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SNAIL KITE DEMOGRAPHY IN BLUE CYPRESS MARSH COMPLEX FINAL REPORT 2010

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ABSTRACT

The purpose of this report is to document snail kite usage and reproduction within the Blue Cypress Marsh Complex (BCMC) during 2008, 2009, and 2010. Comparisons with previous years are also made. Since the snail kite population in Florida is best viewed as a single population, we report additional demographic data at the scale of the whole population.

Fourteen surveys of BCMC were conducted in 2010, with at least one survey occurring in each month of the year. During 2008, 2009, and 2010 the maximum number of snail kites observed during any one survey was 26, 25, and 28 respectively. The highest number of birds were detected during the months of April and May. Similar to most years, more snail kites were typically observed in the eastern section of BCMC than in the western section. The number of kites using BCMC has been considerably greater during 2008-2010 compared to 2007. Nearly all surface water was released from the BCMC in 2007 in an attempt to rejuvenate emergent foraging habitats, and as a result of the intense drawdown, snail kites temporarily left the area. Although water levels were back to normal during 2008-2010, the number of snail kites observed in BCMC remained low relative to recent years (i.e. 2001-2006). A total of four nests were initiated in the BCMC during the 2008 and 2009 breeding season, with all four nests failing before the eggs hatched. Thus, no young were fledged from the BCMC during the 2008 and 2009 breeding season Fourteen active nests were found in the BCMC in 2010, but only one was successful, fledging one young. The slow recovery of the snail kite population in the BCMC marshes may reflect a lag time in the recovery of the apple snail populations from the effects of the 2007 drawdown. There is evidence that BCMC is critical to kites persistence especially when other wetlands experience droughts or drawdowns; however its potential as a source of recruitment is less certain.

Our recent demographic studies show alarming negative trends in the snail kite population. Kite numbers have drastically declined since 1999, with the population essentially halving from 2000 to 2002 and again from 2006 to 2008. A number of factors have likely contributed to the observed population decline, including effects on survival and reproduction from both short-term natural disturbances (e.g. droughts) and long-term habitat degradations (e.g. the conversion of wet prairies to sloughs in WCA3A). There has been a notable decline in snail kite production from two critical snail kite habitats, Lake Okeechobee and WCA3A. Okeechobee, which from 1985 to 1995 was a productive breeding site, has been only a minor contributing unit (in terms of reproduction) since 1996. Snail kite production from WCA3A

declined sharply after 1998, and no kites were fledged there in 2001, 2005, 2007, 2008, or 2010.

This loss of Okeechobee and WCA3A as productive kite habitats has left the population heavily concentrated in and dependent upon the Kissimmee Chain of Lakes (KCOL), particularly Lake Tohopekaliga (Toho), which accounted for 52, 12, 89, 72, 61, and 33 percent of the successful nesting attempts range-wide from 2005-2010, respectively. This strong shift in kite nesting toward Toho raises concerns because the survival of juveniles that fledge there may be significantly suppressed due to their inefficiency at handling the exotic apple snail (*Pomacea insularum*).

A population viability analysis conducted in 2006 predicts very high extinction probabilities in the next 50 years, and the estimate of population size for 2010 (i.e. 826 individuals) suggests that the extinction risk may be even greater than previously estimated.

Eighty percent of the reduction in the stochastic population growth rate is attributable to a decline in adult fertility (i.e. a product of (1) the number of young fledged per adult and (2) juvenile survival). Therefore, we are particularly concerned about the continuing lack of kite production in Okeechobee and WCA3A and potential reductions to juvenile survival due to water management and/or exotic snails because these two demographic parameters are currently limiting population growth

INTRODUCTION

The snail kite (*Rostrhamus sociabilis plumbeus*) is an endangered raptor that inhabits flooded freshwater areas and shallow lakes in peninsular Florida and Cuba (Sykes 1984, Sykes et al. 1995). The historical range of the snail kite once covered over 3.6 million ha in Florida (Davis and Ogden 1994) but is now restricted mainly to the watersheds of the Everglades, Lake Okeechobee, Loxahatchee Slough, the Kissimmee River, and the Upper St. Johns River.

The snail kite is unique in that it is the only avian species whose population in the U.S. is restricted to freshwater wetlands in central and south Florida. The snail kite, in addition to being endangered, is considered by many to be an excellent barometer of the success of the restoration efforts currently underway.

Snail kite habitats in south and central Florida exhibit considerable variation in their physiographic and vegetative characteristics, which include graminoid marshes (wet prairies, sloughs), cypress swamps, lake littoral shorelines, and even some highly disturbed areas such as agricultural ditches and retention ponds (Bennetts and Kitchens 1997a). Three features that remain constant within the selected habitats are the presence of apple snails, sparsely distributed emergent vegetation (Sykes 1983b, 1987a), and suitable nesting substrates.

Snail kites are dietary specialists, feeding almost exclusively on the freshwater apple snail, *Pomacea paludosa* (Sykes 1987a, Sykes et al. 1995). They use two visual foraging methods, flying above the water surface or hunting from a perch (Sykes 1987a), and both require open water and sparse vegetation. Kites typically nest in woody vegetation overhanging water, such as willows, bald cypress, pond apple, wax myrtle, etc. (Beissinger 1988, Bennetts et al. 1988). The snail kite's survival depends on those hydrologic conditions that support these specific vegetative communities and subsequent apple snail availability in at least a subset of critical size wetlands across the region each year (Bennetts et al. 2002).

Wetland habitats throughout central and southern Florida are constantly fluctuating in response to climatic or managerial influences, resulting in a mosaic of hydrologic regimes. Snail kites respond to these fluctuations through movements between wetlands (Bennetts and Kitchens 1997a, 1997b). Developing a thorough understanding of the kite's ability to move between wetlands and of their resistance and resilience to disturbance events (e.g. droughts) or changes in habitat is essential to optimizing the management of the systems inhabited by the snail kite in Florida.

This final report will present data on snail kite usage of Blue Cypress Marsh Complex

(BCMC) of the St Johns River Basin, particularly during the 2008, 2009, and 2010 breeding season. Given the nomadic nature of the snail kite population in Florida, we also deem it essential to report on demography at the scale of the whole population. Consequently this report will also present information on the current demography of snail kites throughout central and southern Florida from 1992 to 2010.

METHODS

Study area

The BCMC comprises approximately 6,000 ha of marsh within the Upper St. Johns River Basin in Indian River County, FL. Toland (1991, 1992, 1994) describes the vegetation and Miller (1996) describes hydrologic characteristics and management plans for the BCMC. The BCMC is a compartmentalized wetland that is split in half by State Road 512, which runs north-south. The two units (Eastern and Western BCMC) are connected by large culverts which for the most part, are operated to allow water levels to equalize between the two areas.

