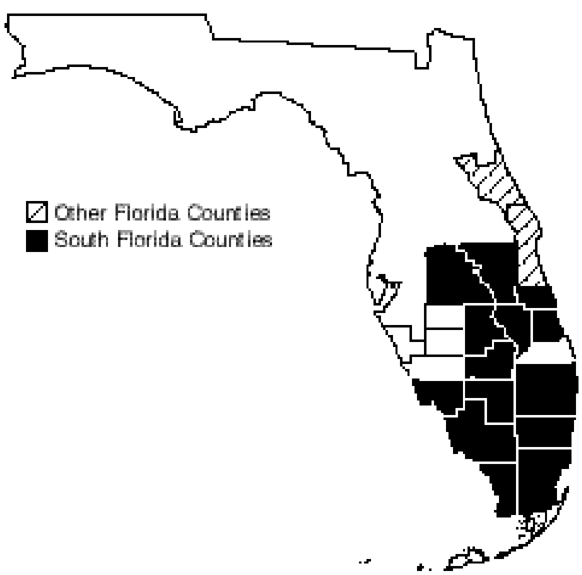
Everglade Snail Kite

Rostrhamus sociabilis plumbeus

Federal Status:	**Endangered (March 11, 1967)**
Critical Habitat:	**Designated (August 1977)**
Florida Status:	**Endangered**
Recovery Plan Status:	**Revision (May 18, 1999)**
Geographic Coverage:	**Rangewide**

Figure 1. Florida distribution of the Everglade snail kite.



The Everglade snail kite (*Rostrhamus sociabilis*) is a wide-ranging New World raptor species found primarily in lowland freshwater marshes in tropical and subtropical America from Florida, Cuba, and Mexico south to Argentina and Peru. The subspecies from Florida and Cuba *(Rostrhamus sociabilis plumbeus)* was first listed as endangered pursuant to the Endangered Species Conservation Act in 1967. The common name used in the original listing was Everglade snail kite and this remains unchanged in the official FWS Code of Federal Regulations, even though the official name for the species is now simply snail kite (AOU 1983).

The Florida population of snail kites is considered to be a single population with considerable distributional shifts. The combination of a range restricted to the watersheds of the Everglades, lakes Okeechobee and Kissimmee, and the upper St. Johns River, with a highly specific diet composed almost entirely of apple snails (*Pomacea paludosa*), makes the snail kite's survival directly dependent on the hydrology and water quality of these watersheds. Each of these watersheds has experienced, and continues to experience, pervasive degradation due to urban development and agricultural activities.

This account represents a revision of the existing recovery plan for the Everglade snail kite (FWS 1986).

Description

The snail kite is a medium-sized raptor, with a total body length for adult birds of 36 to 39.5 cm and a wingspan of 109 to 116 cm (Sykes *et al.* 1995). In both sexes, the tail is square-tipped with a distinctive white base, and the wings are broad, and paddle-shaped. Adults of both sexes have red eyes, while juveniles have brown eyes (Brown and Amadon 1978, Clark and Wheeler 1987). The slender, decurved bill is an adaptation for extracting the kite's primary prey, the apple snail; the bill is a distinguishing character for field identification in both adults and juveniles.

Sexual dimorphism is exhibited in this species, with adult males uniformly slate gray and adult females brown with cream streaking in the face, throat, and breast. Most adult females have a cream superciliary line and cream chin and throat (Sykes *et al.* 1995). Females are slightly larger than males. Immature snail kites are similar to adult females but are more cinnamon-colored with tawny or buff-colored streaking rather than cream streaking. The legs and cere of females and juveniles are yellow to orange; those of adult males are orange, turning more reddish during breeding (Sykes *et al.* 1995).

In the field, the snail kite could be confused with the northern harrier (*Circus cyaneus*), a similarly sized hawk with a white rump. The northern harrier has a longer and narrower tail, with longer and narrower wings held in a dihedral. The snail kite's flight is slower and characterized by more wing flapping, with the head tilting down to look for snails; the northern harrier has a gliding, tilting flight. At a closer distance, the long, curved beak of the snail kite allows it to be easily distinguished from the northern harrier (Sykes *et al.* 1995).

Taxonomy

Three subspecies of the snail kite are currently recognized (Amadon 1975), but a larger sample size of body measurements is needed to confirm if the separation into three subspecies is valid (Sykes *et al.* 1995). These subspecies are: *Rostrhamus . s. plumbeus*, from peninsular Florida, Cuba, and northwestern Honduras; *R. s. major*, from Mexico, Guatemala, and the northern half of Belize; and *R .s. sociabilis*, from southern Nicaragua, through Panama and into South America as far south as northern Argentina. The *plumbeus* subspecies in Florida has a larger body size than that of *R. s. sociabilis*, with a beak of similar size. However, the validity of these subspecies remains a subject of debate; Beissinger (1988) is among those who question the validity of these designations.

The closest related species is the slender-billed kite (*R. hamatus*) from eastern Panama and South America (Ridgely and Gwynne 1989). The slender-billed kite, like the snail kite, feeds on snails of the genus *Pomacea*, but inhabits swamps or wet forests (Beissinger *et al.* 1988, Ridgely and Gwynne 1989).

Distribution

As noted above, the subspecies *R. s. plumbeus* occurs in Florida, Cuba (including Isla de la Juventud) and northwestern Honduras. There is no evidence of movement of birds between Cuba and Florida, but this possibility has not been ruled out (Sykes 1979, Beissinger *et al.* 1983).

In Florida, the original range of the snail kite was larger than at present. Historically, snail kites were known to nest in Crescent Lake and Lake Panasoffkee in north-central Florida and as far west as the Wakulla River (Howell 1932, Sykes 1984). Information on changes in distribution and abundance is in the Status and Trends section of this account.

Everglade snail kite. *Original photograph by Betty Wargo*.

The current distribution of the Everglade snail kite in Florida (Figure 1) is limited to central and southern portions of the State. Six large freshwater systems are located within the current range of the snail kite: Upper St. Johns drainage, Kissimmee Valley, Lake Okeechobee, Loxahatchee Slough, the Everglades, and the Big Cypress basin (Beissinger and Takekawa 1983, Sykes 1984, Rodgers *et al.* 1988, Bennetts and Kitchens 1992, Rumbold and Mihalik 1994, Sykes *et al.* 1995). Habitats in the Upper St. Johns drainage include the East Orlando Wilderness Park, the Blue Cypress Water Management Area, the St. Johns Reservoir, and the Cloud Lake, Strazzulla, and Indrio impoundments. In the Kissimmee Chain of Lakes, snail kites are found at Lake Pierce, Lake Tohopekaliga, East Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, Lake Marion, Lake Marian, Lake Kissimmee, Tiger Lake, Lake Arbuckle, and Lake Istokpoga. Lake Okeechobee and surrounding wetlands are major nesting and foraging habitats, particularly the large marsh in the southwestern portion of the lake and the area southwest of the inflow of the Kissimmee River. In the

Loxahatchee Slough region of Palm Beach County, snail kites are found at the West Palm Beach Water Catchment Area, the Pal-Mar Water Conservation District, and borrow lakes on property belonging to the Solid Waste Authority of Palm Beach County and the City of West Palm Beach. Wetlands in the Everglades region supporting the snail kite are the Arthur R. Marshall Loxahatchee NWR (including WCA 1, WCA 2, WCA 3), Shark River Slough and Taylor Slough in Everglades National Park, and the C-111 basin west of U.S. Highway 1. In the Big Cypress basin, snail kites use the Lostman's and Okaloacoochee sloughs, Hinson Marsh, and the East Loop and Corn Dance units of Big Cypress National Preserve. The Savannas State Preserve, in St. Lucie County, the Hancock impoundment in Hendry County, and Lehigh Acres in Lee County are among the smaller more isolated wetlands used by snail kites (Sykes *et al.* 1995). Although the above list generally describes the current range of the species, radio tracking of snail kites has revealed that the network of habitats used by the species includes many other smaller widely dispersed wetlands within this overall range (R. Bennetts, University of Florida, personal communication 1996, Bennetts and Kitchens 1997a).

Habitat

Snail kite habitat consists of freshwater marshes and the shallow vegetated edges of lakes (natural and man-made) where apple snails can be found. These habitats occur in humid, tropical ecoregions (Bailey 1978) of peninsular Florida and are characterized as palustrine-emergent, long-hydroperiod wetlands (Cowardin *et al.* 1979) often on an organic peat substrate overlying oolitic limestone or sand or directly on limestone or marl (Davis 1946).

Suitable foraging habitat for the snail kite is typically a combination of low profile (< 3 m) marsh with an interdigitated matrix of shallow (0.2-1.3 m deep) open water, which is relatively clear and calm. The marsh vegetation is dominated by spike rush (*Eleocharis cellulosa*), maidencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*), and/or cattails (*Typha* spp.). The shallow open-water areas are with or without sparse vegetation, such as white water lily (*Nymphaea odorata*), arrowhead (*Sagittaria lancifolia*), pickerel weed (*Pontederia lanceolata*), and floating heart (*Nymphoides aquatica*). Giant bulrush (*Scirpus validus*) often grows at the deep-water edge of marshes in the lakes. Low trees and shrubs also are often interspersed with the marsh and open water. These often include willow (*Salix caroliniana*), dahoon holly (*Ilex cassine*), pond apple (*Annona glabra*), bald cypress (*Taxodium distichum*), pond cypress (*T. ascendens*), wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), and *Melaleuca quinquenervia*, an invasive exotic species.

