several other federally protected species, including the eastern indigo snake (*Drymarchon corais couperi*), Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*), Key Largo woodrat (*Neotoma floridana smalli),* and Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*). Snail populations that have been introduced into the Lower Keys now share habitat with the Key deer (*Odocoileus virginianus clavium*).

The effect of the introduction of snails to these habitats is believed to be minimal, but it is essential to monitor any potential changes in the flora and faunal composition as it relates to the presence of the Stock Island tree snail. The Stock Island tree snail now occurs in the native range of *O. r. nesodryas* and *O. floridensis*. The relationship between these species needs to be examined.

Status and Trends

The Stock Island tree snail was listed as threatened by the FWS on July 3, 1978 (43FR 28932) because of population decline, habitat destruction and modification, pesticide use, and over-collecting (FWS 1982). The Stock Island tree snail has, for the most part, been extirpated from its historic range due to a number of factors including habitat destruction, pesticide use, over-collecting, and predation by fire ants and black rats. Most of the hardwood hammocks that could serve as suitable habitat for the snail on Stock Island and Key West have been destroyed or severely altered by past human activities. Remnants of hammock that remain on these Keys tend to be small in size and

low in quality due to disturbance, making them unsuitable for the tree snail.

As a result of unauthorized introduction efforts, the Stock Island tree snail presently occupies six areas outside its historic range. Sites at John Pennekamp Coral Reef State Park, Key Largo Hammock State Botanical Site, and the Everglades NP/Big Cypress Preserve area are publicly owned; however, the other three areas, located in south Key Largo subdivisions, Calusa Cove Camp Ground, and Monkey Jungle, are in private ownership and subject to human disturbance.

Status of Sites within Historic Range

Until surveys conducted in 1996, the Stock Island tree snail was not thought to occur within its historic range. The tree snail has been extirpated from Stock Island (McNeese 1997); but in 1996, snail populations were discovered in Key West.

Florida's population growth has been almost exponential since the late 1800s. In 1940, there were 12,927 people in Key West, constituting 95 percent of the population in Monroe County. By 1950, the population increased to 26,433, comprising over 90 percent of the Monroe County population. The population began to level off in the 1960s with only 71 percent of the population residing in Key West and only 52 percent (27,563) in 1970 (Simpson 1983). By this time, the hammock forests in Key West had been eliminated and there was no snail habitat remaining.

Museum collections have no records of Key West specimens beyond 1938 and Pilsbry (1946) concluded that the snail was extinct from Key West. Although two snails were transplanted into Indigenous Park in Key West in 1989, they have not been found since that time. Until 1996, other surveys confirmed a lack of sightings in Key West.

The population discovered in Key West in 1997 was located in a residential subdivision, along a small street near the center of Key West. Over 65 snails were counted in two large royal poinciana trees (*Delonix regia*) and approximately 30 were found on other vegetation including *Aralia* bushes and mango trees. Most of the snails were one to two years old. The fate of these snails is not certain because the trees are frequently trimmed by the City of Key West and there are reports of heavy collecting. The FWS is coordinating with the City of Key West to help establish management procedures to protect these snails.

The Stock Island tree snail population on Stock Island exhibited a rapid decline. Initial surveys in 1982 revealed between 214 to 321 individuals. This number rapidly decreased each year to the point where no snails exist on Stock Island today (McNeese 1997). The decline is related to the loss of habitat due to construction activities associated with the construction of the Key West Golf Course and the use of various pesticides and herbicides in the area. However, the Key West Botanical Gardens on Stock Island may provide adequate habitat for small numbers of tree snails and could serve as a re-introduction site with proper management.

Status of Occupied Sites Outside of Historic Range

Populations of Stock Island tree snails were established at six locations outside of the historical range. All areas were known to support Stock Island tree snails in the recent past; however, surveys conducted by FWS and GFC biologists in 1995 and 1996 revealed either a decline in populations or no observation of

live snails. More intensive surveys are required to obtain reliable population trend and status data.