BCMC is a small part of the entire network of wetlands that are monitored annually for snail kites (Figure 1). The population of snail kites is best viewed as one continuous population that is distributed among a network of heterogeneous wetland units in central and southern Florida (Bennetts and Kitchens 1997a, 1997b). They use the entire spatial extent of their range (Bennetts and Kitchens 2000), but given the discontinuity of suitable habitats, their population must still be viewed as spatially structured. The study area for the entire population includes a large portion of these different wetland units used by snail kites in peninsular Florida (Figure 1).

Monitoring protocol

Survey method

Multiple consecutive surveys have been conducted throughout the designated wetland units (Figure 1) from March to June at 2-3 week intervals of each year since 1992. This time period coincides with the occurrence of peak nesting (Bennetts and Kitchens 1997a). The surveys followed a format similar to the quasi-systematic transects conducted by airboat for the annual count (Sykes 1979, 1982; Bennetts et al. 1994). Because surveying the entire BCMC in one day was not always possible, we occasionally surveyed the Eastern and Western portions of BCMC on separate days (see Table 1). We note that one should be cautions in interpreting the number of snail kites observed during these surveys in BCMC as indices of relative abundance. Indeed, detection probability could not be estimated for BCMC (sample sizes were too small). Therefore only an unknown proportion of kites using BCMC were reported. Several sources of variation could affect detections (e.g. observer effects, environmental conditions, habitat types, accessibility). Furthermore, there is a possibility that some unmarked birds were counted twice.

Fourteen surveys were conducted yearly in the BCMC from 2008-2010. At least one survey was conducted during each month of the year (Table 1). Six surveys were conducted during the peak of the breeding season (March 1st to June 30th) in conjunction with our range-wide population monitoring effort. After the kite breeding season concluded (June 30), monthly surveys continued throughout the year.

Nest monitoring

Nests were checked with a telescoping mirror pole to determine their status. Water depths at certain nests were determined by placing a meter stick vertically into the water column until it rested on the sediment. GPS (Global Positioning System) locations of the nest, nesting substrate and height were also recorded. We recorded the number of eggs counted in each nest as well as the number of nestlings per nest.

Mark-resighting

Snail kites were banded near fledging time (approximately 25 days old) with alpha-numeric bands. During each of the surveys we recorded the number of marked and unmarked kites that were observed. Individually marked birds were identified using a spotting scope.

Data reported and statistical analysis

Nest Success

We calculated apparent nest success for the period of record using the following estimator:

$$\hat{S} = \mathbf{x/n}$$

Where $\hat{S}$ is the maximum likelihood estimate of the probability of a nest surviving, *x* is the number of nests that produced at least one fledgling (i.e. successful nests), and *n* is the number of nests initially observed to contain at least one egg (i.e. active nests) (Williams et al. 2002). We calculated the standard error (SE) as follows:

$$\mathrm{SE} = \sqrt{\hat{S} * (1\text{-}\hat{S})/n}$$

We used the log-normal approximation to compute 95% confidence intervals (95% CI) (Williams et al. 2002):

$$\text{Lower 95\% CI} = \hat{S} \,/\, \exp[2 * \sqrt{\log[1 + (cv(\hat{S}))^2]}\,]$$

$$\text{Upper 95\% CI} = \hat{S} * \exp[2 * \sqrt{\log[1 + (cv(\hat{S}))^2]}\,]$$

Survival

The Cormack-Jolly-Seber model (CJS, Cormack 1964, Jolly 1965, Seber 1965), implemented in program MARK (White and Burnham 1999), was used to estimate survival probability (denoted phi-hat). The Akaike Information Criterion (AIC) was used to select the best model describing survival (Burnham and Anderson 1998). The protocol and previous survival estimates (up to 2005) have been published elsewhere (Bennetts and Kitchens 1997a, Bennetts et al. 2002, Martin et al. 2006). CJS models were used to estimate detection probability (i.e., the probability of detecting a snail kite given that it is present in the study area during the period of sampling).

Total Population size

We used the superpopulation approach published by Dreitz et al. (2002) to estimate the population size of snail kites between 1992 and 2010.

RESULTS

Number of birds counted

The number of snail kites counted during the individual 2008, 2009, and 2010 surveys of BCMC are summarized in Table 1. See Appendix 1 and Appendix 2 for the spatial distribution. Kites typically used the Eastern portion of BCMC significantly more than the Western portion in 2010 (Two-sample t-test assuming unequal variances, $t = 1.66$, $df = 90$, $P < 0.001$), as has been the trend since 2001 (Appendix 3).

Reproduction

Number of nest observed

In 2010, a total of 258 nests were located range-wide during the survey season. Of this total, 190 nests were observed in an active state (i.e., containing eggs or nestlings) (Table 2). Fifty percent of the active nests occurred in the KCOL, with the majority occurring on Toho, which alone accounted for 34% of the range-wide nesting effort. An unprecedented number of active nests were located in Stormwater treatment Area 5 (STA5) in 2010, and this area accounted for 12% of the range-wide nesting effort (Table 2).

In 2010 a total of 26 snail kite nests were observed in BCMC, but only 14 were active (Table 2; See Appendix 2 for spatial locations). During 2010, snail kite nests that occurred in BCMC accounted for 8% of the nests that were initiated range-wide. Only one of the active nests in BCMC was successful (nest success = 0.07, SE = 0.06), fledging only one young. Therefore, BCMC only contributed minimally to the number of successful nests or young fledged range-wide in 2010 (Table 2).

Thirty-four percent of all successful nests range-wide in 2010 occurred on Toho, where nest success was 0.29 (SE = 0.06) (Table 2). All wetland-specific nest success estimates for 2010 appear in Table 2. In 2010, range-wide nest success averaged 0.28 (SE = 0.03). Estimates of annual range-wide nest success and BCMC-specific nest success from 1992 to 2010 are presented in Figure 2.

Number of juveniles banded and number of young fledged

Out of the 190 active nests that were located, we were able to confirm the fate of 186 of them. From these active nests of known fate, 93 young were confirmed to have fledged (Table 2). We banded 96 nestlings during the pre-fledging stage. However, some nests were depredated after nestling(s) were banded but before fledging; therefore, not all of the nestlings that we banded actually fledged. Also note that we were not able to band all of the young that were confirmed to have fledged; therefore, the total number of young fledged includes banded and non-banded individuals that were known to reach fledging age.

The total number of young fledged throughout the entire state dropped substantially after 1998. Historically, the majority of annual kite production came from the Water Conservation Areas, principally WCA3A; however, in 2001, 2005, 2007, 2008, and 2010 no young were fledged out of WCA3A. In 2010, Toho produced 39% of the young that were fledged statewide. There is an increasing trend in the relative contribution of the KCOL, and of Toho in particular, to the annual number of young fledged range-wide (Figure 3).