Snail kites require foraging areas that are relatively clear and open in order to visually search for apple snails. Therefore, dense growth of herbaceous or woody vegetation is not conducive to efficient foraging. The interspersed emergent vegetation enables apple snails to climb near the surface to feed, breathe, and lay eggs. Nearly continuous flooding of wetlands for > 1 year is needed to support apple snail populations that in turn sustain foraging by the snail kite (Sykes 1979, Beissinger 1988). Cultural eutrophication of water bodies in Florida is occurring through disposal of domestic sewage and runoff of nutrient-laden water from agricultural lands. This degradation of water quality promotes dense growth of exotic and invasive native plants, particularly, cattail, water lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), and hydrilla (*Hydrilla verticillata*). Dense growth of these plants reduces the ability of snail kites to locate apple snails.

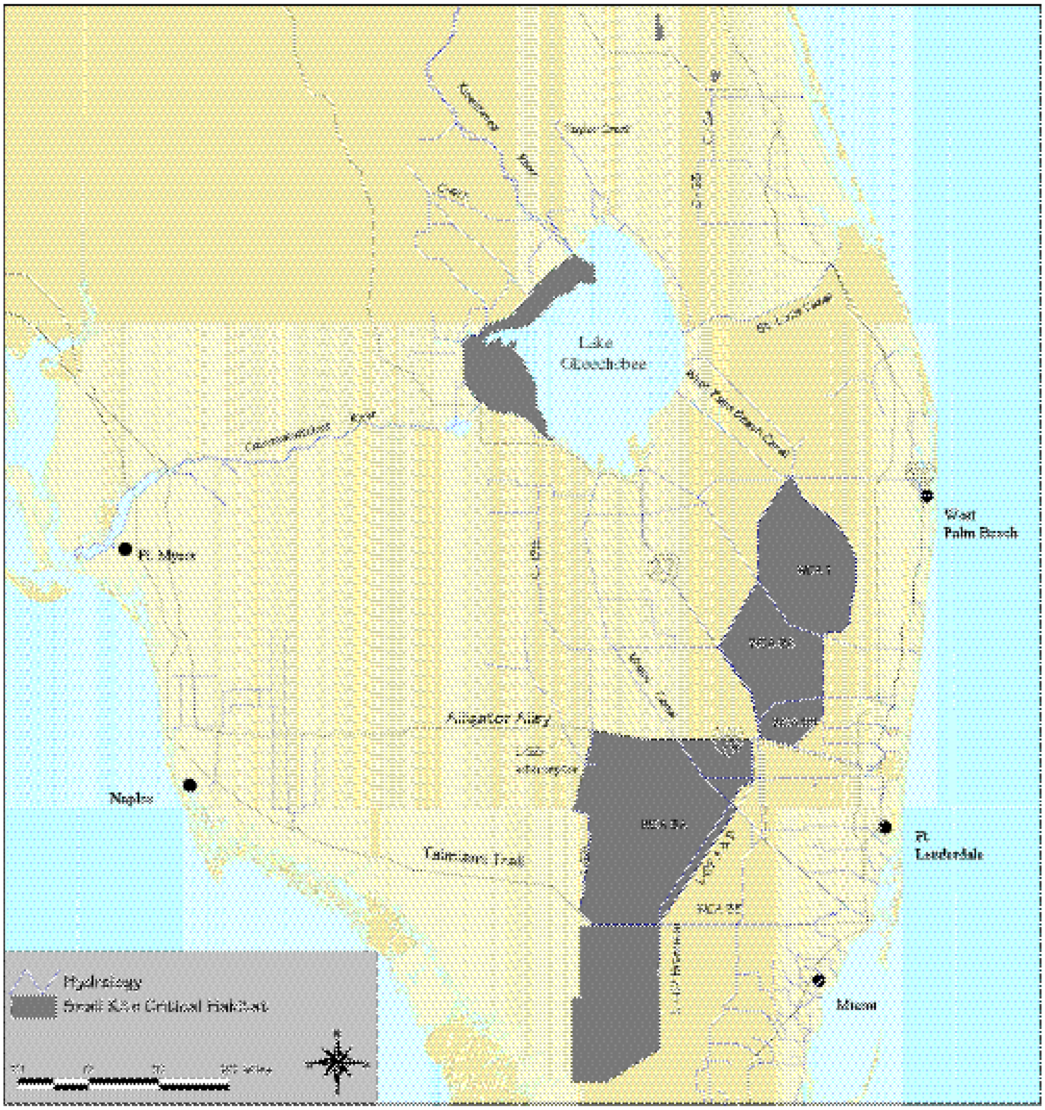
Nesting almost always occurs over water, which deters predation (Sykes 1987b). Nesting substrates include small trees (usually < 10 m in height), including willow, bald cypress, pond cypress, *Melaleuca*, sweetbay (*Magnolia virginiana*), swamp bay (*Persea borbonia*), pond apple and dahoon holly. Shrubs used for nesting include wax myrtle, cocoplum (*Chrysobalanus icaco*), buttonbush, *Sesbania*, elderberry (*Sambucus simpsonii*), and Brazilian pepper (*Schinus terebinthifolius*). Nesting also can occur in herbaceous vegetation, such as sawgrass, cattail, bulrush, and reed (*Phragmites australis*) (Sykes *et al.* 1995). Nests are more frequently placed in herbaceous vegetation around Lake Kissimmee and Lake Okeechobee during periods of low water when dry conditions beneath the willow stands (which tend to grow to the landward side of the cattails, bulrushes and reeds) prevent snail kites from nesting in woody vegetation. Nests constructed in herbaceous vegetation on the waterward side of the lakes' littoral zone are more vulnerable to collapse due to the weight of the nests, wind, waves, and boat wakes, and are more exposed to disturbance by humans (Chandler and Anderson 1974; Sykes and Chandler 1974; Sykes 1987b; Beissinger 1986, 1988; Snyder *et al.* 1989a). It is important to note that suitable nesting substrate must be close to suitable foraging habitat, so extensive areas of contiguous woody vegetation are generally unsuitable for nesting.

Roosting sites are also almost always located over water. In Florida, 91.6 percent are located in willows, 5.6 percent in *Melaleuca*, and 2.8 percent in pond cypress. Roost sites are in the taller vegetation among low-profile marshes. Snail kites tend to roost around small openings in willow stands at a height of 1.8 to 6.1 m, in stand sizes of 0.02 to 5 ha. Roosting in *Melaleuca* or pond cypress is in stands with tree heights of 4 to 12 m (Sykes 1985a).

Critical Habitat

Critical habitat was designated for the snail kite in 1977 and, since then, has not been revised. Critical habitat (Figure 2) includes the Arthur R. Marshall Loxahatchee NWR, WCA 2, portions of WCA 3, portions of Everglades NP, western portions of Lake Okeechobee, the Strazzulla and Cloud Lake reservoirs in St. Lucie County, and portions of the St. Johns Marsh in Indian River County. A complete description of the critical habitat is available in 50 CFR 17.95. Although snail kites have nested in several lakes (particularly East Lake Tohopekaliga, Lake Tohopekaliga, and Lake Kissimmee) in the headwaters of the Kissimmee River since the early 1980s, at the time of designation of critical habitat, potential habitat around these lakes was used only sporadically by snail kites, and was not included in the critical habitat.

Figure 2. Snail kite critical habitat.



Behavior

Non-breeding snail kites use communal roosts throughout the year in association with other birds, particularly anhingas (*Anhinga anhinga*), herons, and vultures. The snail kite can nest solitarily, but more often in uneven clusters, and often hunts in close proximity without defending a foraging territory. However, defense of feeding territories, outside of the breeding season, occurs more often than previously thought; typically, however, these birds display no territorial behavior and feeding areas overlap (Stieglitz and Thompson 1967; Sykes 1979, 1985a, 1987a, b, c; Beissinger 1983, 1984, 1988).

Courtship

Pair bonds are formed by a series of behaviors with each nesting. Males often begin construction of the nest prior to attracting a mate. Materials are gathered with feet or bill and are carried in the bill one piece at a time to the nest site. The nest is a bulky loosely woven structure of dry sticks and other dry plant material. Thirty-two species of plants are known to be used in construction, with sticks from willow and wax myrtle the most common material (Sykes 1987b). Snail kites often use green nest material, especially the upper lining that forms a cup for holding the eggs; this functions to insulate the otherwise porous structure of dry sticks. Males display either in the air or at perch near the chosen nest site. Aerial displays often include carrying a stick in the bill and vocalizing; these displays may include skydance or undulating flight, deep wing beats, pendulum, mutual soaring, tumbling, and grappling. The male may feed the female a snail or bring her a stick. In Florida, most pair bonds form from late November to early June. Once a pair bond is established, the female may spend time at or near the nest site and may assist the male in completing the nest (Beissinger 1987a, 1988; Sykes 1987c).

