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# SNAIL KITE DEMOGRAPHY IN BLUE CYPRESS WATER MANAGEMENT AREA FINAL REPORT 2006–2007

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

# SNAIL KITE DEMOGRAPHY IN BLUE CYPRESS WATER MANAGEMENT AREA
# FINAL REPORT 2006-2007.

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By
Christopher Cattau, Wiley Kitchens, Brian Reichert,
Andrea Bowling, and Julien Martin.

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U. S. Geological Survey
Florida Cooperative Fish and Wildlife Research Unit
University of Florida
PO Box 110485
Gainesville, Florida 32611

## EXECUTIVE SUMMARY

This report presents data on snail kite use of the Blue Cypress Water Management Area (BCWMA) in 2006 and 2007. In both years kites used BCWMA-East considerably more than BCWMA-West. Table 1 lists the survey dates and the total number of snail kites observed for both areas. Appendix 1 contains detailed maps of each survey, showing the GPS location for each snail kite observed. Appendix 2 provides a map of each snail kite nest observed during the 2006 breeding season. A total of 16 initiated nests (i.e. nests containing eggs or young) were observed in 2006, but only 3 were successful, one fledging two young and two other nests fledging one each. In 2007 no nesting was observed and the number of kites using the BCWMA was low. In 2007 the BCWMA experienced a complete drawdown. These conditions also impeded our ability to access the area by airboat. From May through July, surveys could not be conducted. Because the snail kite population in Florida is best viewed as a single population, it is important to consider the demographic results (i.e. abundance, survival, reproduction) at a statewide scale. Recent demographic results show alarming trends concerning the snail kite population in Florida. Kite abundance drastically declined between 1999 and 2003. The population size estimates for 2004-2007 do not indicate any significant recovery. Reproduction in 2005 was exceptionally low and perhaps more importantly, no kites fledged out of the Water Conservation Areas (WCAs) which are the largest most extensive wetland habitats in which the kites complete the entirety of their life cycle. Interestingly, 2005 was one of the rare years in which nest success in BCWMA (29%) was higher than the nest success averaged across all other areas (15%). This level of nest success did not occur again in 2006 or 2007. Nest success for BCWMA during 2006 (12.5%) was notably lower than the nest success for all other areas combined (26%). In 2007, the estimate of nest success for the entire population was 42%. There is evidence that the BCWMA is critical to the kite's persistence especially when other areas are experiencing drought; however, its potential as a source of recruitment is less certain. Nesting success in the BCWMA is usually poor. The small size and compartmentalized nature of this wetland may make nests particularly vulnerable to predation. However, when nearby wetlands are experiencing extreme dry conditions, consideration should be given to deviating from the long-term water management plan for the BCWMA to prevent drying of this areas as well. Holding water levels higher would provide drought refugia habitat that may enhance regional adult survival even if reproductive success continues to be low.

## 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 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 report will present data on snail kite usage of Blue Cypress Water Management Area

(BCWMA) of the St Johns River Basin during 2006 and 2007. Because the BCWMA-West experienced drying in 2006 and the entire BCWMA was dry in 2007, we will discuss some of the implications of those management actions for kites. 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 2007.

## METHODS

### Study Area

The BCWMA 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 BCWMA. The BCWMA is a compartmentalized wetland that is fragmented by State Road 512. The two units are connected by large culverts, which for the most part, are operated to allow water levels to equalize between the two areas.

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). BCWMA is a small part of the entire network of wetlands that are monitored annually for snail kites (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 BCWMA in one day was not always possible, we often surveyed the eastern and western portions of

BCWMA on separate days (see Table 1 below). We note that one should be cautions in interpreting numbers reported for BCWMA as indices of relative abundance. Indeed, detection probability could not be estimated for BCWMA (sample sizes were too small). Therefore, only an unknown proportion of kites using BCWMA 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.

***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 reported the number of eggs counted in each nest as well as the number of nestlings per nest. In 2006, six surveys were conducted between the 18$^{th}$ of March and the 24$^{th}$ of June to correspond with the peak snail kite nesting season. During the sixth and final survey period (i.e. mid- to late-June), the west side of St John's Marsh was inaccessible to airboats due to low water levels. After the kite breeding season concluded (June 30), monthly surveys continued throughout the year. There were two months (August and December) in which surveys could not be conducted as a result of logistical restrictions (i.e. equipment failure).