In 2010, only one young was observed to have fledged in BCMC. The observed number young to have fledged annually in each wetland region from 1992 to 2010 appears in Figure 3.

Survival

Adult survival dropped significantly from 2000 through 2002, and again from 2006 through 2008 (Figure 4). These historically low survival estimates correspond temporally to significant declines in the population (Figure 5) and to region-wide droughts. Adult survival decreased by 16% from 2000 to 2002 (Martin et al. 2006), and by approximately 22% from 2006 to 2008. Juvenile survival has varied widely over time but reached a record low in 2000 (Figure 4). Evidence shows that juvenile survival significantly decreased in the years 2004 to 2006 and rebounded in 2007 (Figure 4). Although Florida also experienced severe drought conditions in 2007, there was no corresponding decrease in juvenile survival. This disjunct is likely due to the fact that the majority of young fledged in 2007 came from the KCOL. Lake levels in the KCOL have historically been less affected by adverse drought conditions (Bennetts and Kitchens 1997).

Total Population Size

The snail kite population in Florida progressively and dramatically decreased between 1999 and 2002 from approximately 3400 to 1700 birds. Population size estimates of abundance between 2002 and 2006 suggested a possible stabilization at approximately 1500-1600 birds. The population estimate for 2007 was significantly less than the estimates for both 2006 and 2005. Furthermore, the population estimates for 2008 and 2009 were significantly less than the 2007 estimate and suggest that the snail kite population halved again between 2006 and 2008 (Figure

5). The 2010 population size estimate (826, SE = 49) is larger than the 2008 and 2009 estimates, but it does not differ significantly and cannot be interpreted as a rebound.

DISCUSSION

Discussion of results specific to BCMC

Significantly more snail kites utilize Eastern BCMC than Western BCMC. This is likely due, in some degree, to different acreages of suitable habitat. Excluding Lake Miami Ranch (because it is a deeper impoundment), Western BCMC has 1,778 acres of emergent marsh where Eastern BCMC has 5, 279 acres of emergent marsh. Interestingly, there were significantly more kites counted in BCMC during the breeding seasons of 2004 and 2006 than during any other year from 2001 to 2010 (see Appendix 3). In 2006 the number of snail kites counted during the breeding season exceeded the number counted in 2004. We hypothesize that kites moved from the Kissimmee Chain of Lakes (KCOL) to BCMC in 2004 because of the drawdown of the KCOL. However, we note that these observations should be interpreted with caution because they rely primarily on counts that do not consider detection probabilities. Furthermore, no drawdown of the KCOL occurred in 2006. Regardless, the discrepancies between snail kite counts in KCOL and BCMC support the hypothesis that snail kite habitat management activities should be regionally integrated to ensure important refugia habitat remains available for birds that may be negatively impacted by site specific activities. Ideally, habitats that are located nearby should not be managed totally independently of one another.

A total of four nests were initiated in the BCMC during the 2008 and 2009 breeding season, with all four nests failing before the eggs hatched. Thus, no young were fledged from the BCMC during the 2008 and 2009 breeding season. In 2010, thirteen of the fourteen active nests in BCMC failed. The one successful nest fledged one young. The low nesting effort may be attributable to the delayed recovery of the apple snail population after the 2007 drought. However, this hypothesis has not been tested as we do not have the capacity to perform the required snail sampling. Due to the abrupt ecotone with terrestrial habitats present in the BCMC, one likely factor contributing to low nest success is predation. Three potentially major predators are: raccoons, snakes, and Great Horned Owls (Bennetts and Kitchens 1997a), and some of these predators have been observed in BCMC. In 2004, we observed great horned owls in BCMC on several occasions (including one instance of one owl caring for young owls at the nest in the southwestern portion of Cell 3 on the eastern side). This year (2010), great horned owls were observed in the Eastern region of the BCMC during the snail kite breeding season with a pair of owls observed in the East during the November survey. In addition to the owls, a juvenile bald eagle was observed in the Eastern portion of the BCMC during the 2010 December survey. In

2006, we observed raccoons during the driest part of the breeding season in BCMC. Strong circumstantial evidence for raccoon predation has also been observed on Lake Toho, particularly during the 2005 breeding season when the lake level fell rapidly and exposed several snail kite nests in Goblet's Cove to terrestrial habitat. Raccoons favor nests that are located on fairly dry land. Snakes have also been observed occasionally at proximity of nest sites, but snakes typically only predate eggs or young chicks, and snakes do not leave any evidence of predation as they swallow the entire chick or egg and typically do not damage nests.

Since February 2009 randomly selected nests have been monitored on the KCOL (primarily on Toho) using game cameras. As of September 2010 a total of twenty-three nesting failures have been documented using this method. Five of the failures were a result of nest abandonment primarily occurring during the extreme cold temperatures that took place earlier in the nesting season (Jan-Feb). One nest was observed to have been depredated by a purple gallinule (*Porphyrio martinica*), which managed to flush the female off the nest and remove the only egg in the nest. Seven failed nests were the result of snake depredation; five by a yellow rat snake (*Elaphe obsoleta quadrivittata*) and two by an unknown species. In all cases the snake consumed both the young and the eggs in the nest. Three nest failures occurred when raccoons (*Procyon lotor*) depredated eggs or young in the nest, two nest failures resulted when Marsh Rice Rats (*Oryzomys palustris*) removed young from one nest and consumed eggs from another. Inexperienced adults and/or unviable eggs resulted in four nest failures. A great horned owl (*Bubo virginianus*) was believed to have depredated a nest of three young several days before they were to fledge. Although images of the owl were not obtained, the size of the young, time of predation and speed of young removal from the nest all indicate a large flighted nocturnal predator.

At this point we cannot make any definitive statements about the relative importance of predation on nest success of kites at BCMC, as we do not currently have any means to record predation events accurately at that location and are awaiting further information from the KCOL.

Discussion of results pertaining to the entire snail kite population

Our recent demographic studies point toward alarming trends in the snail kite population in Florida. Kite numbers have drastically declined since 1999, with the population essentially halving from 2000 to 2002 and again from 2006 to 2008 (Figure 5) (see also Chapter 3 Martin et al. 2007c). Concurrent with the population decline is a corresponding decline in nesting attempts, nest success, and the number of young fledged (Figure 3) (see also Chapter 4 Martin et al. 2007c). A number of factors have likely contributed to these observed declines, including short-term natural disturbances (e.g. drought) and long-term habitat degradations (e.g. the conversion of wet prairies to sloughs in WCA3A).