Reproduction

Copulation can occur from early stages of nest construction, through egg-laying, and during early incubation if the clutch is not complete. Egg laying begins soon after completion of the nest or is delayed a week or more. An average 2-day interval between laying each egg results in the laying of a three-egg clutch in about 6 days. The clutch size is 1 to 5 eggs, with a mode of three (Sykes 1987c, Beissinger 1988, Snyder *et al.* 1989a). Incubation may begin after the first egg is laid, but generally after the second egg (Sykes 1987c). In Florida, the incubation period lasts 24 to 30 days (Sykes 1987c). Incubation is shared by both sexes, but the sharing of incubation time between sexes varies among nests (Beissinger 1987b).

Hatching success is variable from year to year and between areas. In nests where at least one egg hatched, hatching success averaged 2.3 chicks/nest. The most successful months for hatching are February (19 percent), March (31 percent), and April (23 percent) (Sykes 1987c).

The breeding season varies widely from year to year in relation to rainfall and water levels. Ninety-eight percent of the nesting attempts are initiated from December through July, while 89 percent are initiated from January through June (Sykes 1987c, Beissinger 1988, Snyder *et al.* 1989a). Snail kites often renest following failed attempts as well as after successful attempts (Beissinger 1986, Snyder *et al*. 1989a), but the actual number of clutches per breeding season is not well documented (Sykes *et al.* 1995).

Foraging

The snail kite feeds almost exclusively on apple snails (*Pomacea paludosa*) in Florida. The snail kite uses two visual foraging methods: course-hunting, while flying 1.5 to 10 m above the water surface, or still-hunting from a perch. While course-hunting, the flight is characterized by slow wing beats, alternating with gliding; the flight path is usually into the wind, with the head oriented downward to search for prey. Snails are captured with the feet at or below the surface, to a maximum reach of approximately 16 cm below the surface. Snail kites do not plunge into the water to capture snails and never use the bill to capture prey. Individuals may concentrate hunting in a particular foraging site, returning to the same area as long as foraging conditions are favorable (Cary 1985). Capture rates are higher in summer than in winter (Cary 1985), with no captures observed at a temperature less than 10°C. Snail kites frequently transfer snails from the feet to the bill while in flight to a perch. Feeding perches include living and dead woody-stemmed plants, blades of sawgrass and cattails, and fence posts.

The snail kite is known to feed on the introduced snail *Pomacea bridgesi* (Takekawa and Beissinger 1983). On rare occasions, snail kites in Florida prey on small turtles (Sykes and Kale 1974, Beissinger 1988, Bennetts *et al.* 1988). Snail kites have also been observed feeding upon crayfish (*Procambarus* spp.) and a speckled perch (*Pomoxis nigromaculatus*) (Bennetts *et al*. 1994).

Migration

Snail kites in Florida are not migratory. They are restricted to South and central Florida. Snail kites are nomadic in response to water depths, hydroperiod, food availability, and other habitat changes (Sykes 1978, 1983a; Beissinger and Takekawa 1983; Bennetts *et al.* 1994). Radio-tracking and sighting of marked individuals have revealed that nonbreeding individuals disperse widely on a frequent basis (Sykes 1979, 1983a; Beissinger 1988; Snyder *et al.* 1989b; Bennetts and Kitchens 1992; Bennetts *et al.* 1994). Shifts in distribution can be short-term, seasonal, or long-term, and can take place between areas from year to year (Rodgers *et al.* 1988), between areas within a given nesting season (Beissinger 1986), within areas in a given nesting season, and within or between areas for several days to a few weeks (Sykes (1983a) noted that during colder winters, snail kites will shift their distribution more to the southern part of their range. As noted above, there is no evidence of movement between Florida and Cuba, but the possibility has not been ruled out (Sykes 1979, Beissinger *et al.* 1983).

Rearing

The mating system of snail kites is characterized by sequential polygamy (ambisexual mate desertion). Desertion occurs in years with abundant food supply, but not during drought years. The deserted mate continues to tend the nest until independence of the chicks, which is for another 3 to 5 weeks (Beissinger 1984, 1986, 1987b; Beissinger and Snyder 1987). Young are fed through the nestling period and after fledging until they are 9 to 11 weeks old (Beissinger and Snyder 1987, Beissinger 1988). Chicks assume food begging postures and vocalizations when the tending adult approaches the nest with a snail. As the chicks mature, the food progresses from pieces of torn snail fed bill to bill, whole snails removed from the shell and with operculum removed, to completely intact snails (Beissinger 1988). When food is scarce, larger siblings may dominate the food supply brought to the nest. While rearing young, the adults forage no more than six km from the nest (Beissinger and Snyder 1987), and generally less than a few hundred meters

Relationship to Other Species

Snail kites and limpkins (*Aramus guarauna*) both feed on apple snails; habitat partitioning occurs between the two species where they feed in the same areas.

Limpkins feed tactually in dense emergent or floating vegetation as well as in open patches (Snyder and Snyder 1969), while snail kites feed visually in open water with a range of water depths.

When nesting, snail kites drive off turkey vultures (*Cathartes aura*) within 20 to 30 m of the nest. Aggressive behavior by snail kites near nests has been observed directed against other birds, including black-crowned night herons (*Nycticorax nycticorax*), ospreys (*Pandion haliaetus*), red-shouldered hawks (*Buteo lineatus*), limpkins, and boat-tailed grackles (*Quiscalus major*) (Sykes 1987b). Red-shouldered hawks, fish crows (*Corvus ossifagus*), and boat-tailed grackles are known to drive snail kites from a perch (Sykes *et al.* 1995).

Snail kite eggs are taken by fish crows, boat-tailed grackles, rat snakes (*Elaphe obsoleta*), and raccoons (*Procyon lotor*) (Chandler and Anderson 1974; Beissinger 1986, 1988; Sykes 1987c; Snyder *et al.* 1989a). Nestlings are lost to rat snakes and cottonmouths (Beissinger 1986, 1988; Sykes 1987c; Bennetts and Caton 1988), despite the fact that snail kites select nest sites in flooded wetlands, which tends to make the nests less vulnerable to predation.

The ranges of the endangered wood stork (*Mycteria americana*) and Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) overlap the range of the snail kite. While hydrological conditions most favorable to one species may not be most favorable for another, all of these animals survived the hydrologic variability characteristic of the natural system. The reduced heterogeneity and extent of the present system make these species more vulnerable to natural and man-caused threats. Management actions may be required on a temporary basis to protect a particular species from a high risk of extinction, but long-term management goals should not be driven by protection of a single species, because such actions may threaten the sustainability of the entire ecosystem.

Status and Trends

When the snail kite was listed as endangered in 1967 (32 FR 4001), the species was considered to be at an extremely low population level. In 1965, only 10 birds were found, eight in WCA2A and two at Lake Okeechobee. A survey in 1967 found 21 birds in WCA2A (Stieglitz and Thompson 1967). On this basis, the snail kite was included in the first group of species to be listed under the Endangered Species Conservation Act, the predecessor to the current Endangered Species Act. The publication Threatened Wildlife of the United States (Bureau of Sport Fisheries and Wildlife 1973) cited the following as the status of the snail kite:

> Jeopardized because of the very small population and increasingly limited amount of fresh marsh with sufficient water to ensure an adequate supply of snails on which it depends for food.

Historic records of snail kite nesting include areas as far north as Crescent Lake and Lake Panasoffke in north-central Florida and as far west as the Wakulla River (Howell 1932, Sykes 1984). Several authors (Nicholson 1926, Howell, 1932, Bent 1937) indicated that the snail kite was numerous in central and South Florida marshes during the early 1900s, with groups of up to 100 birds. Sprunt (1945) estimated the population to be 50 to 100 individuals. The snail kite apparently plummeted to its lowest population between 1950 and 1965. By 1954, Sprunt estimated the population at no more than 50 to 75 birds

(Sprunt 1954). Stieglitz and Thompson (1967) reported eight birds in 1963 at the Loxahatchee NWR, 17 on the refuge and two at Lake Okeechobee in 1964, eight in WCA2A and two at Lake Okeechobee in 1965, and 21 in WCA2A in 1966. Limited resources were available at that time for researchers to reach potential snail kite habitats, and the resulting low level of survey effort may have biased these low snail kite population estimates. However, there is no doubt that the snail kite was severely endangered at that time and that its range had been dramatically reduced.

Sykes (1983b) mentioned two reports, by other observers, of lone snail kites at Lake Kissimmee in 1973 and 1980. Sykes (1984) reported the range of the snail kite in Florida, as of 1980, included the following areas: southwestern Lake Okeechobee (Glades County), portions of WCAs 1, 2B, and 3A (Dade, Broward, and Palm Beach counties), the Lake Park Reservoir (Palm Beach County), the northern portion of Everglades National Park just south of Tamiami Trail (Miami-Dade County) the Savannas (St. Lucie County), and the headwaters of the St Johns River (Indian River and St. Lucie counties). Sykes (1984) did not mention the two isolated reports at Lake Kissimmee. Beissinger and Takekawa (1983) report that 3 to 25 snail kites were observed on Lake Kissimmee and 6 to 32 were sighted on Lake Tohopekaliga in 1981-1982, and classified these among a number of “drought related habitats.” The first reported nesting of snail kites occurred on these two lakes during that period. Rodgers (1994) has continued to find significant nesting and foraging by snail kites in the Kissimmee Chain of Lakes into the mid-1990s, which he characterized as a reoccupying of a portion of the species’ historic range.