Monthly surveys were continued through December of 2007. Similar to 2006, six surveys were also attempted during the 2007 snail kite breeding season (Mar 23 through June 25). Due to dry conditions only the first three breeding-season survey attempts were successful, as access to BCWMA via airboat was severely limited. These dry conditions persisted through July.

***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 Analysis**

***Nest Success***

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

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

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, and n is the number of nests initially observed to contain at least one egg (Williams et al. 2002). We also used a logistic regression to test whether there were any statistically significant differences in nest success between BCWMA and other areas.

The sampling variance was computed as follows:

$$Var(\hat{S}) = \hat{S} * (1 - \hat{S}) / n$$

The standard error was computed as the square root of the sampling variance.

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

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

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

Despite a relatively high number of nesting attempts, nest success was exceptionally low in 2006. We found evidence of predation or post mortality scavenging for at least 10% of the nests in 2006 (these percentages correspond to a minimum, as a number of predation or post scavenging events may have gone undetected). Again, no nesting occurred in BCWMA during 2007.

***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 1999) have been published elsewhere (Bennetts and Kitchens 1997a, Bennetts et al. 2002). 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 population size of snail kites between 1997 and 2007. Estimates presented in this report for the period 1997 to 2005 are also available from Martin et al. (2006).

## RESULTS

### Number of birds counted

The number of snail kites counted during the surveys of BCWMA is summarized in Table 1 (See Appendices 1 and 2 for the spatial distribution). In 2006 the maximum number of kites counted in BCWMA-East was 77. In BCWMA-West the maximum number of kites observed was 19. In 2007 the maximum number of kites observed in either area was 7.

### Reproduction

***Number of nest observed***

A total of 32 snail kite nests were observed in the BCWMA in 2006. Of these 17 contained eggs or young. Only two nests were successful (i.e. young survived more than 24 days). A third nest included one young but we are not sure whether it reached 24 days or not (we noted this nest with a question mark in the column "Young Fledged" of Table 2.a). In 2007, no snail kite nests were observed in the BCWMA.

***Nest success***

In 2006, S-hat was 0.125 (SE-hat = 0.08) in BCWMA and it was 0.26 (SE-hat = 0.04) for all other areas combined. Average nest success in BCWMA between 1992 and 2007 was 0.22 (SE-hat = 0.03), but it was 0.39 (SE-hat = 0.02) for all other areas combined. Nest success between 1992 and 2007 is presented in Figure 2.

***Number of juveniles banded***

Five young were marked in BCWMA during 2006, but only four of these successfully fledged. The number of young marked in BCWMA in 2006 represented 6% of the total number of young marked for the entire state. This is the typical percentage that has come from BCWMA since 2001. No young were marked in BCWMA during 2007. The total number of young banded throughout the entire state has dropped substantially since 1998. In 2005 it was particularly low (Figure 5).

Prior to 1998, the number of young banded throughout the entire state varied between 117 and 306. From 1999 to 2003, the annual number varied between 26 and 97. The bulk of birds produced over time have been generated from the Water Conservation Areas, principally WCA3A. Notable deviations form this pattern occurred in 1992, 1993, 2001, 2005, and 2007.

**Survival**

Adult survival remained fairly constant from 1993 to 2000 (approximately 0.88) but dropped between 2000 and 2002 (especially during the period 2001-2002; 0.59). This reduction in survival is believed to be a response to the regional drought of 2000-2001, and indeed, adult survival rebounded after the drought effect passed (Figure 3.a, from Martin et al. 2006). Juvenile survival varied widely over time, but it also reached a record low between 2000 and 2001 (Figure 3.a, from Martin et al. 2006). This analysis was consistent with the one conducted by Bennetts et al. (2002) which provided similar survival estimates for non-drought years. Note that detection probability (probability of resighting a snail kite given that it is present in the sampled area) increased over time (Figure 3.b, from Martin et al. 2006).

**Total Population Size**

The population of snail kites in Florida decreased dramatically between 1999 and 2002 (Figure 4). The population size estimates in 1999 and 2002 were 3577 and 1332 respectively. Population estimates between 2003 and 2007 remained fairly constant, but there was no evidence of recovery (Figure 4). The estimate for 2006 was 1648, and the estimate for 2007 was 1204.