First of all, one of the major historic components of the kite's habitat network in Florida, Lake Okeechobee, has remained relatively unproductive for over a decade. Okeechobee, which from 1985 to 1995 was a productive breeding site, has been only a minor contributing unit (in terms of reproduction) since 1996, and this has been attributed to a shift in the water management regime (Bennetts and Kitchens 1997). Hurricanes in 2004 further degraded kite nesting and foraging habitat in Okeechobee (*personal observation*). Since 1996 most kite nesting attempts on Okeechobee have occurred in the Clewiston Flats southwest of Moonshine Bay; however, this habitat becomes unsuitable for kites at lake stages below 15 feet NGVD. In 2010, only two successful nests were observed in Okeechobee. Not only has recruitment from Okeechobee dropped to almost nothing, but the loss of suitable habitat at this critical stopover point also likely affects kites that are moving among wetlands, as Okeechobee lies nearly in the center of the kite's range. The loss of refugia and stopover habitat may have significant demographic consequences, especially during drought.

WCA3A is another critical habitat that has become unproductive in recent years. Snail kite reproduction in WCA3A decreased sharply after 1998 (Figure 3) (see also Martin et al. 2008), and alarmingly, no kites were fledged in 2001, 2005, 2007, 2008, or 2010. This lack of reproduction in WCA3A may also stem, at least in part, from a shift in water management regimes (Zweig and Kitchens, 2008). Current water regulation schedules in the WCAs have the potential to drastically shorten the window during which kites can breed successfully (Mooij et al. 2002). In addition, rapid water level recession rates can present enormous foraging difficulties to both juvenile and even adult kites (Mooij et al., 2002). During low precipitation regimes the current regulation schedule increases the likelihood of localized drought, which may reduce kite survival if other habitats are not available in close proximity (Martin, 2007). Furthermore, prolonged high water events may lead to long-term habitat degradation that affects snail kite nesting and foraging (Martin et al., 2008; Zweig and Kitchens, 2008).

This loss of Okeechobee and WCA3A as productive kite habitats has left the population heavily concentrated in and dependent upon the KCOL, particularly Lake Toho, which accounted for 52, 12, 89, 72, 61 and 34 percent of the successful nesting attempts range-wide in

2005-2010 respectively. This strong shift in kite nesting toward Toho raises concerns because the survival of juveniles that fledge there may be significantly suppressed due to their inefficiency at handling the exotic apple snail (*Pomacea insularum*) (Cattau et al. 2010). The exotic snail invaded Toho as early as 2001 (Darby, *personal communication*) and has been the dominant snail present on the lake since the 2003-2004 drawdown (Desa 2008). However, native snail populations are also returning to Toho (Desa, 2008) and anecdotal evidence suggests that juvenile kites are attracted to areas of the lake in which native snails are present (*personal observation*). We also observed smaller-sized exotic snail shells under kite feeding perches in 2008-2010 than in 2005-2007, which may suggest that either more "appropriately-sized" snails are available or that kites are learning to select smaller snails. It is possible that the resurgence of the native snail population and the utilization of smaller-sized exotic snails may buffer the negative survival effects that the larger-sized exotic snails can have on juvenile survival.

We are particularly concerned about the continuing lack of kite production in Okeechobee and WCA3A and potential reductions to juvenile survival due to water management and/or exotic snails because these two demographic parameters are currently limiting population growth (Martin et al. 2008). Our 2006 population viability analysis predicts high probability of extinction in the next 50 years (see Chapter 9 Martin et al. 2007c); however, this analysis did not include data from 2007 to present, which would likely result in even higher extinction probabilities.

RECOMMENDATIONS

Recommendations relevant to the management of the entire population

Since the snail kite population is at risk of extinction and because adult fertility plays such an overwhelming role in the population growth rate, it is critical to identify and attempt to remedy all factors that negatively affect snail kite production and juvenile survival. In recent years, kites have been highly concentrated in the KCOL during the breeding season. It is critical for the persistence of the snail kite population that we actively manage for kites in the KCOL while restoration efforts are being made to bring other historic nesting areas (e.g. WCA3A, Okeechobee) back online. All proposed water and vegetation management actions should undergo critical evaluation processes in order to eliminate, or at least minimize, any potential negative impacts on snail kites.

The water regulation schedule in WCA3A does not mimic the seasonal patterns driven by the natural hydrological cycle; therefore, water management in WCA3A may be in conflict with the life history strategy of the snail kite. In recent years water levels in WCA3A have been maintained at unusually high levels (in part due to recent hurricanes) for the period September to January. At times, these high water stages during the pre-breeding season have been coupled with fast recession rates through the breeding season and dry conditions during and after the breeding season (i.e., when juveniles would be fledging and dispersing). Such a scenario shortens the window of opportunity for snail kite reproduction and may decrease nest success and juvenile survival. Several researchers (e.g. Mooij et al. 2002, Kitchens et al. 2002, Darby et al. 2005, Zweig and Kitchens 2008) have raised concerns about potentially adverse effects of prolonged high water stages in WCA3A. Over the last few years, we have provided assistance to the USFWS in addressing these concerns, and a white paper outlining WCA3A water schedule targets specific to the snail kite, among other species, has been recently released (See USFWS 2010).

Management of the kite population will also require landscape scale considerations. A recent radio telemetry study showed that although kites move extensively among contiguous wetlands (i.e. among lakes in the KCOL or among compoundments in the WCAs) most kites do not move as freely as previously thought among wetlands that are isolated by extensive areas of unsuitable habitats (e.g. between KCOL and the WCAs) (see Chapter 6 Martin et al. 2007c). This may actually impede a significant proportion of birds from moving successfully to refugia habitat during drying events. As stated by Martin et al. (*in review*) “This observation is of particular importance to management of the Everglades Ecosystem, given the paradigm that the persistence of good natural habitats requires occasional drying events (Bennetts *et al.* 1998; Kitchens *et al.* 2002). Restoration projects that involve wholesale dry downs of an entire region (e.g. restoration of Toho) (Welch 2004) may want to consider the option of conserving water in at least some local patches within the region to be affected, to serve as refuge for snail kites." The drawdowns of local patches should occur sequentially, allowing a sufficient recovery period for previously dried areas to return to a productive level.

We also would like to reiterate the importance of maintaining a monitoring program to document snail kite population changes, apple snail densities, and habitat quality relative to kite usage. The proportion of marked individuals within the population is declining, as a large scale adult banding effort has not been undertaken in over ten years. In order to maintain precision, we recommend that another cohort of adults should be trapped and banded (see Bennetts and Kitchens 1997).