John Pennekamp Coral Reef State Park, Key Largo: Approximately 33 snails were placed here in 1993. By 1995, no snails were found. About three snails were released here in 1996, but surveys conducted shortly after that revealed no snails. The absence of snails suggests inability to adapt to the habitat, interference (*e.g*., relocating, collecting) from snail collectors, or simply dispersion. The status of this population is considered to be declining, and possibly extirpated.

Key Largo Subdivisions, Key Largo: Due to the declining population of snails on Stock Island, collectors moved an unknown number of snails to several single family lots in various Key Largo subdivisions. In one known subdivision, several lots have snails present. In December 1995, one densely populated lot was cleared. Direct snail destruction and habitat removal resulted. The adjoining lot is also being planned for clearing. A FWS survey conducted in August 1996 on this lot revealed 72 snails present. Most of these snails were young (1 to 2 years old). A different lot in the same area contains over 50 snails, most of which are older snails (5+ years old). Although other lots have not been surveyed, snails may be present. The snails in these subdivisions face imminent threats from habitat destruction, illegal collecting, biocides, and mosquito spraying. The FWS is working with Monroe County to alleviate some of these threats. Additional surveys are necessary, but the status of the snails in this area is considered to be declining.

Crocodile Lake NWR/Key Largo Hammocks State Botanical Site, Key Largo: Several snails have been observed on both the Refuge and the State Botanical Site. Their presence is due to collectors moving them. Because thorough surveys have not been conducted, the status of these snails is unknown.

Calusa Cove Campground, Key Largo: Snails were introduced here by collectors because of the large amount of undisturbed suitable habitat. In past years, this area contained the largest population of snails. Surveys conducted in 1994 and 1995 showed a drastic reduction of live snails, and several dead shells at the base of trees. A brief survey in 1996 reported a few live snails and a few snail shells, but detailed surveys have not been conducted. Monitoring of this population is necessary to track changes in their status. This property is privately owned and currently listed on the Conservation and Recreation Lands list as a priority for purchase. Because surveys have reported a decrease in the number of snails, this population is considered to be declining.

Monkey Jungle, Miami: Monkey Jungle is managed as a tourist facility and the owner has no current plans to modify any of the hardwood habitat occupied by tree snails. However, ownership and/or management plans could change at any time. Although snails are known to occur here, the date of their introduction is not known. The habitat is very sparse, consisting of only a few small tree islands surrounded by asphalt, and the quality of the habitat is low. Researchers from the University of Florida surveyed this site in February 1992 and collected approximately 460 individuals for captive propagation experiments. Of those, only 200 survived, several of which were released in 1993 at Monkey Jungle. Between 180 to 195 eggs were hatched in 1993 at the

University of Florida's laboratory, but the majority of them died. Approximately five of those were still alive in 1996, four of which were released by researchers on John Pennekamp Coral Reef State Park property. Follow-up monitoring was not conducted, so the fate of those snails is unknown. The one remaining snail was released with other Stock Island tree snails by the FWS on public property and is currently being monitored. Although the Monkey Jungle habitat suffered considerable disturbance in 1992 from Hurricane Andrew, the snail population rebounded and continues to persist today. Surveys conducted in 1996 found at least 35 snails present at Monkey Jungle. The combined threat of free roaming monkeys and the disturbance of habitat by exotic vegetation is believed to be partially responsible for the continued decline in the status of these snails.

Everglades National Park (ENP) and Big Cypress Preserve: Snails were first introduced by collectors to a small area in ENP in the late 1980s. Between 1987 to 1994, the presence of snails was reported, but by 1995, surveys revealed the snails were no longer present. The disappearance of the snails from ENP may be due to a number of causes including over-collecting, hurricanes, exotics, competition, or inability to adapt to the surroundings. A population of snails has recently been reported in Big Cypress, but surveys are necessary to confirm this. The status of the populations in ENP and Big Cypress is considered to be declining or extirpated.

Since the Stock Island tree snail's original listing as a threatened species in 1978, its populations and its habitat have drastically declined. Snails once found on Stock Island, formerly the largest and most stable population, are now extinct. According to the definitions of the ESA, this species now qualifies for reclassification as an endangered species-"any species which is in danger of extinction throughout all or a significant portion of its range." If it were not for the population recently found in Key West, which is presumably a direct transplantation from Stock Island, the snail would be considered extinct from its entire historic range. The stability and protection of those populations outside of its historic range are extremely important and will be necessary for the persistence of this species.