## DISCUSSION

### BCWMA

Since 2001 more snail kites have used BCWMA-East for both nesting and foraging during the breeding season than BCWMA-West. This general pattern of disproportionate usage also held true during the non-breeding seasons in 2006 and 2007. (See Table 1 for 2006 and 2007; see Appendix 3 for 2001 to 2005). This is likely due in some degree to the different acreages of suitable habitat. Excluding Lake Miami Ranch (because it is a deeper impoundment) BCWMA-West has 1,778 acres of emergent marsh where BCWMA-East has 5, 279 acres of emergent marsh (Miller 1996). There were considerably more birds (50 to 400% more depending on the survey month) counted in BCWMA in 2004 than in any other year between 2001 and 2005 (see Appendix 1). In 2004, we hypothesize that kites moved from the Kissimmee Chain of Lakes (KCL) to BCWMA because of the draw down of the KCL. However, these observations rely on counts that do not consider detection probabilities.

BCWMA snail kite counts in 2006 superseded those made in 2004. From 2005 to 2006, nesting attempts and breeding season counts declined in the KCL concurrent with the increases in BCWMA. We hypothesize the decline in KCL snail kite usage may be due to habitat degradation (we are currently investigating this possibility) and the snail kites that moved from the KCL may have been recorded in the BCWMA. In 2007, this trend was reversed. Due to dry conditions in the BCWMA, breeding season counts were the lowest since 2001. While counts in the BCWMA were comparatively low in 2007, counts in the KCL, especially Lake Tohopekaliga, increased from 2006.

A management decision (with support from Florida Cooperative Fish and Wildlife Research Unit) was made early in 2007 to allow the BCWMA to dry down, as the consensus was that the habitat was changing undesirably and that the emergent vegetation needed to be rejuvenated. BCWMA-East has had high water levels for over 12 years, which falls outside a suitable duration of flooding for optimal habitat. Reduced survival of young in areas with prolonged flooding is consistent with Bennetts habitat suitability model that a drydown should occur every 3-5 years. Unfortunately, after the dry down was implemented, BCWMA was not able to serve as a refuge during the unforeseen region-wide drought that began in 2006. Fortunately, the decision to dry down BCWMA was made with regional management in mind, and kites found refuge in the KCL.

Offsetting increases and decreases in kite numbers between the BCWMA and the KCL in relation to hydrologic conditions strongly suggest that birds move between these basins in search of suitable habitat. When the BCWMA is dry, kites tend to move to the KCL, when the KCL is dry, they move to the BCWMA. This has important regional water management implications. Site-specific water management activities (e.g. Lake Kissimmee drawdowns for fisheries enhancement) should be integrated with regional water management strategies to ensure that refugia habitat for kites are available. More precisely, efforts should be made to ensure, to the greatest extent possible, that both the KCL and the BCWMA do not experience extreme drying conditions during the same year.

Despite a relatively high number of nesting attempts, nest success was exceptionally low in 2006. Due to the abrupt ecotone with terrestrial habitats present in the BCWMA, 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). In 2004, we observed great horned owls in BCWMA 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). In 2007, we did not see as much owl activity but we did detect them in the area. We observed raccoons during the driest part of the 2006 breeding season. Strong circumstantial evidence for raccoon predation was observed on Lake Tohopekaliga during the 2005 breeding season, when the lake level fell rapidly, exposing dry substrate under several snail kite nests in Goblet's Cove. 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 very 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. At this point we cannot make any definitive statements about the relative importance of predation on nest success of kites at BCWMA, as we do not currently have any means to record predation events accurately. We note that we have only recorded information about predation in BCWMA since 2004.