Recommendations specific to BCMC

BCMC is clearly a critical part of the network of wetlands used by kites, as it is consistently utilized by a portion of the kite population (Martin et al. 2006). BCMC may also serve as a refugia habitat, particularly when other wetlands are experiencing drought conditions (via natural drying events or managed drawdowns). The higher number of kites observed during the drawdown of the KCOL, as well as modeling of snail kite movements, suggests that wetlands that are in close proximity to BCMC (e.g. KCOL) should be managed given this perspective (Martin et al. 2006). On the other hand, the potential for a high rate of nest predation, as observed anecdotally in 2004, and the low nesting success in 2006, 2008, 2009 and 2010 should concern managers of the potential for BCMC to serve as an ecological trap (Schlaepfer et al. 2002). Indeed, the small size and compartmentalized nature of this wetland complex may make it particularly vulnerable to predation. The West Palm Beach Catchment Area (i.e. Grassy Waters) is of a similar compartmentalized nature, and we characteristically observe circumstantial evidence for nest predation and low nest success in this area. Birds breeding in BCMC may suffer predation on both adults at the nest, as well as eggs and young. Nest success is usually lower in the BCMC compared to the combined nest success of the rest of the wetlands within the kite's range (see Figure 2). The anomaly was 2005; however note the large confidence intervals. We emphasize that the hypothesis that BCMC may serve as an ecological trap (because of predation on nests or breeding kites) is for now just a hypothesis that remains to be supported by rigorous analyses, but we feel that managers of BCMC should continue to keep this in mind.

Managed drawdowns of the BCMC may be necessary to maintain suitable foraging habitat for kites, however the intensity and frequency of these events should be carefully examined. We suggest that managed drawdowns should be avoided when wetlands nearby are experiencing exceptionally dry conditions. Maintaining sustained water levels in BCMC during drought may be greatly beneficial for kites. The BCMC could serve as refugia to drought, mitigating at least partially, the effect of drought on survival (particularly adult survival). Thus, if logistically feasible, drawdowns of BCMC should be attempted during wetter years (for instance during El Nino years), or when no other managed drawdowns are planned, especially in the KCOL. By contrast drawdowns should be avoided during La Nina years which are typically characterized by drier conditions (Martin et al. in prep).

Kites still use the Western section of BCMC; however, foraging kite habitat in this section of BCMC has been degraded due to cattail expansion. Restoring this section should be a priority since it could be done with little risk to kites. The Western part of BCMC could serve as an experimental unit to test ways to restore suitable foraging habitat using hydrology. Because the Western part of BCMC can be drawn down independently of the Eastern part, could serve as refugia while restoration of the Western part is undertaken. Assuming drying events may be important in restoring foraging habitat, caution should be taken to initiate a drawdown of the Western BCMC *before* snail kite breeding activity begins as to not create an ecological trap for the birds and risk high nest abandonment or failure.

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Table 1. Kites observed during the 2008, 2009, and 2010 surveys of BCMC.

Section	Survey	# Birds in 2008	# Birds in 2009	# Birds in 2010
East	Jan	2	0	2
West	Jan	0	0	0
East	Feb		13	5
West	Feb		0	0
East	I (Mar)	4	15	11
West	I (Mar)	0	5	11
East	II (Apr)	14	11	20
West	II (Apr)	0	7	8
East	III (Apr)	26	20	10
West	III (Apr)	3	5	10
East	IV (May)	20	14	9
West	IV (May)	0	6	5
East	V (Jun)	13	11	14
West	V (Jun)	0	0	0
East	VI (Jun)	14	3	8
West	VI (Jun)	0	0	3
East	Jul	2	2	4
West	Jul	0	0	0
East	Aug	6	0	2
West	Aug	5	1	0
East	Sep	0	7	5
West	Sep	0	0	1
East	Oct	7	11	11
West	Oct	0	0	1
East	Nov	3	21	8
West	Nov	0	0	1
East	Dec	8	9	2
West	Dec	0	0	2

Table 2. Snail kite nests by wetland in 2010 and their production/fate.

Area	BICY	ENP	ETOHO	GW	HM	HUNG	IST	LH	LJ	KISS	LOX	OKEE	SJM	STA5	TOHO	WCA3B	WCA2A	WCA3A	**TOTAL**
Total Nests (includes uninitiated nests)	0	4	15	11	11	0	1	3	19	4	2	16	26	29	83	13	0	21	**258**
Total Active Nests (only initiated nests)	0	3	12	8	7	0	1	3	13	1	2	14	14	25	63	9	0	15	**190**
Active Nests with Known Fates	0	3	12	8	6	0	1	3	13	1	2	14	14	23	63	8	0	15	**186**
Active Nests (Failed)	0	2	12	8	4	0	0	0	8	0	1	12	13	18	43	4	0	15	**140**
Active Nests (Successful)	0	1	3	3	2	0	1	3	5	1	1	2	1	8	18	4	0	0	**53**
Nest Success	NA	0.33	0.25	0.38	0.33	NA	1.00	1.00	0.38	1.00	0.50	0.14	0.07	0.35	0.29	0.50	NA	0	**0.28**
Contribution to Active Nesting	0	0.02	0.06	0.04	0.03	0	0.01	0.02	0.07	0.01	0.01	0.08	0.08	0.12	0.34	0.04	0	0.08	
Contribution to Successful Nesting	0	0.02	0.06	0.06	0.04	0	0.02	0.06	0.09	0.02	0.02	0.04	0.02	0.15	0.34	0.08	0	0.00	
Total Young Produced	0	1	6	4	3	0	1	5	9	2	3	3	1	14	36	5	0	0	**93**
Average Nest Productivity	0	1	2	1.33	1.5	0	1	1.67	1.8	2	3	1.5	1	1.75	2.00	1.25	0	0	**1.75**
Contribution to Total Young Produced	0	0.01	0.06	0.04	0.03	0	0.01	0.05	0.10	0.02	0.03	0.03	0.01	0.15	0.39	0.05	0	0	

Figure 1. Study area, with the number indicating the area sampled during the surveys.