Threats

The greatest threat to the Stock Island tree snail is the loss and modification of its habitat, although natural disasters, such as hurricanes and drought, can have a significant effect. Increased urbanization in the Keys has led to the destruction, fragmentation, and reduction in quality of habitat throughout the historic and present range. Because of its limited range, the Stock Island tree snail faces a high risk of extinction from habitat loss or a single, natural disaster.

Other threats include habitat loss, pesticide use, collecting, and predation by black rats, birds, raccoons, and fire ants (*Solenopsis invicta*). Fire ants are becoming more abundant in the Keys and hence an increasing threat to the Stock Island tree snail as well as other species. Tuskes (1981) observed fire ants killing *Liguus* snails, despite the snails' ability to ward off other ant species. Residential and commercial construction destroys habitat important to the tree snail. The areas that currently harbor populations of tree snails are small isolated tracts of land,

which makes highly susceptible to the snails threats of habitat loss, fragmentation, and reduction in quality. Destruction of habitat reduces reproduction by disrupting hammock soils and leaf litter used as nest areas. Habitat fragmentation may destroy the microclimate (air temperature and humidity) important for feeding, shelter, and reproduction.

The use of pesticides on or near snail habitat can kill snails directly or alter behavior associated with feeding and reproduction. These effects decrease the likelihood of survival and recovery of the Stock Island tree snail in the wild. Urbanization within or near snail habitat promotes the establishment of black rats and fire ants that feed on snails.

Management

Efforts to manage the Stock Island tree snail have been complicated by two problems. First, since Deisler's 1987 study, little or no information has been collected or published about the life history of the Stock Island tree snail. What little information does exist is found in letters, memos, unreleased or incomplete data from researchers, and through conversations and speculations. Second, although the status of a few snail populations has been monitored over the years, the most difficult thing to monitor is how snail collectors and other parties have been moving this species to areas within and outside of its range. Although the relocation of snails to other areas may have protected the snails from extinction, it has complicated the management and protection of this species.

Relatively few section 7 consultations have been conducted for the Stock Island tree snail. In 1980, a Biological Opinion was completed that addressed Farmers Home Administration (FmHA) financing of the Florida Keys Aqueduct Authority (FKAA) pipeline improvements in the Keys. After reviewing effects of the FKAA pipeline, the FWS concluded the proposed action was likely to jeopardize the continued existence of the Stock Island tree snail, American crocodile, Key deer, and Schaus swallowtail butterfly. This opinion was based on the likelihood that pipeline improvements would result in a loss of habitat and an increase in human disturbance that would be detrimental to the mentioned species. As an alternative, the FmHA chose to exclude certain areas from water delivery. These loan conditions were subsequently accepted by the FKAA.

In September of 1998, the FWS provided funding to the Florida Audubon Society and the Key West Garden Club to restore tropical hardwood hammock and freshwater wetlands at the Key West Botanical Gardens on Stock Island. The project will occur on a 3-acre site and includes the removal of exotic vegetation, planting of native species, and relocation of snails from other populations back to the Gardens.

There have been several cases of alleged section 9 "take" violations in Key Largo. Both Federal and State Wildlife Officers are currently investigating these incidents. Management efforts are also in progress to coordinate more efficiently with Monroe County and the city of Key West. The FWS will be developing species information, digital maps, and conservation recommendations to help provide better protection for the snail.

In 1992, researchers from the University of Florida removed the last

known remaining snails from Stock Island and began an attempt to maintain and breed snails in captivity (Emmel *et al*. 1992). The first few months of the captive propagation efforts appeared to be successful, with the snails showing signs of foraging and possible mating. Additional snails (>400) were removed from Monkey Jungle and brought into captivity, but approximately half of these snails died and the other half had to be released. Several other remaining captive snails also died. By 1996, only five to six snails were alive in captivity, all of which were returned to the wild. The cause of the unsuccessful effort to captively maintain and breed this species is not known, but it is attributed to the inability to imitate natural hammock conditions in the laboratory. Based on the inability to breed tree snails, the recovery team recommended stopping all captive propagation efforts and instead, focusing on protecting remaining living wild populations. Prior to additional propagation efforts, the recovery team recommended developing a plan that outlines specific criteria for propagating this species in captivity. Future propagation efforts should be done *in situ* in order to retain the conditions of the natural habitat (FWS 1996).