Prior to 1969 the snail kite population was monitored only through sporadic and haphazard counts (reviewed by Sykes 1984). From 1969 to 1994, an annual quasi-systematic mid-winter snail kite count was conducted by a succession of principal investigators. Counts since 1969 have ranged from 65 in 1972 to 996 in 1994. Bennetts *et al.* (1993, 1994) caution that the 1993 and 1994 counts were performed with the advantage of having numerous birds radio-tracked. This certainly influenced the total count, because radio-instrumented birds could be easily located and often led researchers to roosts that had not been previously surveyed. Bennetts and Kitchens (1997a) and Bennetts *et al.* (1999a) have analyzed these counts and have analyzed the sources of variation in these counts, including observer effects, differences in level of effort, and sampling error. This analysis provides a convincing argument that these data could provide a crude indication of trends, provided that all influences of detection rates had been adequately taken into account. The sources of variation should be recognized prior to using these data in subsequent interpretations, especially in attempting to determine population viability and the risk of extinction. Table 1 presents the annual count data for the period 1985 to 1994.

While acknowledging the problems associated with making year-to-year comparisons in the count data, some general conclusions are apparent. Lake Okeechobee apparently retains some suitable snail kite habitat throughout both wet and dry years. In contrast, kite use of WCA3A fluctuates greatly, with low use during drought years, such as 1991, and high use in wet years, such as

Table 1. Mid-winter Everglade snail kite survey, 1985-1994.

Location	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	10-yr. Mean
St. Johns Marsh	8	6	7	30	38	68	81	81	10	27	36
L. Kissimmee	38	28	42	33	73	61	49	38	38	46	45
L. Tohopekaliga	17	13	1	1	19	118	2	19	2	7	20
East L. Tohopekaliga	0	0	0	0	18	30	5	9	24	21	11
L. Okeechobee	108	71	94	175	122	83	146	216	113	129	126
WCA2A	1	1	0	4	11	20	14	42	1	0	9
WCA2B	16	58	4	48	0	0	10	2	32	142	31
WCA3A	170	353	117	166	166	13	7	113	345	470	192
WCA3B	24	13	11	9	0	1	2	2	10	11	8
Big Cypress NP	0	0	0	0	0	0	0	32	28	43	10
Everglades NP	1	1	6	10	3	1	3	67	16	29	14
The Pocket	7	9	19	9	3	0	20	11	89	1	43
Other sites	10	10	24	13	11	27	17	113	139	70	43
Total for Year	400	563	325	498	464	422	356	745	847	996	562

1994. However, we caution against using these figures as absolute values for shifts in habitat use or measures of changes in total population. Although sharp declines have occurred in the counts since 1969 (for example, 1981, 1985, 1987), it is unknown to what extent this reflects actual changes in population. Rodgers *et al.* (1988) point out that it is unknown whether decreases in snail kite numbers in the annual count are due to mortality, dispersal (into areas not counted), decreased productivity, or a combination of these factors. Despite these problems in interpreting the annual counts, the data since 1969 have indicated a generally increasing trend (Sykes 1979, Rodgers *et al.* 1988, Bennetts *et al.* 1994). The degree of this apparent increase in the snail kite's population needs to be confirmed with alternative methods of estimating population size.

Bennetts and Kitchens (1997a) found that radio telemetry is an effective, but costly, method for estimating survival of snail kites. They suggest that mark-resighting is an effective and statistically reliable method for determining survival and population size. The FWS endorses the proposal to replace the annual snail kite counts with the mark-resighting methodology. This will require a continued commitment to support this work to ensure that a sufficient number of birds are marked. As the number of marked birds increases over several continuous years of marking, the number of resightings should increase, and this will allow a population estimate with a reasonable level of precision.

It is difficult to identify any long-term trend in reproductive success, because of the considerable variability in nest success among years, locations, and local nest environments (Sykes 1979, 1987c; Beissinger 1986; Bennetts *et al.* 1988; Snyder *et al.* 1989a), but several of these researchers have attributed the variability to water levels. As noted above, part of this effect, particularly in the lakes, is attributed to differences in nest site selection (more herbaceous substrates in low-water years versus a higher proportion of woody substrates in high-water years). The basis of comparison is between high-water years versus low-water years, rather than within-year differences between water depth at nest sites. Drought may affect nesting success by depressing apple snail populations (Kushlan 1975, Beissinger and Takekawa 1983) and through increased access by terrestrial predators (Beissinger, 1986).

Collapse of nests constructed in herbaceous vegetation is also cited as a cause of increased nest failure during low-water years. This is because the water table is usually below the ground surface at willow heads and other stands of woody vegetation during drought, causing snail kites to nest in herbaceous vegetation, where the nests are more vulnerable to collapse. This effect is more prevalent in the lakes than in the Everglades. Weather causes great variability in nesting success; wind storms cause toppling of nests, particularly on Lake Okeechobee and Lake Kissimmee due to the long wind fetch across these large lakes. Cold weather can cause nest failure, either through decreased availability of apple snails or mortality of young due to exposure. Abandonment of nests before egg-laying is common, particularly during drought or following passage of a cold front. The overall fledging success to a nestling age of 6 weeks in the 1980 to 1993 period was 0.83 fledgling/nest or 0.29 fledgling/egg (n = 776 nests) (Sykes *et al.* 1995). Although considerable variability (due to natural and man-caused variation in water levels) should be expected in future years of monitoring, this may serve as a baseline to compare the relative productivity of the snail kite population.

The snail kite has apparently experienced population fluctuations associated with hydrologic influences, both man-induced and natural (Sykes 1983a, Beissinger and Takekawa 1983, Beissinger 1986), but the amount of fluctuation is debated. The abundance of its prey, apple snails, is closely linked to water regime (Kushlan 1975; Sykes 1979, 1983a). Drainage of Florida’s interior wetlands has reduced the extent and quality of habitat for both the snail and the kite (Sykes 1983b). The kite nests over water, and nests become accessible to predators in the event of unseasonal drying (Beissinger 1986, Sykes 1987c). In dry years, the kite depends on water bodies which normally are suboptimal for feeding, such as canals, impoundments, or small marsh areas, remote from regularly used sites (Beissinger and Takekawa 1983, Bennetts *et al.* 1988, Takekawa and Beissinger 1989). These secondary or refuge habitats are vital to the continued survival of this species in Florida.

The principal threat to the snail kite is the loss or degradation of wetlands in central and South Florida. Nearly half of the Everglades has been drained for agriculture and urban development (Davis and Ogden 1994). The Everglades Agricultural Area alone eliminated 8,029 km^2 of the original Everglades, and the urban areas in Miami-Dade, Broward and Palm Beach counties have also reduced the extent of habitat. North of Everglades National Park, which has preserved only about one-fifth of the original extent of the Everglades, the remaining marsh has been dissected into shallow impoundments. The Corps of Engineers' Central and Southern Florida Project encompasses 46,600 km^2 from Orlando to Florida Bay and includes about 1,600 km each of canals and levees, 150 water control structures, and 16 major pump stations. This system has disrupted the volume, timing, direction, and velocity of freshwater flow.

The natural sheet flow pattern under which the Everglades evolved since about 5,000 years ago has not existed for about 75 years (Parker *et al.* 1955, Leach *et al.* 1972, Klein *et al.*1974). The loss of fresh water to seepage, flood control releases to tidal waters, and extraction for irrigation and urban water supply has led to saltwater intrusion in some portions of the former Everglades. Although the major drainage works completed conversion of wetlands to agriculture in the Everglades Agricultural Area by about 1963, loss of wetlands continues to the present at a slower, but significant, rate. In the entire State of Florida between the mid-1970s to the mid-1980s, 105,222 ha of wetlands (including marine and estuarine offshore habitats) were lost (Hefner *et al.* 1994); we do not have an estimate for the loss of freshwater wetlands specifically in central and South Florida in those years.

Degradation of water quality, particularly runoff of phosphorous from agricultural and urban sources, is another threat to the snail kite. The Everglades was historically an oligotrophic system, but major portions have become eutrophic. The concentration of total phosphorus in Lake Okeechobee almost doubled from 49 µg/L in 1973 to 98 µg/L in 1984 (Janus *et al.* 1990). Most of this increase has been attributed to non-point source runoff from agricultural lands north of the lake, in the Kissimmee River, Taylor Slough and Nubbin Slough drainages (Federico *el al.* 1981). Eutrophication also is a concern in the Kissimmee chain of lakes. Nutrient enrichment leads to growth of dense stands of herbaceous emergent vegetation, floating vegetation (primarily water hyacinth and water lettuce) and woody vegetation, which inhibits the ability of snail kites to find food (See also Habitat section above).

Regulation of water stages in lakes and the WCAs is particularly important to maintain the balance of vegetative communities required to sustain snail kites. This is discussed in the Management section of this account.

Shooting of snail kites has been cited in the early literature as a threat (Sprunt 1945; Stieglitz and Thompson 1967; Sykes 1978, 1979). Although waterfowl hunting, particularly on Lake Okeechobee, may lead to shooting of snail kites, there are no recent documented cases (J. Rodgers, GFC, personal communication 1995).

Contaminant analyses have been conducted on snail kites and apple snails, and all contaminant residues (DDT, DDD, DDE, dieldrin, PCBs, mercury, lead, and arsenic) have been found at low levels (Stickel *et al.* 1969, 1970, 1984; Lamont and Reichel 1970; Wiemeyer *et al.* 1980; Patee *et al.* 1981; Sykes 1985b; Sykes *et al.* 1995; Eisemann *et al.* 1997).