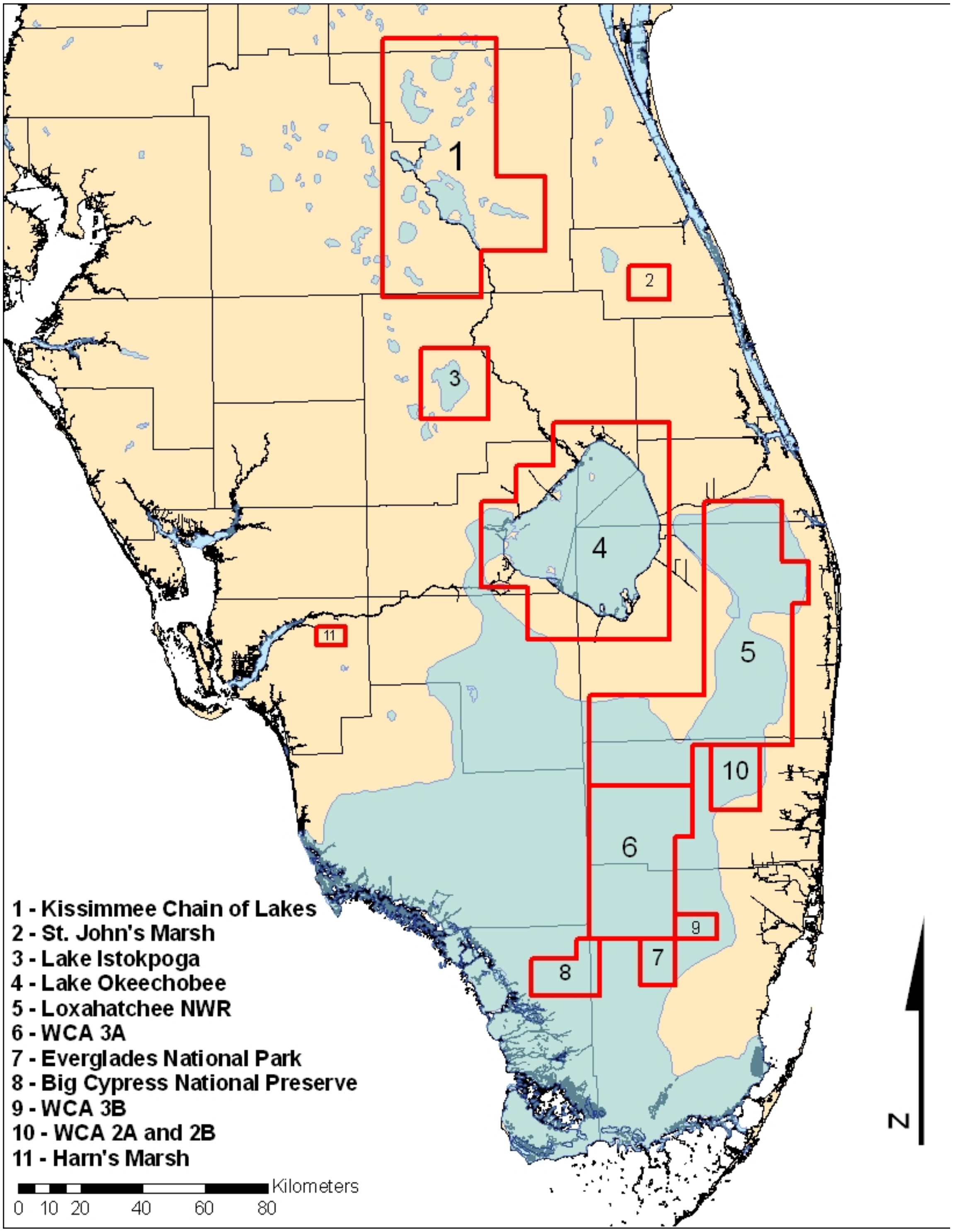


Figure 2. Comparison of nest success in BCMC versus all other wetlands combined between 1992 and 2010. Error bars correspond to 95% confidence intervals. Note that only BCMC data was available for 1992 and 1993. No nesting occurred in BCMC in 1994, 2001, or 2007.

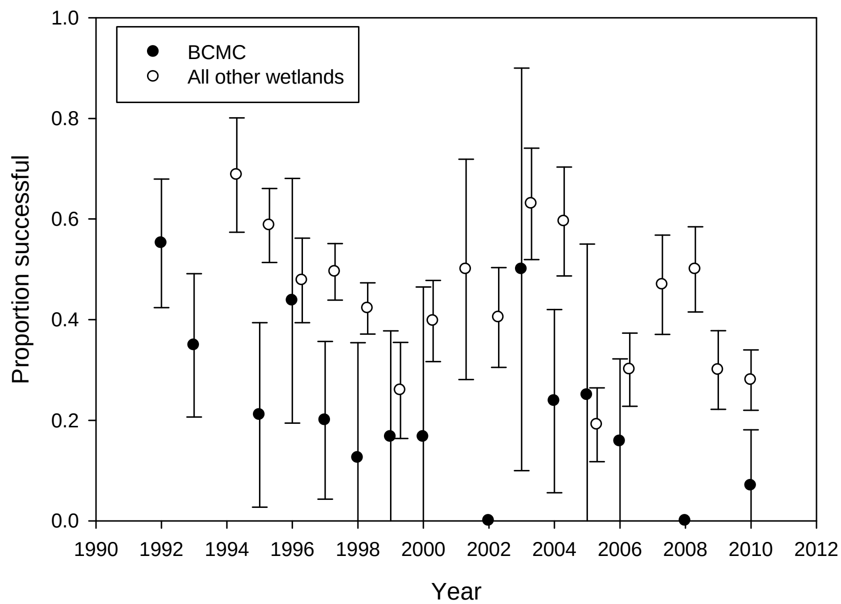


Figure 3. Observed number of young fledged per year (1992-2010) in BCMC, Everglades, Kissimmee Chain of Lakes (KCOL), and Okeechobee.

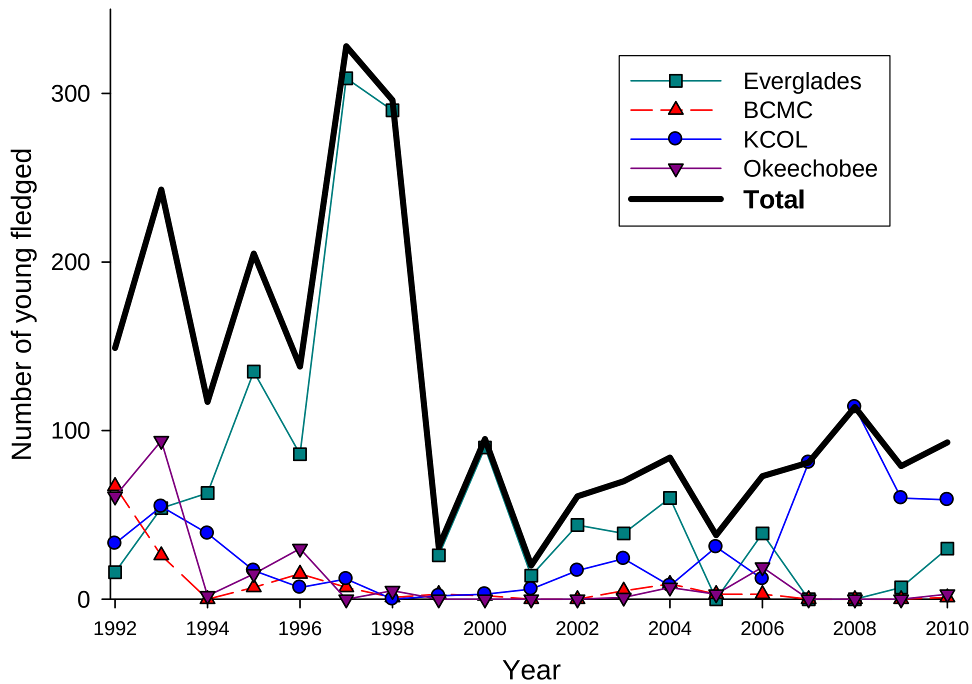


Figure 4. Model averaged estimates of adult (open circles) and juvenile (dark circles) survival between 1992 and 2010. Error bars correspond to 95% confidence intervals.