Craig, A.K. 1972. Observations on the arboreal snail *Orthalicus floridensis*. Quarterly

Literature Cited

Journal of the Florida Academy of Sciences 35(1): 15-20.

Deisler, J.E. 1987. The ecology of the Stock Island tree snail, *Orthalicus reses reses* (Say). Bulletin Florida State Museum Biological Science 31(3): 107-145.

Deisler J.E. 1982. The Stock Island tree snail *Orthalicus reses reses* (Say). Pages 8-9 *in* R. Franz, ed. Rare and endangered biota of Florida, volume 6, invertebrates. University Press of Florida; Gainesville, Florida.

Emmel, T.C., P.J. Eliazar and D.L. Freberg. 1992. Captive propagation and restoration ecology of the endangered Stock Island tree snail, Quarterly Project Report. U.S. Fish and Wildlife Service, Unit Cooperative Agreement #14-16-0009-1544, Research Work Order #94; Gainesville, Florida.

McNeese, P.L. 1989. A proposal for the study of the Stock Island tree snail, *Orthalicus reses reses*, at its type locality. Monroe County Environmental Resources Department; Marathon, Florida.

McNeese, P.L. 1997. Survey of Key West and Stock Island for the Stock Island tree snail *Orthalicus reses reses.* Monroe County Environmental Resources Department; Marathon, Florida.

Pilsbry, H.A. 1946. Land Mollusca of North America (north of Mexico). Monograph Academy of Natural Science, Philadelphia 3[2(1)]: 1-520.

Simpson, L. 1983. The Island of Key Largo, Florida. Mayfield Printing Company; Mayfield, Kentucky.

Tuskes, P.M. 1981. Population structure and biology of *Liguus* tree snails on Lignumvitae Key, Florida. Nautilus 95(4): 162-169.

U.S. Fish and Wildlife Service [FWS]. 1996. Multispecies Recovery Team/Keys Group meeting, April 1996.

U.S. Fish and Wildlife Service [FWS]. 1982. Stock Island tree snail recovery plan. U.S. Fish and Wildlife Service; Atlanta, Georgia.

Voss, R.S. 1976. Observations on the ecology of the Florida tree snail *Liguus fasciatus* (Muller). Nautilus 90: 65-69.

Recovery for the Stock Island Tree Snail

Orthalicus reses

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

Recovery Criteria

Surveys conducted over the past 3 years indicate the Stock Island tree snail is threatened with extinction due to a loss of more than 90 percent of its habitat to urbanization and other anthropogenic factors such as over collecting and pesticide use. The objective of this recovery plan is to delist the Stock Island tree snail by protecting and managing its habitat in the Lower Keys, restoring potential habitat, increasing the size of populations, and establishing populations in the Lower Keys. This objective will be achieved when: further loss, fragmentation, or degradation of suitable, occupied habitat in the Lower Keys has been prevented; occupied habitat on priority acquisition lists for the Lower Keys is protected either through land acquisition or cooperative agreements; potential habitat on these protected lands is managed, restored, or rehabilitated to provide habitat for the Stock Island tree snail; four stable populations of the Stock Island tree snail 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.

Species-level Recovery Actions

S1. **Determine the distribution and status of the Stock Island tree snail.** The distribution of the Stock Island tree snail has changed due to relocation activity by snail collectors. Past investigations have consisted of presence/absence surveys and thorough surveys are still needed. Conduct detailed surveys to determine the distribution and status of the Stock Island tree snail.

S1.1. **Survey snail populations in the Lower Keys.** Snails have been observed in several areas in the Lower Keys. Survey these areas to determine their status.

S1.1.1. **Determine status of snails on Stock Island.** The snail population on Stock Island has decreased dramatically since the 1980s and is now considered possibly extirpated. Conduct thorough surveys of Stock Island to determine if snails are present.