**STATEWIDE**

Our demographic studies point toward alarming trends in the snail kite population in Florida. First, kite numbers have drastically declined since 1999 (Figure 4). Correspondingly, there has been a decline in both nesting attempts and the number of young fledged (Figure 5). A number of factors have likely contributed to these observed declines. Lake Okeechobee, which historically has been a productive breeding site, has become only a minor contributing unit since

1996. Loss of productive emergent wetlands due to changes in water and plant management regimes have likely have influenced this shift. In 2000 and 2001 nearly all of south Florida experienced a major drought although the KCL was less affected (Martin et al. 2006). The KCL did not experience extreme drought conditions because it is a highly managed system that is regulated to follow specific flood control schedules. Thus, water levels are more stable and less vulnerable to extreme short-term (or seasonal) fluctuations in rainfall. In 2001 water levels were near normal in the KCL and survival of kites in this system did not decrease to the extent observed in other wetlands. The extent of the drought effect on kites that used BCWMA was less clear, but it is possible that the BCWMA also served as a refugia in 2001(Martin et al in review). Like the KCL, the BCWMA is also a highly regulated system in which water levels more closely follow regulation schedules than rainfall patterns. Indeed confidence intervals of survival estimates of birds that used BCWMA during the 2001 drought were so wide that we could not measure precisely the magnitude of the drought effect on BCWMA (Martin et al. 2006).

In 2004 there was an intensive draw down of the Upper Kissimmee Chain of Lakes to facilitate extensive aquatic weed control activities in the littoral zone of the Lake Toho. No nesting occurred on East or West Toho in 2004 and only 8 nests were detected on Kissimmee (Rodgers et al. 2001; pers. observation).

We are concerned about the continuing lack of snail kite recruitment which is currently limiting population growth. The affect of the decrease in recruitment in 2006 and 2007 on population estimates are yet unknown but will become apparent in the 2008 population estimate. Nonetheless, a recent population viability analysis predicts high extinction probabilities in the next 50 years if survival and reproduction maintain rates similar to those observed during the last 5 years (Martin 2007). While the kite population decreased significantly from 2000 to 2002 largely due to drought effects, the population has not rebounded because fecundity and juvenile survival remain suppressed. Our observations suggest that poor water and vegetation management decisions may negatively impact fecundity and juvenile survival, but we have yet to rigorously test this hypothesis using a multiple competing hypotheses framework.

Given the historic contribution of the WCA's to the annual total production of kites there is little doubt that their persistence depends principally on maintaining high quality habitat in these areas. Current water regulation schedules implemented for the WCA's have drastically shortened the window during which kites have historically bred in these areas (Mooij et al. in review) (see "Recommendations"). In addition, water levels now recede more rapidly from elevated February stages. Exacerbated recession can negatively influence reproduction and survival in several ways. Rapidly receding water may force adults to forage further from their nests, and the associated energetic expenditure associated with foraging flights may limit the number of young they can provision and may even result in complete nest abandonment. Rapidly receding water levels may also increase the chance of nest predation, as nests become exposed to terrestrial predators (Beissinger & Snyder 1987; Sykes 1987b; Bennetts et al. 1988; Snyder et al. 1989; Kitchens & Bennetts 1997). Even when young are successfully fledged, they typically remain in their natal location and dependent on their parents for up to ten weeks; however, if conditions are too dry to allow for foraging, kites will immigrate and juveniles often die while dispersing through unsuitable foraging habitat (Mooij et al. in review).

During low rainfall years, the current regulation schedule also increases the likelihood of localized drought, which may reduce kite survival if other habitats are not available in close proximity (Martin et al in review). In 2004, we estimated 430 juveniles were fledged in the WCA's under fairly high early season water levels. However, out of 56 birds that we radioed, only 3 were re-observed in December indicating recruitment was low. For a majority of the radio-tagged kites lost, a mortality signal was detected before the onset of the hurricane season; therefore, we did not have an appropriate sample size to test for hurricane effects. We attribute this mortality to the premature and prolonged drying of the WCA 3A. This drying event began in March 2004 and lasted through July (Fig. 6). In addition, this drying event occurred at the same time as the managed draw down of the KCL, which greatly reduced the availability of emergent foraging and nesting habitat in this region; however, the regional affects on survival have yet to be determined.