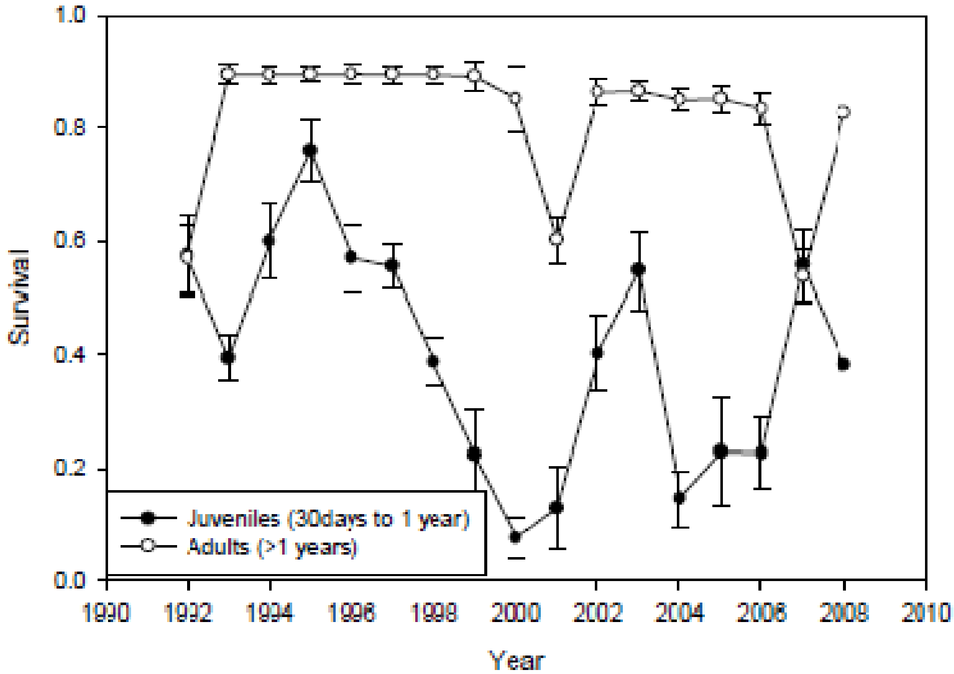
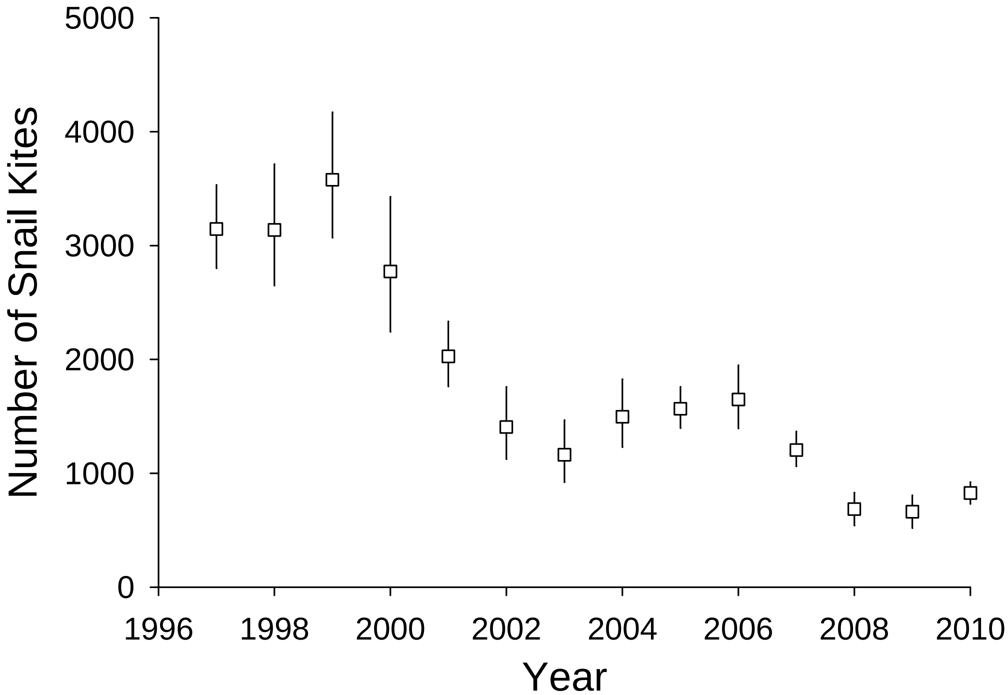
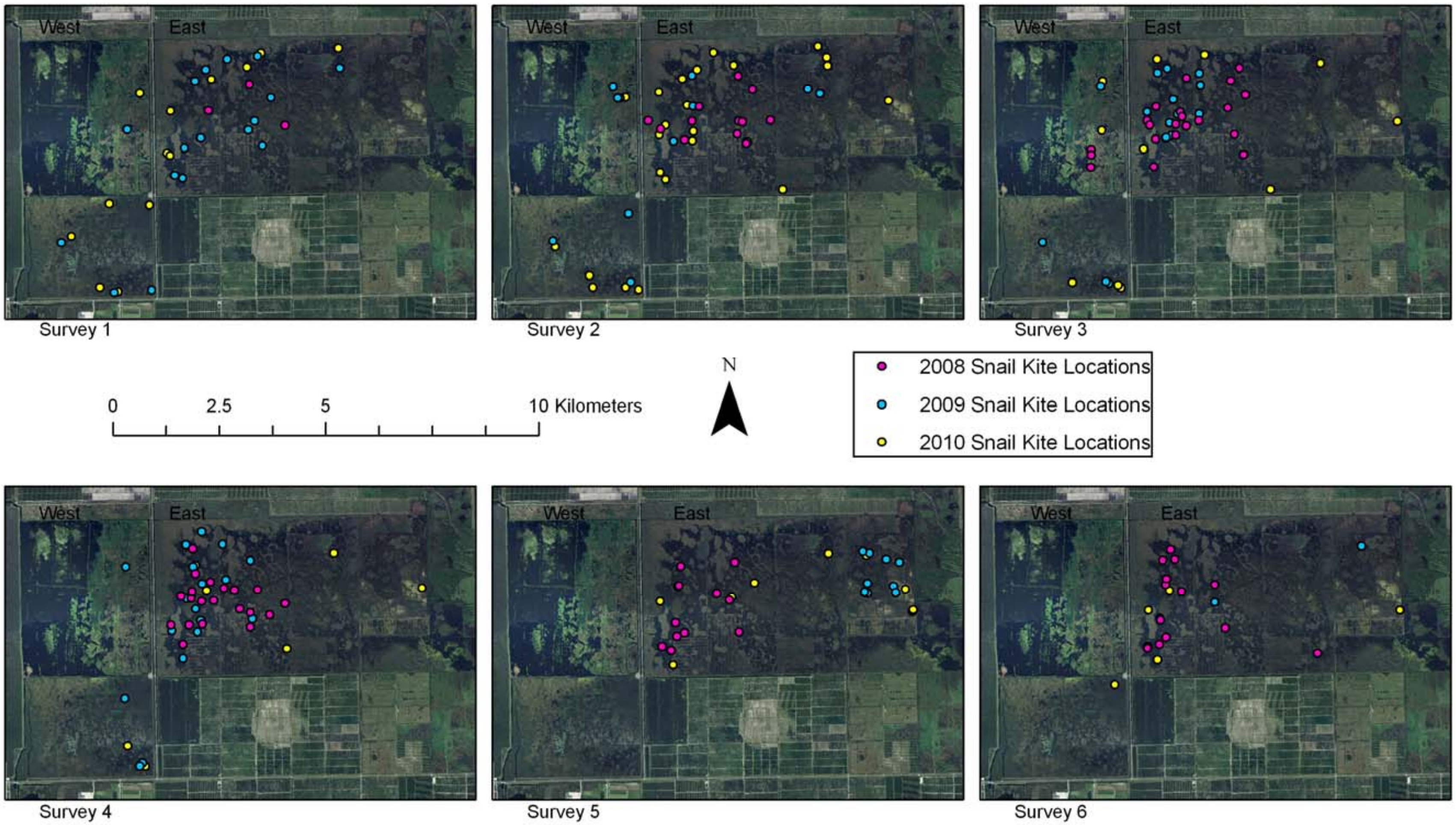