S1.1.2. **Determine status of populations in Key West.** In 1996, populations of snails were discovered in the City of Key West. Survey other areas in Key West to determine if snails are present.

S1.2. Survey snail populations in the Middle and Upper Keys.

S1.2.1. Determine the status of snails in Key Largo subdivisions and other areas in Key Largo. Several of the Key Largo subdivisions contain populations of snails, but this area has not been thoroughly surveyed. Survey other suitable areas within these subdivisions and throughout Key Largo.

S1.2.2. Determine status of snails present in Calusa Cove. Since 1994 there has been a reduction of the number of snails here. Survey this area to determine the status of snails.

S1.2.3. Determine status of snails in John Pennekamp Coral Reef State Park. Determine the status of snails that were placed here in 1993, 1994, and 1996.

S1.2.4. Determine status of snails in Crocodile Lake NWR/Key Largo Hammocks State Botanical Site, Key Largo. Several snails have been observed on both the Refuge and the State Botanical Site. Survey these areas to determine their status.

S1.3. Determine status of snails on mainland Florida.

S1.3.1. Determine the status of snails at Monkey Jungle. The number of snails observed here has varied over the years and recent surveys conducted in 1996 indicated a decline. Survey this area to determine the status of the snail population.

S1.3.2. Determine status of snails in Everglades National Park (ENP) and Big Cypress National Preserve (BCNP). Snails have been observed in ENP and possibly in BCNP. Survey these areas to determine if snails are present.

S1.4. Maintain and improve the GIS database for snail information. Maintain GIS database on the presence of snails and suitable habitat.

S2. Protect and enhance existing populations of Stock Island tree snail. The survival of the Stock Island tree snail is dependent upon the few remaining populations left in the wild. Active protection and management of this species and its habitat are essential for the snail's survival considering all significant populations are outside of the historic range.

S2.1. Assign a biologist responsible for implementing recovery actions for the threatened or endangered species of the Lower Keys. Recovery actions implemented to recover the Stock Island tree snail will benefit other threatened or endangered species in the Lower Florida Keys, including the Key deer, marsh rabbit, tree cactus, and silver rice rat. The number of actions that will be necessary to recover threatened or endangered species in the Lower Florida Keys will require the attention of a biologist dedicated specifically to addressing the recovery needs of these species.

S2.2. Conduct Stock Island tree snail reintroductions from wild populations. Relocation and reintroduction may be the only strategy to ensure the survival of the Stock Island tree snail. To recover this species it is necessary to establish and enhance populations within the historic range and relocate populations from private to public or protected lands.

S2.2.1. Develop a standard protocol for conducting, monitoring, and evaluating all reintroduction, translocation, and supplementation efforts of Stock Island tree snails using the IUCN/SSC Guidelines for Reintroductions..Develop criteria that determine the type of release to be conducted, evaluate and select release site, identify source and health of

release stock, develop and monitor short-and long-term success indicators, and develop a policy on intervention. Ensure release sites are relatively free of threats, especially mosquito spraying, pesticides, and collecting prior to any release of snails.

S2.2.2. **Relocate snails to secure areas in the Lower Keys.** Relocate imperilled snail populations located outside of the historic range to one of the release sites described below or other appropriate secure areas in the historic range. Relocation of one population will be conducted over a period of at least 2 years to ensure relocation efforts are successful before relocating other populations. The FWS will conduct or oversee all relocations and develop a management plan for each relocation site selected.

Key West Botanical Garden (Garden), Stock Island-The Garden is within this species' historical range, was previously occupied by snails, and contains suitable vegetation for the snails. Historically, this site contained a large number of snails. Since 1988, no snails have been observed. The FWS is coordinating with the Garden and the Stock Island Golf Course to develop a restoration plan for the Garden. Continual management will be needed to ensure the snails survive. Direct effects may occur from pesticides and herbicides that are applied all around the periphery of the Garden by the Stock Island Golf Course, as well as from spraying for mosquito control. In addition, the remaining vegetation is not believed to be large enough to support a sustainable, self-sufficient population of snails.

Weapons Hammock, NAS, Key West-The Weapon's Hammock is within the Lower Keys historic range, contains suitable habitat, and is on Federal property. The FWS and GFC are coordinating with NAS to develop a relocation program. This site contains enough habitat to sustain a large stable population of snails.