Demographic concerns appear to outweigh immediate genetic threats for the snail kite in Florida. Rodgers and Stangel (1996) performed electrophoresis on samples from 150 snail kite nestlings at four wetland sites: Lake

Kissimmee, Lake Okeechobee, WCA2B, and WCA3A. They found short genetic distances among snail kites at the four wetlands, suggesting little differentiation within Florida. Despite the historic reduction in the snail kite population to low levels, heterozygosity in the snail kites at these locations varied from 4.1 percent to 5.2 percent, which is within typical values for birds. If the snail kite population were to decline in the future, this study provides a baseline to determine if heterozygosity has been reduced. However, there is no immediate concern about reaching a genetic bottleneck.

Management

Water management actions in the Everglades and in the lakes are the most important human-controlled factors in survival and recovery of the snail kite. A balanced approach to water level management is required to maintain favorable habitat conditions for the snail kite. Nearly continuous flooding of wetlands for > 1 year is needed to sustain apple snail populations (Sykes 1979, Beissinger 1988). Prolonged drying of wetlands, especially in an impounded area with little variation in water depth, can cause the local depletion of apple snails. Snyder *et al.* (1989a) attributed poor reproductive success of snail kites in WCA3A in years following drought to a lag time between re-flooding and recovery of apple snails to levels that allow higher nesting success.

When low-water stages occur during the nesting season on Lake Okeechobee and the Kissimmee Chain of Lakes, snail kites frequently nest in the waterward edge of herbaceous vegetation, where nests are more vulnerable to collapse due to the inability of the vegetation to support the nest and the greater exposure to wind, waves, and boat wakes. The location of the nests closer to open water during periods of low water also exposes snail kites to a potentially greater level of human disturbance. A water stage of 4.42-4.57 m on Lake Okeechobee is recommended near the beginning of the snail kite nesting season during most years (Sykes *et al.*1995, Rodgers 1996, J. Rodgers, GFC, personal communication 1996). The water stages can be allowed to recede gradually during the February through May period, to allow for successful foraging by wading birds, but should not be allowed to decline rapidly. However, prolonged periods (1 or 2 years) of water stages over 4.57 m are considered adverse to maintaining marshes in the littoral zone of Lake Okeechobee. Extended periods of high-water stages in Lake Okeechobee will drown out vegetation in the littoral zone. The lake is surrounded by a levee; above a water elevation of 4.57 m, water begins to rise against the levee, and there is no opportunity for marsh vegetation to expand to higher ground elevations. Rodgers (GFC, personal communication 1996) has initiated a similar analysis intended to correlate water stages in Lake Kissimmee with successful nesting. However, it should be noted that Lake Kissimmee is not surrounded by a levee, and although extended high-water stages might temporarily disrupt existing vegetation patterns, wetland vegetation could adjust in the longer term by shifting landward to higher ground elevations. In impounded areas, such as the WCAs and the St. Johns marshes, extended periods of high water can drown out willow or other woody vegetation. The availability of woody vegetation often results in higher fledging success through reduced nest collapse, which is more prevalent in non-woody substrates.

Lake Kissimmee and the surrounding lakes have been restricted to narrow water regulation schedules when compared to their natural degree of variability in years prior to regulation. Overly dense concentrations of vegetation begin to grow in the littoral zone, which restricts water flow and leads to the buildup of organic sediment in bands around the lakes' shorelines. This pattern is harmful to the overall productivity of the lakes. Ideally, lake management schedules throughout the Kissimmee Chain of Lakes should be modified to resemble the degree and timing of water level fluctuations in the pre-management period. However, water regulation schedules are now restricted by the proximity of floodable structures to shorelines and by water supply considerations.

Because these societal constraints make it impractical to fluctuate water levels according to historic cycles of flooding and drought, the SFWMD and the GFC have proposed periodic extreme drawdowns, with or without physical removal of organic sediment. Drawdowns were conducted on Lake Tohopekaliga in 1986 and East Lake Tohopekaliga in 1990. Snail kites did not resume nesting after the 1986 drawdown at Lake Tohopekaliga until 1990. The drawdown at East Lake Tohopekaliga caused the abandonment of 10 of 12 nests in 1990 (Rodgers 1994). The reason for the delay in resumption of nesting after the 1986 drawdown at Lake Tohopekaliga is not fully understood. However, snail kites have returned to nest in that lake in recent years, so the impact appears to be temporary. The loss of snail kite nests at East Lake Tohopekaliga in 1990 apparently was caused by the inability to remove the water quickly enough to below the level of the waterward edge of the littoral marsh before snail kites began to nest. Emergency dredging of an outlet canal was required to accelerate the drainage of water beyond the edge of the marsh. Lake Kissimmee was drawn down 1.5 m below its normal regulation schedule in 1977 and again in 1996. No recent snail kite nesting occurred on Lake Kissimmee prior to 1982. In 1996, dredging across a shoal occurred prior to commencement of the drawdown to speed up the drainage. Lake Kissimmee water stages were drained quickly enough before February 1996 such that snail kites did not attempt to nest there; presumably, snail kites dispersed to other suitable areas to nest. Snail kites returned to nest in Lake Kissimmee in 1997 and 1998, following the 1996 drawdown.

With adequate planning, extreme drawdowns can apparently be carried out without adversely affecting the snail kite and can enhance foraging conditions by opening up the dense vegetation. Any restrictions preventing rapid drainage of water need to be removed in advance. To date, the FWS has recommended that drainage should be initiated immediately after the threat of hurricanes has passed (around November 30) and that the water should be lowered beyond the extent of herbaceous vegetation prior to February 1 to discourage nesting of snail kites in areas where nests are likely to collapse. However, recent research by Darby *et al.*(1997) indicates that early drying may be far more detrimental to apple snail populations (and by extension, detrimental to snail kites) than the incidental take of snail kite nests that early drying is intended to avoid. Darby *et al.*(1997) suggest that the adverse impact on apple snails is lessened when drying occurs after the snails have completed their reproductive cycle and the young are of sufficient size to withstand a drying event. Not suprisingly, this point is "normally" reached during late May or June, the time that the natural system reached its minimum water levels. Further research on apple snail biology and the effects of the timing of drying events on snail kite nesting is needed to provide water managers guidance on the timing of intentional drawdowns that will maximize the long-term benefits on habitat structure while minimizing the short-term adverse impacts on snail kites and apple snails.

Anthropogenic drying of snail kite habitat in one watershed (*e.g.* St. Johns Marsh) should not coincide with natural drying in another watershed (*e.g.* Everglades). Although long-range prediction of drought and wet cycles is still not exact, consideration of the periodicity of these cycles should be factored into planning for periodic drying of managed areas. A strong correlation between the *El Niño*-Southern Oscillation (ENSO) cycle and precipitation in Florida was reported by Hanson and Maul (1991). Zhang and Trimble (1996) used three indicators of global climate cycles (sunspot number, geomagnetic activity, and the Southern Oscillation Index) in a neural network computing environment to predict inflows to Lake Okeechobee. Neidrauer *et al.* (1997) suggest that a combination of these indices can be used in water management decisions for Lake Okeechobee, based on a 6-month inflow forecast. These models should be refined and further tested, and as suggested by Zhang and Trimble (1996), the model's forecast horizon should be extended to determine how reliably it can predict longer-term shifts in rainfall patterns. The FWS recommends that this be based not only on inflows to Lake Okeechobee, but also be calibrated against other gages in the C&SF system. Because strong *La Niña (*conditions oposite to *El Niño*) conditions are generally associated with drought in Florida (Zhang and Trimble 1996), these indices may be useful in planning several years into the future to reduce the probability of human-caused drawdowns in one watershed coinciding with drought in another watershed. Human-caused drawdowns might be most adverse to the snail kite at the onset of multiple-year droughts, because it may be difficult to refill lakes or marsh impoundments during the following years, and the snail kite will have reduced opportunity to find suitable habitat.

Reduction of nutrient loading to marshes is needed to slow the growth of dense vegetation which hampers efficient foraging by snail kites. Efforts to reduce nutrient loading are being conducted to benefit the South Florida Ecosystem as a whole, and will have benefits to a number of fish and wildlife species in addition to the snail kite. Best Management Practices (BMPs) have been effective in reducing nutrient input to Lake Okeechobee from the Kissimmee River, Taylor Slough, and Nubbin Slough drainages. BMPs are included in implementation provisions of the Everglades Forever Act of 1994 (Chapter 373.4593 FS), as are the construction of Stormwater Treatment Areas. More effort needs to be directed at identifying and rectifying problems with nutrient inputs to the peripheral habitats so critical to the snail kite during drought.

Control of aquatic weeds has probably improved foraging conditions for the snail kite in a few localized areas by opening up dense growths of water hyacinth, water lettuce, and *Hydrilla.* However, spraying should not occur near snail kite nests located in non-woody species (*e.g.*, cattail, bulrush). The SFWMD, the GFC, and the DEP have cooperated in closing areas to herbicide spraying around snail kite nests, which reduces the risk of nest collapse in Lake

Okeechobee and Lake Kissimmee. However, more research is needed on the long-term effects of the herbicides being used on the aquatic food web in general, and particularly apple snails with respect to snail kites.