In 2005, only 33 fledglings (16 in Lake Tohopekaliga, 7 in Lake Istokpoga, 4 in the BCWMA, 3 in Lake Okeechobee on the marsh near Old Moore Haven Canal, 2 in Lake Kissimmee, and 1 at West Palm Beach / Grassy Waters) were marked, which was a record low since 2001. No fledglings were observed in the WCAs, which are typically the most productive areas. This absence of reproduction is particularly disturbing given that the WCAs did not dry extensively. Had there been an extensive drying event, such low reproduction could be expected. Causal factors leading to the absence of reproduction in the WCA's in 2005 have yet to be identified. One hypothesis is that the extensive drying in 2004 may have adversely affected the apple snail population. However we note that over 80 kites were fledged and marked in 2002 which followed the 2001 drought. Therefore, other factors may be involved (see recommendations). In 2006, 15 snail kites were fledged from the WCAs. Unfortunately another drought occurred in 2007 and again no birds fledged from the WCAs. The lack of suitable habitat and failing or low reproduction in the WCA's during consecutive years further stresses the importance of implementing regional water management strategies that ensure some viable refugia habitat are maintained throughout the kite's range during drought years.

## RECOMMENDATIONS

### Recommendations Relevant to the Management of the Entire Population

A recent radio telemetry study showed that although kites move extensively among contiguous wetlands (i.e. KCL or WCAs), most kites do not move as freely as previously thought among wetlands isolated by extensive areas of unsuitable habitat (Martin et al. 2006). This may actually impede a significant proportion of birds from moving successfully to refuge habitats during drying events, and they most likely perish. This observation is of particular importance to management of the Everglades, 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 habitats (e.g., restoration of Lake Tohopekaliga) (Welch 2004) should consider conserving water in adjacent habitat areas to serve as refuge for snail kites such as the other KCL lakes like East Lake Toho and Lake Kissimmee (Martin et al. 2006). The timing of draw downs of local patches should occur sequentially, allowing a recovery period (still to be determined) for previously dried areas to return to a productive level. We also would like to reiterate the importance of the water regulation of WCA3A and maintaining a monitoring program to document habitat shifts and quality relative to kite usage.

### Recommendations Specific to BCWMA

BCWMA is clearly a critical part of the network of habitat used by kites. A portion of the kite population occupies and utilizes these wetland complexes consistently (Martin et al 2006). It may also provide refugia habitat when other wetlands are experiencing drought conditions (natural drying events or managed draw down). The higher number of kites observed during the draw down of the KCL, as well as modeling of snail kite movements, suggests that wetlands that are in close proximity to BCWMA (e.g., KCL) 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 should concern managers of the potential for BCWMA to be an ecological trap (Schlaepfer et al. 2002). Indeed, the small size and compartmentalized nature of this wetland complex may make nests particularly vulnerable to predation. The West Palm Beach Catchment Area (i.e. Grassy Waters) is of a similar compartmentalized nature, and circumstantial evidence for nest predation in accordance with low nest success is frequently observed in this area. Although documented predation was not as prolific in 2006, 81% of the initiated nests failed, possibly due to undocumented predation or starvation. Adult birds breeding in BCWMA may also suffer predation. Nest success is consistently low in the BCWMA. The anomaly was 2005. We emphasize that the hypothesis that BCWMA may serve as an ecological trap (because of predation on nests or breeding kites) is for now just a hypothesis. We recommend that more research be conducted (e.g., deploying camera traps) to determine a) the main snail kite nest predators in BCWMA and b) the significance of predation in nest failure. Such information would allow us to make further management recommendations (e.g., if owls are determined to be major predators then we would recommend eliminating the trees used by owls on the levees).

Drying events within the BCWMA are necessary to maintain suitable foraging and nesting habitat for kites. We suggest that management decisions allowing for these drying events should continue to take into account regional conditions, specifically in the KCL. This type of coordination in water management needs to be facilitated by those researchers responsible for monitoring snail kite numbers through communication with the USFWS. Maintaining sustained water levels in BCWMA during regional drought may be greatly beneficial for kites. The BCWMA could serve as refugia to drought, mitigating at least partially, the effect of drought on adult survival even if recruitment is poor. If managed drawdowns are needed to meet constraints in the Biological Opinion for the BCWMA, draw downs of BCWMA should be attempted during wetter years, or when no other managed draw downs are planned in the KCL. By contrast draw downs should be avoided during La Nina years which are typically characterized by drier conditions (Martin et al. in prep).