National Key Deer Refuge-Several suitable sites are present within refuge boundaries. Snails currently exist here and can easily be augmented.

S2.2.3. **Monitor all reintroduced/relocated populations.** Develop protocol for monitoring the flora and fauna of reintroduction sites both before and after relocation of snails. Monitor to determine survival, growth, and reproductive success of introduced snails, as well as the effects of the snail's presence on other floral and faunal species.

S2.3. **Utilize Federal regulatory mechanisms for protection. Conduct section 7 consultations on Federal activities.** Federal agencies whose actions may affect the Stock Island tree snail include COE, FEMA, Federal Housing Administration, and the Rural Electrification Administration. Determine jeopardy thresholds for the tree snail. Estimate and evaluate the type of Federal activities over the next 20 years that are likely to cause jeopardy and determine threshold levels for the total population. Coordinate with Law Enforcement to prevent take under section 9. Identify what activities could result in take of tree snails, such as tree trimming and collecting.

S2.4. Provide information about Stock Island tree snails to Federal, State, county, and city agencies. Distribute information regarding the presence of Stock Island tree snails, their protection under the ESA, and ways to minimize impacts. Non-Federal agencies that may influence the Stock Island Tree Snail include DEP, DCA, GFC, Department of Agriculture and Consumer Services, Monroe County Mosquito Control, Florida Keys Aqueduct Authority, and Monroe County Government.

S2.5. Reduce disturbance or mortality of Stock Island tree snails. Human-related mortality must be minimized if the subspecies is to survive.

S2.5.1. Minimize the impact of mosquito spraying and other herbicide use. Coordinate with public and private entities to avoid directly spraying snails with pesticides and herbicides, especially mosquito spray.

S2.5.2. Reduce illegal collecting. Unauthorized snail collecting and relocating continues to be a considerable problem. Inform snail collectors to eliminate these impacts. Coordinate with law enforcement to increase enforcement efforts.

S2.5.3. Minimize the impacts of native and non-native predators to snails. Black rats, birds, raccoons, and fire ants are known predators of tree snails. Reduce the negative impacts of these species.

S2.5.4. Develop a Memorandum of Agreement (MOA) with Monroe County to ensure their actions do not harm this species. The highest priority area for snail protection is Key Largo, especially subdivisions in North Key Largo. Many of the populations are in private ownership and will require coordination with Monroe County and the homeowner. Provide information to Monroe County on where snails are located and means to protect tree snails. Ensure mosquito spraying and pesticide use does not impact the snail. Areas with snails present should be identified and the necessary permitting offices and homeowners notified to avoid any negative impact on the snail. The ultimate goal is to relocate any imperilled snails from private property to secure sites in the Lower Keys over the next 5 years.

S3. Determine if the total population size is large enough to prevent functional extinction and genetic extinction. As of July 1997, the population contains a minimum of 225 individuals distributed in several disjunct sites. Conduct a model to predict the persistence of this species. Determine what effective population size is necessary to prevent inbreeding depression.

S3.1. Investigate the genetics of snails from different sites. Determine if the relocation and manipulation of tree snails has affected its genetic makeup.

S3.2. Identify factors that affect the persistence of the Stock Island tree snail. Determine what aspect of this species' ecology makes it most vulnerable to extinction (*e.g.*, predation, lack of food, inability to find mate). Investigate relationships between nuisance competitors or predators and determine their effect on the snail's persistence.

S3.3. Determine the number of subpopulations necessary for a stable or increasing population. There are approximately eight different areas that have small disjunct groups.

S3.3.1. Determine subpopulations most vulnerable to extinction. Snail populations on private property are extremely vulnerable to loss of habitat and pesticide use, especially those located in the Key Largo subdivisions. Evaluate the vulnerability of snail populations to prioritize relocation needs and recovery actions.

S3.3.2. Determine the necessary number of subpopulations and level of exchange that will enable the snail to persist for 100 years.