Nest baskets have been used effectively to reduce the collapse of nests in herbaceous substrates along the northwestern shoreline of Lake Okeechobee (Sykes and Chandler 1974). Similar nest supports have been used by GFC on Lake Tohopekaliga and East Lake Tohopekaliga. Although use of nest baskets may be a useful management technique in specific areas and instances (for example, to protect nests during a drawdown), their use on a routine basis is now considered to provide limited benefits relative to the intensive effort required (R. Bennetts, University of Florida, personal communication 1996; J. Rodgers, GFC, personal communication 1996).

Because snail kites use habitats with long hydroperiods, fire is not normally considered a management concern. However, fire is a natural component in the ecology of the Everglades and all of South Florida, and it is reasonable to expect that intense fires occurred historically during periods of drought in the snail kite's habitat. Intense fires that burn peat can transform habitats in the Everglades; dense sawgrass marshes having heavy fuel loads can be converted into a spikerush (*Eleocharis*) marsh, which will not carry fire for many years (Craighead 1971, Hoffman *et al.* 1994). Although such a fire would most likely eradicate apple snails from a particular location, its conversion to a spikerush marsh would, following recolonization by apple snails, make the area more suitable for foraging by snail kites. Prescribed burning could be implemented in conjunction with the intentional drawdowns mentioned above and in selected areas during drought.

The challenge for land managers is that intense fires are more difficult to control. Peat fires can smolder for weeks after initial passage of the fire (Craighead 1974, Robertson 1955); it may be difficult to prevent such fires from entering tree islands and hammocks, which may be of concern to managers if these areas are not the intended targets of the burn. Monitoring of vegetation, apple snails, and snail kite foraging in test plots before and after prescribed burns would provide useful information for refining fire management practices. Use of fire as a management tool in lakeshore environments may be more predictable and desirable than in the Everglades, where muck fires are considered to be damaging to tree island habitats and probably contributing to invasion of cattails.

Some authors have emphasized the importance of the availability of suitable habitat during periods of drought, which were thought to be a limiting factor in the population (Beissinger 1986, Sykes 1987b). Drainage of Florida's interior wetlands has reduced the extent and quality of habitat for both the snail and the kite (Sykes 1983b). Also, the kite nests over water, and nests become accessible to predators in the event of unseasonal drying (Beissinger 1986, Sykes 1987c). In dry years, the kite depends on water bodies which often are suboptimal for feeding during periods of normal rainfall, such as canals, impoundments, or small marsh areas, remote from regularly used sites (Beissinger and Takekawa 1983, Bennetts *et al.* 1988, Takekawa and Beissinger 1989). Beissinger and Takekawa (1983) and Takekawa and Beissinger (1989) divided snail kite habitat into “primary,” secondary” and “drought-related” areas. Bennetts (University of Florida, personal communication 1996) disagrees with characterizing any particular area into those categories; he believes that snail kites spread the risk of fluctuating habitat conditions by their ability to move long distances across the landscape within a “network” of habitats. Bennetts and Kitchens (1997b) hypothesize that the spatial extent and heterogeneity of habitat quality throughout the snail kite’s range buffers the risks that may be posed by droughts, because the spatial extent and duration of drought conditions will vary across the species’ range. Protection of both larger and smaller wetlands in several subregions (St. Johns Marsh, Kissimmee Chain of Lakes, Lake Okeechobee, Loxahatchee Slough, and Everglades/Big Cypress) is required to maintain this spatial heterogeneity and spatial extent. Because the 1992 to 1995 duration of Bennetts’ study did not include a period of drought, continued radio tracking of snail kites during a drought will be necessary to confirm this hypothesis.

Bennetts *et al.* (1988) found that snail kites nesting in WCA3A used wetlands having multi-year hydroperiods ranging from about 84 percent to 99 percent. However, Bennetts and Kitchens (1997a) have emphasized that foraging snail kites use a heterogeneous mosaic of wetlands. Snail kites will forage in shorter hydroperiod portions (wet prairies) within larger areas of longer hydroperiod (predominance of slough or lacustrine communities). Snail kites will also forage in smaller sloughs within areas that are primarily wet prairies. Therefore, in defining the desired future condition of the WCAs following hydropattern restoration, one must recognize the importance of a heterogeneous landscape within wetlands of relatively long (>85 percent) average hydroperiod. One must also acknowledge that these areas will dry out periodically. In evaluating the effects of these drying events on the demography of the snail kite, one must consider the average interval between drying events, their duration, and their spatial extent. Localized drying events are thought to have little adverse effect on the snail kite population, but droughts across the region extending from the St. Johns Marsh and the Kissimmee Chain of Lakes to the southern Everglades are likely to have adverse effects, particularly if the droughts occur in 2 or more consecutive years (Bennetts and Kitchens 1997a, 1997b).

Another factor to be considered in evaluating restoration of the WCAs is water depth. The compartmentalized system of WCAs differs from the natural system in at least two ways. First, increasing water flows in the natural system resulted in spreading of water across the landscape. In the managed system, water is confined within levees; increased water volumes result in water depths greater than those found in the natural system. Second, the levees surrounding the WCAs result in over-drained conditions at the upstream northern ends, and deeper water accumulation at the southern ends of the WCAs. The duration of these deep water conditions behind the levees is artificially prolonged relative to historic conditions (Gunderson and Loftus 1993). The appropriate restoration target for major portions of the WCAs is a heterogeneous wetland having a prolonged hydroperiod over most of the area, but without extended periods of deep water.

Another factor in restoration of the WCAs that will affect the habitat conditions for the snail kite and a variety of Everglades fauna is the effect of hydropattern restoration on growth of cattails. Rehydration of currently drained portions of the WCAs, such as northern WCA3A, will most likely result in growth of cattails, due to elevated phosphorus levels in the soil. The extent of the affected area and the time period that the cattail stands will persist is currently being debated. This effect must be considered in predicting habitat conditions in the WCAs following hydropattern restoration.

The Everglade snail kite population is now considered more resilient than previously thought to natural climatological fluctuations, but the resilience of kites to human-induced changes is less certain (Bennetts *et al.* 1994). The species is adapted to “boom and bust” cycles, and any consideration of recovery must be based on long-term (at least 5- to 10-year) averages in population levels and/or reproductive success. Radio telemetry indicates that snail kites use a broader network of wetland habitats than was previously recognized. Additional research is needed on survival following periods of drought. Previous opinions regarding the amount of mortality following drought may have been biased by lack of knowledge about the full range of dispersal of the species; mortality may have been overestimated because widely dispersed individuals were living in habitats not regularly searched (Bennetts *et al.* 1999a; Valentine-Darby *et al.* in prep.). Despite the previously mentioned problems in interpreting the annual counts, the general consensus is that the snail kite population has been at least stable since 1969, and has likely increased, on average, within a broad range of fluctuation (Bennetts *et al.* 1999a).

Anticipated restoration projects should benefit the Everglade snail kite. The FWS has predicted that the Kissimmee Headwater Lakes Revitalization Project and the Kissimmee River Restoration will benefit a variety of fish and wildlife, including the snail kite. Restoration of the Everglades should provide opportunities for recovery of the kite, but Bennetts *et al.* (1994) point out:

> Undoubtedly, compromise solutions will need to be identified in order to accommodate increasing demands for water, habitat for snail kites, and flow systems that will maintain the unique Everglades environment. Almost any proposed solution to the problems of the Everglades and the kite will meet with opposition from individuals or groups with differing objectives or viewpoints. Current restoration planning in the southern Everglades is no exception. Arguments can easily be made for restoring longer hydroperiods in the historic Shark River Slough. It is likely that the deeper areas of the slough and other pools within the Everglades basin were once used extensively by kites. It can also be argued, however, that the impoundments of the WCAs now serve this role and that substantial reductions in hydroperiod in these impoundments may, at least in the short term, have a negative impact on kites. It is not even clear that substantial reductions in hydroperiod would occur in the specific areas that are used most heavily by kites. What is certain is that whatever plans are adopted, they will not be unopposed.

It is appropriate to cite the fate of the WCAs as an example of likely controversy in Everglades restoration; the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy) must carefully consider the design of hydropattern restoration in the WCAs.

Another controversial issue not addressed in the above quotation is the management of water stages in Lake Okeechobee with respect to the downstream portions of the C&SF system. Opinions vary on the degree to which the ecological values of the littoral zone of Lake Okeechobee (which includes a portion of the Everglade snail kite's critical habitat) can be sacrificed to create increased water storage capacity to drive restoration of the Everglades. This and possibly many other pivotal issues must be evaluated through the C&SF Restudy.

A balanced restoration plan for the Everglades must be found that will mimic the hydrologic variation and other habitat characteristics of the natural system. We believe the restoration can be planned and carried out without conflicts among the recovery goals for listed species.

Because of the particular habitat requirements of the snail kite, the loss of spatial extent of the wetlands throughout the species' range, and the possibility of back-to-back catastrophic events, it may not be possible to remove the species entirely from protected status. {We believe the prognosis for recovery of the snail kite from endangered status to threatened by 2020 is good.}. The recovery goal should not be based solely on population estimates, but should also include measures of survivorship and fecundity. Reclassification to threatened could occur with a minimum population size of 650 individuals over a 10-year period, with a multi-year average finite rate of population change (λ, lambda) greater than or equal to 1. The breeding population should be distributed over enough individual "colony" sites and over a broad enough total area to ensure survival through catastrophic events, but until more precise stochastic modeling is available, we do not have a specific recovery criterion of this type. If the species meets these goals for reclassification as threatened, the FWS would then consider requirements for de-listing.