Figure 5. Population size (estimated using the superpopulation approach, Dreitz et al. 2002) of snail kites from 1995-2010. Error bars correspond to 95% confidence intervals.



Appendix 1. Observed snail kite locations during each survey conducted over the course of the peak-breeding season, 2008 – 2010.



Appendix 2. Snail kite nest locations 2008 – 2010.

Appendix 3. Count of snail kites during surveys of the East and West portions of BCMC between 2001 and 2010.

Year	Date	West	East	Total
2001	15-Mar	?	?	56
2001	5-Apr	?	?	57
2001	26-Apr	?	?	23
2001	10-May	?	?	16
2001	29-May	?	?	8
2001	15-Jun	?	?	6
2002	10-Mar	2	23	25
2002	15-16 Apr	?	?	48
2002	10-May	?	?	48
2002	1-2 Jun	4	38	42
2002	24-Jun	7	31	38
2003	10-11-Mar	7	33	40
2003	1-2-Apr	5	29	34
2003	18-Apr	?	27	NA
2003	27-Apr	5	?	NA
2003	11-May	?	14	NA
2003	25-May	10	?	NA
2004	1-2-Mar	13	33	46
2004	25-26Mar	5	46	51
2004	18-19-Apr	23	39	62
2004	6-7May	19	28	47
2004	3-5Jun	7	35	42
2004	20-22-Jun	13	33	46
2005	19-21 Apr	11	36	47
2005	10-11 May	14	17	31
2005	28-30 May	9	16	25
2005	17-18 Jun	1	10	11
2006	19-Mar	5	41	46
2006	9-10 Apr	13	48	61
2006	27-Apr	13	51	64
2006	15-16 May	19	57	76
2006	2-3 Jun	9	77	86
2006	24-Jun	NA	58	58
2006	28-Jul	0	22	22
2006	30-Aug	0	20	20
2006	Sep	NA	NA	0
2006	2-Nov	0	26	26
2006	30-Nov	1	5	6
2006	Dec	NA	NA	0

Appendix 3 continued

Year	Date	West	East	Total
2007	15-Jan	0	NA	0
2007	14-Feb	0	7	7
2007	23-Mar	0	3	3
2007	7-Apr	0	2	2
2007	26-Apr	0	0	0
2007	19-May	NA	NA	0
2007	5-Jun	NA	NA	0
2007	25-Jun	NA	NA	0
2007	7-Jul	NA	NA	0
2007	14-Aug	0	0	0
2007	23-Sep	0	0	0
2007	Oct	0	0	0
2007	30-Nov	0	0	0
2007	14-Dec	0	1	1
2008	9-Jan	2	2	4
2008	13-Mar	0	4	4
2008	3-Apr	0	14	14
2008	23-24 Apr	3	26	29
2008	14-May	0	20	20
2008	4-Jun	0	13	13
2008	26-Jun	0	14	14
2008	30-Jul	0	2	2
2008	28-29 Aug	5	6	11
2008	22-Sep	0	0	0
2008	30-Oct	0	7	7
2008	24-Nov	0	3	3
2008	18-Dec	0	8	0
2009	31-Jan	0	0	0
2009	23-Feb	13	0	13
2009	19-Mar	15	5	20
2009	6-7 April	11	7	18
2009	29-Apr	NA	5	5
2009	1-May	20	NA	20
2009	15-May	14	6	20
2009	4-Jun	11	0	11
2009	29-Jun	3	0	3
2009	15-Jul	2	0	2
2009	17-Aug	0	1	1
2009	24-Sep	7	0	7
2009	21-Oct	11	0	11
2009	18-Nov	21	0	21
2009	9-Dec	9	0	9

Appendix 3 continued

2010	18-Jan	0	2	2
2010	22-Feb	0	5	5
2010	15-Mar	11	11	22
2010	5-Apr	8	20	28
2010	26-27 Apr	10	10	20
2010	17-May	5	9	14
2010	4-Jun	0	14	14
2010	29-Jun	3	8	11
2010	15-Jul	0	4	4
2010	10-Aug	0	2	2
2010	27-Sep	1	5	6
2010	29-Oct	1	11	12
2010	22-Nov	1	8	9
2010	16-Dec	2	2	4