S3.4. Determine what constitutes a stable age structure and group size for the snail. Recent surveys have shown representatives from several age classes, suggesting some reproduction is occurring, but it is not known what comprises a stable age structure or group size. Investigate these parameters to determine what constitutes a stable population structure.

S4. Monitor Stock Island tree snail populations. Although some presence/absence surveys have been conducted over the years, long-term monitoring of snail populations has not been conducted. Develop a monitoring protocol to survey the status of snail populations.

S4.1. Develop methods to monitor presence of snails, population dynamics, and habitat use.

S4.2. Develop methods to monitor demographic parameters. Monitor sex ratios, age class structure, survivorship, age of dispersal, and dispersal distance of snail populations.

S4.3. Monitor the success of tree snail reintroduction efforts. Develop monitoring guidelines as part of the reintroduction protocol and monitor all relocated snails.

S4.4. Determine the effects of relocated snails on flora and fauna already present. The effect of the introduction of snails to these habitats is believed to be minimal, but it is essential to monitor any potential changes in the floral and faunal composition as it relates to presence of the Stock Island tree snail.

S5. Increase public awareness and stewardship for the Stock Island tree snail. Inform public, especially snail collectors, about the snail, its protections under Federal law, and its importance as an integral part of the ecosystem. Inform homeowners on how to protect and manage snails on their property. Coordinate with snail collectors to reduce the amount of illegal snail collecting or manipulation, including the unauthorized relocation of snails to various locations.

S6. Establish reclassification and delisting criteria. Develop measurable reclassification criteria that reflect a stable or increasing population including: total population size, number of subpopulations, age structure, habitat condition and availability, and level of threats. Evaluate and monitor the tree snail's status in relation to reclassification criteria.

Habitat-level Recovery Actions

H1. Prevent degradation of existing habitat. Habitat loss is the main reason for the Stock Island tree snail's decline. Most of the hardwood hammocks that could serve as suitable habitat for the snail on Stock Island and Key West have been destroyed or severely altered by past human activities. Remnants of hammock that remain on these Keys tend to be small in size and low in quality. Habitat degradation can decrease the number of snails an area can support, contributing to the overall probability of extinction.

H1.1. **Acquire Stock Island tree snail habitat.** Acquire tree snail habitat essential to the snail's survival. Develop an acquisition plan based on habitat in greatest need, while taking into consideration the need for reserve design (*e.g.*, corridors, core areas).

H1.1.1. **Continue Federal acquisition efforts.** Continue to acquire habitat within the Crocodile Lake NWR, National Key Deer Refuge, and Great White Heron NWR boundaries.

H1.1.2. **Support State acquisition efforts.** Continue to support the acquisition of State lands including Key Largo Botanical Site and programs such as Florida's Conservation and Recreation Lands (CARL) program.

H1.1.3. **Support and encourage land acquisition by non-governmental agencies.** Habitat not listed for Federal, State, or county acquisition may become available for private purchase and management by such organizations as The Nature Conservancy and Florida Keys Land Trust.

H1.2. **Protect and manage Stock Island tree snail habitat.** Most tree snail sites are small in size and are near high concentrations of people. Protect and manage these areas to prevent negative impacts on the tree snail. Loss or damage of these habitats may destroy the microclimate (air temperature and humidity) important for food, shelter, and reproduction.

H1.2.1. **Protect tree snails on public lands.** Develop a habitat management plan that outlines priority habitat for acquisition and methods to protect, restore, and minimize impacts on tree snails and their habitat. Acquire and incorporate snail habitat into Federal, State, and county land protection systems. Manage public lands for exotics, off-road vehicles, dumping, exotic predators, and vehicular traffic. Identify and minimize other causes of tree snail death or mortality on public lands.

H1.2.2. **Protect tree snails on private lands where feasible.** When opportunities exist, protect tree snail populations on private land through acquisition, conservation easements or agreements, and landowner outreach. Develop agreements between the FWS and private landowners to minimize impacts such as certain landscaping techniques and exotics.

H1.2.3. **Protect important core areas.** Several tree snail populations are concentrated in a few small areas. Protect the habitat of these core areas by coordinating with the appropriate parties to avoid any negative impact on the snail.

H1.2.4. **Remove invasive exotic vegetation.** Continue efforts to remove exotic plants in snail habitat, especially Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*).