Recent biological studies of the Everglade snail kite indicate the species is highly mobile and adaptable, which might support a more optimistic view of the status and prognosis for the snail kite. However, recent information on the apple snail indicates that the species suffers high post-breeding mortality each year regardless of the hydrological condition, and may suffer poor recruitment of juvenile snails in the year following a drydown (P. Darby, University of Florida, personal communication 1997). Apple snails are stranded by receding water levels, even along a lake shore, where presumably snails could migrate to the remaining pool. Adult snails survived an average of 4 weeks under drydown conditions at the St. Johns Marsh (Darby *et al.* 1996a) and at Lake Kissimmee (Darby *et al.* 1996b, 1997). The vulnerability of apple snails to localized severe population declines must be considered in water management policy and in assessment of threats to the snail kite.

Continued monitoring of the snail kite population will be needed before, during, and after implementation of the many elements presently under consideration that together will result in restoration of the South Florida Ecosystem. Among the factors favoring the selection of the snail kite as a key indicator of success are the following:

a. The snail kite is an endangered species and is reasonably familiar to a large segment of the public.
b. In the United States, the snail kite is found only in the central and South Florida Ecosystem, making it a suitable biological symbol for the ecosystem as a whole.

c. The snail kite is a species adapted to the variable climatic conditions in central and South Florida, and the Everglades in particular. Water management in the restored ecosystem must be flexible enough to ensure survival and recovery of the snail kite through climatological extremes. Successful recovery of the snail kite should be included as one of several indicators of restoration of the dynamic variability of the long hydroperiod wetlands within South Florida.

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Recovery for the Everglade Snail Kite

Rostrhamus sociabilis plumbeus

Recovery Objective: RECLASSIFY to threatened once recovery criteria are met.

Recovery Criteria

The objective of this recovery plan is to restore the Everglade snail kite to a stable, secure and self-sustaining status allowing the reclassification of the species from endangered to threatened under the ESA. Due to the limited distribution of the species, its specialized ecological niche, and the irreversible loss of a significant portion of the Kissimmee/Okeechobee/Everglades watershed, the FWS believes it unlikely that the snail kite will ever be elevated above the threatened status. This objective will be achieved when: the 10-year average for the total population size is estimated as greater than or equal to 650, with a coefficient of variation less than 20 percent for the pooled data over the 10-year period; no annual population estimate is less than 500 in the 10-year period; the rate of increase of the population to be estimated annually or biannually, and over the 10-year period, will be greater than or equal to 1.0, sustained as a 3-year running average over 10 years; the feeding range of snail kites will not decrease from its current extent, including as a minimum, the St. Johns Marsh, the Kissimmee Chain of Lakes, Lake Okeechobee, Loxahatchee Slough, Loxahatchee NWR, all of the water conservation areas, Everglades National Park, Big Cypress National Preserve, Fakahatchee Strand, Okaloacoochee Slough, and marshes surrounding the Corkscrew Swamp; and snail kite nestings regularly occurs over the 10-year period in the St. Johns Marsh, Kissimmee Chain of Lakes, Lake Okeechobee, and at least one of the present compartments of the water conservation areas.

The FWS recognizes that the snail kite is a resilient species in a highly changeable environment and that to some degree a "boom and bust" population fluctuation is characteristic of the species. The above criteria for reclassification to threatened are flexible enough to allow substantial declines in population within a given year, while setting goals over a 10-year period. The global climate fluctuations that are correlated with cycles of flood and drought in South Florida occur on a periodicity of 9 to 14 years (Zhang and Trimble). 1996. The use of 650 individuals as a criterion for recovery needs to be supported by improved techniques of Population Viability Analysis (**H3.1**, below). Beissinger (1995) suggested that snail kite populations become viable above a minimum population size of 300 individuals, but this PVA needs to be re-evaluated based on the more precise population estimates anticipated from mark/resight techniques.

Species-level Recovery Actions

S1. Maintain information on the distribution and status of the Everglade snail kite. The present distribution of the snail kite and its recent history of distribution are well documented. Distribution must be monitored in the future. Radio-telemetry has provided information on movement of individuals within the species' range, but would not be continued on a routine basis.

S1.1. Estimate population size, through mark/resighting of banded individuals. This method is considered technically superior to counts of snail kites at index locations because it allows estimation of the proportion of kites not observed and is less subject to certain errors, such as those caused by differences in experience among individuals conducting the counts and by year-to-year differences in the level of effort. Annual counts of snail kites at index locations do not provide a reliable estimate of population size, nor do they allow estimation of the coefficient of variation (Bennetts *et al.* 1999a), which is an integral part of the recovery criteria expressed above. An ongoing pilot study by Victoria Dreitz indicates that the mark/resighting techniques used by Bennetts *et al.* (1999b) to estimate survival is promising as a methodology to estimate population size (R. Bennetts, Station Biologique de la Tour du Valat, personal communication 1998). This method requires considerable commitment of resources to annually mark sufficient numbers of snail kites; this level of funding and personnel may be difficult to sustain in the long term.

S1.2. Continue surveys of nesting effort and success at the principal breeding areas. Monitoring of breeding should continue at principal breeding sites, such as the St. Johns marsh, Kissimmee Chain of Lakes, Lake Okeechobee, and Water Conservation Areas 2 and 3.

S1.3. Expand and refine existing information on movements and distribution of the snail kite, particularly changes attributable to drought. Radio telemetry has provided information on movements of snail kites within South Florida; it is expensive and labor-intensive. It may be logistically impractical to design and implement a radio telemetry study quickly enough to respond to a specific drought event. Additional radio telemetry studies should be initiated only to test specific hypotheses that cannot be tested through other methods.

S1.4. Organize and maintain a network of biologists to report Everglade snail kite sightings to a clearinghouse. In the past, information on snail kite sightings was requested from the general public, which led to unreliable reports. However, professional biologists can often provide reliable and useful sighting information, particularly when snail kites are dispersed during droughts.

S2. Protect and enhance the existing population. Because of the nomadic nature of snail kites, they integrate habitat conditions over a large geographic area and are dependent on natural and human-caused environmental conditions throughout the South Florida Ecosystem. The majority of management activities to protect and enhance the snail kite population must occur at an ecosystem level (see below). Actions at the level of the individual or groups of individuals included in the 1986 recovery plan are now considered extremely labor-intensive and would have limited benefit to the species. Such activities include installation of artificial perches and installation of artificial nest structures. Limited experimentation with captive propagation has shown it to be difficult, and the snail kite population is now considered more resilient and not currently in need of such emergency measures. Only two species-specific recovery tasks in this category are considered necessary at this time:

S2.1. Update the critical habitat designation for the Everglade snail kite. Critical habitat has not been modified since its original designation in 1977 and is in need of revision. Earlier publications correctly pointed out the importance of Lake Okeechobee and the Everglades as snail kite habitat. However, more recent information suggests that although restoration of Lake Okeechobee and the Everglades must be compatible with snail kite recovery, greater emphasis must be placed on larger wetland systems in the species, range and on smaller peripheral wetlands. Nesting of snail kites in Lake Kissimmee, Lake Tohopekaliga, and East Lake Tohopekaliga since the early 1980s is a significant change that should be considered in revising critical habitat. Although a portion of the St. Johns Marsh south of State Road 60 is included in the current critical habitat, the principal areas being used by snail kites north of that highway need to be included. Other areas outside of the Okeechobee/Everglades basin that should be considered for designation are the Big Cypress National Preserve and marshes surrounding the Corkscrew Swamp.

S2.2. **Use provisions of section 7 of the ESA to protect the Everglade snail kite**. Water management of the COE's C&SF project is critical to the survival and recovery of the snail kite. The SJRWMD and SFWMD are involved with the COE in water management decisions subject to section 7 consultation. The FWS needs to provide conservation recommendations to enhance habitat conditions for the snail kite throughout the C&SF project. Specific guidance should include water regulation of the St. Johns Marsh impoundments, Kissimmee Chain of Lakes, Lake Okeechobee, Loxahatchee NWR, Water Conservation Areas 2 and 3, Everglades National Park and Big Cypress National Preserve.

S3. Continue or initiate research on the life history of the Everglade snail kite.

S3.1. **Expand information on survival of juvenile and adult snail kites.** Although snail kites have been banded for decades, intensive banding for estimation of survival has occurred only since 1992. Intensive banding must be continued through long-term meteorological cycles to estimate the effects of drought on snail kite survival. This is a key unknown element in the life history of the species that has significance in assessing opportunities for recovery and probability of extinction relative to natural cycles and water management policy.

S3.2. **Develop and validate a snail kite model that can evaluate both stochastic natural events and human-caused modifications of habitat throughout the species' range.** An individual-based spatially explicit snail kite model is being developed as part of the Across Trophic Level System Simulation (ATLSS). The geographic scope of ATLSS does not include the Kissimmee Chain of Lakes or the St. Johns Marsh. While complete modeling across all trophic levels will not include these northern areas, they should be appended to the boundaries of the model at levels dealing with snail kite dispersal, reproduction, and survival, to model the snail kite population as a whole.

S3.3. **Investigate the genetic variability of the Everglade snail kite.** Analysis by electrophoresis has not indicated the potential for a genetic bottleneck in the snail kite population. Although additional genetic research does not appear to be a high recovery priority, analysis of heterozygosity using DNA analysis would be desirable.