H1.2.5. **Prevent habitat areas from being modified.** Prevent excessive watering of ornamental plants and lawns which modifies snail behavior by bringing snails out of aestivation during the winter months and exposing them to cold temperatures and desiccation.

H1.2.6. **Restrict access to snail habitat on public lands.** Restrict access to occupied snail habitat to prevent death and injury, over-collecting, and unauthorized relocations.

H2. **Restore suitable tree snail habitat.** Habitat degradation from housing and road construction, trash dumping, and invasive exotic vegetation have altered the integrity of hardwood hammock forests and facilitated the ability of exotic plants and animals to invade native habitats. As a result, habitat quality and availability have been reduced or eliminated. Identify and prioritize areas in greatest need of habitat restoration and conduct restoration efforts.

H2.1. **Restore both occupied and unoccupied tree snail habitat that has been degraded to optimal conditions.**

H2.2. **Improve habitat by planting or encouraging native plant species.** Plant native vegetation in areas that have been scarified or degraded. Encourage homeowners to plant native plant species important to the snail.

H2.3. **Create habitat by refilling and revegetating areas that have been destroyed or altered.**

H2.4. **Restore snail habitat at Key West Botanical Garden**. Remove exotic vegetation and manage habitat so snails can be relocated here according to the relocation protocol.

H3. **Conduct research to determine habitat needs for the Stock Island tree snail.** Specific habitat requirements are not known, but tree snails are believed to need an area large enough to provide for foraging and reproductive requirements as well as provide adequate temperature and humidity conditions.

H3.1. **Investigate how snails utilize different habitat components for survival (*e.g.*, food, shelter, and reproduction).** Hammocks that contain well-developed soils or leaf litter are important for reproduction and dispersal. Light intensity and moisture content influence the amount of food available. Investigate how snails rely on various habitat components.

H3.1.1. **Determine minimum area required for snails to persist**. No data are available on minimal hammock size needed to support a viable population of tree snails.

H3.1.2. **Compare and characterize occupied tree snail habitat.** Tropical hardwood hammocks in the Keys tend to have higher species diversity and structural variety than hammocks on the mainland. Several differences also exist between hammocks in the Upper Keys as compared to the Lower Keys (*e.g.*, elevation, canopy height, soil, etc.). Investigate habitat components and compare among the different snail populations (*i.e.*, compare habitat of Key West, Key Largo, and Monkey Jungle habitat).

H3.1.3. **Investigate the effect of habitat change on the snail's persistence.** Investigate how variables such as disturbance of leaf litter, soil composition, light intensity, and moisture content affect the ability of an area to support snails.

H3.1.4. **Investigate the use of ornamental and exotic vegetation as food and habitat.** Several Stock Island tree snails have been observed on a variety of ornamental and exotic plants. Determine the level of use and quality of habitat these plants provide.

H3.2. Determine an index of habitat fragmentation. It is not known whether Stock Island tree snails prefer interior or edge hammock areas. Recent surveys of snails in Key Largo populations have shown higher numbers of snails along the edge of the hammock than in the interior, but this may be an artifact of where snails were originally released by collectors. Investigate the effects of fragmentation on the snail's use of its habitat.

H3.2.1. Investigate movement patterns and the spatial utilization of habitat to determine important core areas.

H3.2.2. Determine if the amount and configuration of remaining occupied and unoccupied habitat is sufficient to support a stable population of Stock Island tree snails.

H4. Monitor the status of Stock Island tree snail habitat. Conduct yearly monitoring evaluations of the status of the tree snail's habitat. Overlay habitat quality with GIS mappings of habitat locations, including what patches are being altered or lost each year. Monitor through GIS the availability of snail habitat by updating the loss or change of habitat due to residential or commercial construction. Monitor habitat of relocated populations.

H5. Increase public awareness of Stock Island tree snail habitat and instill stewardship. Conduct workshops with the public to inform private landowners on how to establish safe management practices to protect and enhance snail habitat. Encourage private landowners to remove exotics, plant native vegetation, and restore disturbed areas. Prepare literature to provide information regarding the snail's habitat and ways to protect and conserve it.