S4. Monitor trends in Everglade snail kite population and levels of contaminants.

S4.1. **A mark-resighting effort will provide estimates of both total population size and survival.** Because marking of birds is most often conducted at nesting aggregations, routine monitoring has included counting the total nests and determining nesting success. However, there is general agreement among researchers that changes in the kite population is more sensitive to survival than reproduction. Although researchers should continue to monitor reproduction at the major nesting areas, the emphasis of long-term monitoring should be estimation of total population size and survival.

S4.2. Conduct periodic monitoring of contaminant levels in apple snails and Everglade snail kites. The limited sampling of apple snails and Everglade snail kites to date has emphasized the potential risks of methylmercury contamination. Although this limited sampling has not suggested an immediate threat to snail kites from mercury contamination, additional studies should be conducted on a regular basis in the long term (approximately 5 to 10 year intervals). Apple snails can be collected specifically for analysis, whereas analysis of snail kites is generally limited to occasional discovery of dead specimens or analysis of shed feathers. More emphasis must be placed on detection of herbicides in both apple snails and snail kites. Snail kites can ingest apple snails containing herbicides (such as bypiridyls), applied in agricultural fields and transported by runoff into the aquatic food web, or herbicides (such as fluoridone), applied to control aquatic vegetation.

S5. Increase public awareness about Everglade snail kites. A snail kite brochure has been distributed via donations from the St. Johns River Water Management District, Palm Beach County Solid Waste Authority, and Florida Power and Light Co. This material should be reviewed, updated, and published as a second edition. The GFC is developing signs to inform ORV users at launching sites along I-75 about responsible ORV use, including protection of the snail kite. Funding is needed to produce and install similar signs informing the public about protection of snail kites at boat launching sites in the Kissimmee Chain of Lakes, St. Johns marsh, and Lake Okeechobee. Information on the biology of the snail kite and the threats it faces should be included in middle school and high school curricula.

Habitat-level Recovery Actions

H1. Prevent degradation of existing Everglade snail kite habitat.

H1.1. Plan and carry out periodic extreme drawdowns of individual lakes on a rotational basis in the Kissimmee Chain of Lakes. These projects involve extensive cooperation and cost sharing among a number of agencies, often including simultaneous lake management activities, such as muck removal, discing, burning, and aquatic weed control. Water levels must be lowered early enough to avoid initiation of nesting by snail kites and thus prevent incidental take of nests. Cooperation is needed between the water management districts to ensure that no more than one human-caused drawdown occurs simultaneously among the principal habitats for the snail kite.

H1.2. Control or remove exotic vegetation in wetlands. The long-term direct and secondary effects on snail kites or apple snails of spraying aquatic weeds are poorly known. Research on these long-term impacts should be initiated. Current control programs are mainly directed at *Melaleuca quinquenervia*, *Schinus terebinthifolius*, and *Hydrilla verticillata.*

H1.3. Use controlled burns to open up areas of overly dense herbaceous and/or shrubby vegetation in lake littoral zones and marshes. Burning can be accomplished under natural low water conditions or in conjunction with the extreme drawdowns mentioned above. Although controlled burns with the presence of surface water or saturated soils may be beneficial, it would probably not be practical or advisable to attempt to change plant communities through uncontrollable muck fires in the Everglades.

H1.4. Ensure that information on wetlands of importance to Everglade snail kite nesting and feeding is considered in review of regulatory permits. The COE and DEP are preparing GIS data layers that will be routinely available to regulators. Information on snail kite nesting areas and other important habitats needs to be included.

H1.5. Prevent cultural eutrophication of lakes and marshes. Addition of nitrogen and phosphorus from agricultural and residential areas is accelerating eutrophication of Florida's lakes and marshes. Long-term degradation of habitat caused by eutrophication leads to buildup of organic muck, overly dense herbaceous and shrubby vegetation, and oxygen depletion. Moderate eutrophication may not harm the snail kite, but in the long term, both the abundance of apple snails and the ability of snail kites to locate snails in dense vegetation is reduced. Reduction of nutrient inputs at the source needs to be addressed by best management practices, including rates of application and stormwater retention on site. Construction and maintenance of wastewater treatment plants must be improved to control discharge of nutrients in lakes and streams.

H1.6. Evaluate effects of Lake Okeechobee's regulation schedule on Everglade snail kite habitat. Observations since 1992 suggest a general degradation of nesting habitat in the littoral zone of Lake Okeechobee from the loss of willows in nesting areas (R. Bennetts. Station Biologique de la Tour du Valat, personal communication 1998). Modification of the regulation schedule to increase water storage could cause additional loss of vegetation in the littoral zone, which would be adverse to the ecology of the lake as a whole, including the snail kite. Conversely, extending periods of low water in the lake through a combination of agricultural, urban, and environmental restoration demands would also be detrimental to the snail kite. Evaluation of proposed changes to water regulation in Lake Okeechobee must consider the effect on the snail kite in the context of protection of all the fish and wildlife resources in the lake and elsewhere in the C&SF system. Long-term monitoring of changes in wetland vegetation in relation to water management practices needs to be conducted throughout the C&SF system as indicators of habitat suitability for snail kites, rather than relying on short-term changes in snail kite population, distribution, or reproduction.

H2. Restore areas to suitable habitat.

H2.1. Reverse the expansion of cattails as a dominant plant in portions of the Everglades through reduction in nutrient loading from agricultural and urban sources. Portions of the Water Conservation Areas and the Holey Land WMA are now relatively unsuitable habitat for the snail kite due to growth of dense monocultures of cattails. The Everglades Construction Project and additional treatment areas (such as portions of the Water Preserve Areas in the C&SF Restudy) need to be implemented. The influence of nutrient levels bound in the soil on the persistence of cattails after water quality improvement needs to be predicted and then determined empirically.

H2.2. Construct and operate the Modified Water Deliveries to Everglades National Park and C-111 projects. These projects will restore flow patterns to northeast Shark River Slough and other portions of the southern Everglades, enhancing Everglade snail kite habitat.

H2.3. **Through the C&SF Restudy, investigate, plan, and carry out restoration projects in the Kissimmee/Okeechobee/Everglades watershed.** As a whole, restoration projects proposed through the C&SF project should restore water quantity, water quality, timing, and sheetflow, as opposed to flow through canals Wherever practical, impoundment of water behind levees should be reduced, provided that this action does not overdrain areas upstream of the presently impounded areas. The establishment of Water Preserve Areas and additional compartments for storage and treatment of water should be reviewed for management opportunites that may support recovery of the Everglade snail kite.

H3. Conduct research on the biology and life history of the Everglade snail kite.

H3.1. **Complete and use ATLSS modeling of the snail kite to predict the response of snail kites to changes in hydropattern anticipated for specific water management proposals.** In addition to the need to correctly describe the life history of the snail kite itself, the ATLSS modeling must include linkage to apple snail distribution and abundance, vegetation characteristics in the landscape influencing the snail kite's successful foraging, and linkage of all these factors to hydrology. ATLSS simulations (and/or other Population Viability Analysis models) can also provide estimates of the vulnerability of the snail kite population as a whole to extinction. Such information should be used to refine, if necessary, our use of 650 birds as a recovery criterion.

H3.2. **Continue and expand research on the effects of natural and human-caused hydrologic events on the ecology of the apple snail.** This research will provide needed information for the ATLSS modeling described above, and even before completion of ATLSS, this research can be used in decisions on water management.

H3.3. **Evaluate the effectiveness of long-term climate predictions to reduce the likelihood of coincidence of human-caused drawdowns and drought.** Prediction of long-term climate patterns is still inexact, but climatological monitoring can increasingly predict the probability of *El Niño* events perhaps 1 or two years in advance. Florida's subtropical climate is significantly affected by these global shifts, and this may be useful in adjusting water regulation schedules according to anticipated "wet" or "dry" years. Human-caused drawdowns should be avoided prior to entering a drought, because snail kites will have fewer options for refuge from drought and because refilling of drained lakes or marshes will be prolonged during drought.

H3.4. **Perform a detailed statistical analysis of rainfall records throughout central and South Florida to identify the intensity and spatial and temporal extent of droughts.** This information will provide an estimate of the threat to the snail kite from region-wide drought. It will be used to estimate the probability of extinction over long time scales in response to severe drought under a range of future land use scenarios.

H3.5. **Evaluate the need for secondary treatment in addition to the nutrient removal afforded by macrophytic stormwater treatment areas.** Determine effective methods of treatment to reduce nutrients below levels affecting the ecology of the Everglades.

H4. Monitor habitat/ecological processes. Expansion of existing monitoring programs throughout the C&SF system is expected as restoration projects are generated through the C&SF Restudy, with an increased emphasis on adaptive management. The snail kite should be included in monitoring of ecological indicators along with analysis of vegetation patterns and hydrology throughout the system.

H5. Increase public awareness of ecological relationships, environmental stressors, and restoration activities in the South Florida Ecosystem. Because the range of the snail kite coincides closely with the C&SF system and because it is endangered, it can serve as a symbolic species for restoration efforts in South Florida. Information on the kite's status, threats, and its ecological relationship with other species should be integrated in public education on restoration activities. Public outreach can include newsletters, newspapers, magazines, the worldwide web, and classroom materials.