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**Table 1.** Kites observed during BCWMA surveys.

| 2006 | | | |
|---|---|---|---|
| **AREA** | **DATE** | **SURVEY** | **# birds** |
| EAST | 19 Mar | I | 41 |
| WEST | 18 Mar | I | 5 |
| EAST | 10 Apr | II | 48 |
| WEST | 9 Apr | II | 13 |
| EAST | 27 Apr | III | 51 |
| WEST | 27 Apr | III | 13 |
| EAST | 16 May | IV | 57 |
| WEST | 15 May | IV | 19 |
| EAST | 3 Jun | V | 77 |
| WEST | 2 Jun | V | 9 |
| EAST | 24 Jun | VI | 58 |
| WEST | 24 Jun | VI | NA |
| EAST | 28 Jul | - | 22 |
| WEST | 28 Jul | - | 0 |
| EAST | 30 Aug | - | 20 |
| WEST | 30 Aug | - | 0 |
| EAST | Sep | - | NA |
| WEST | Sep | - | NA |
| EAST | 2 Nov | - | 26 |
| WEST | 2 Nov | - | 0 |
| EAST | 30 Nov | - | 5 |
| WEST | 30 Nov | - | 1 |
| EAST | Dec | - | NA |
| WEST | Dec | - | NA |

| 2007 | | | |
|---|---|---|---|
| **AREA** | **DATE** | **SURVEY** | **# birds** |
| EAST | 15 Jan | - | NA |
| WEST | 15 Jan | - | 0 |
| EAST | 14 Feb | - | 7 |
| WEST | 14 Feb | - | 0 |
| EAST | 23 Mar | I | 3 |
| WEST | 23 Mar | I | 0 |
| EAST | 7 Apr | II | 2 |
| WEST | 7 Apr | II | 0 |
| EAST | 26 Apr | III | 0 |
| WEST | 26 Apr | III | 0 |
| EAST | 19 May | IV | NA |
| WEST | 19 May | IV | NA |
| EAST | 5 Jun | V | NA |
| WEST | 5 Jun | V | NA |
| EAST | 25 Jun | VI | NA |
| WEST | 25 Jun | VI | NA |
| EAST | 7 July | - | NA |
| WEST | 7 July | - | NA |
| EAST | 14 Aug | - | 0 |
| WEST | 14 Aug | - | 0 |
| EAST | 23 Sep | - | 0 |
| WEST | 23 Sep | - | 0 |
| EAST | Oct | - | 0 |
| WEST | Oct | - | 0 |
| EAST | 30 Nov | - | 0 |
| WEST | 30 Nov | - | 0 |
| EAST | 14 Dec | - | 1 |
| WEST | 14 Dec | - | 0 |

**Table 2**. Nests in BCWMA (2006): Coordinates (in UTM NAD 83), substrate, maximum number of eggs reported in each nest, maximum number of young observed, and number of young successfully fledged. The symbol '?' indicates that the status of the nest is unknown.

| UTMX | UTMY | Substrate | Max number eggs | Max number young | Young Fledged |
|---|---|---|---|---|---|
| 538580 | 3059908 | Cladium | 0 | 0 | |
| 536240 | 3060249 | Myrica | 2 | 2 | |
| 536076 | 3060248 | Myrica | 3 | 0 | |
| 535986 | 3060327 | Myrica | 0 | 0 | |
| 539654 | 3059893 | Salix/Typha | 3 | 1 | |
| 538992 | 3061180 | Sabal | 0 | 0 | |
| 540114 | 3061693 | Snag/Myrica | 1 | 0 | |
| 542139 | 3059882 | Typha | 0 | 0 | |
| 536278 | 3061929 | Taxodium | 0 | 0 | |
| 537160 | 3061889 | Annona | 0 | 0 | |
| 539503 | 3060656 | Annona | 0 | 0 | |
| 539595 | 3060388 | Magnolia | 3 | 0 | |
| 538696 | 3061812 | Magnolia | 0 | 0 | |
| 542134 | 3059913 | Typha | 3 | 0 | |
| 541466 | 3062773 | Myrica | 3 | 2 | **1** |
| 540082 | 3062704 | Salix | 3 | 0 | |
| 536327 | 3060904 | Taxodium | 3 | 1 | **?** |
| 537283 | 3063145 | Annona | 2 | 0 | |
| 537642 | 3062905 | Annona | 0 | 0 | |
| 537662 | 3062832 | Annona | 3 | 3 | **2** |
| 538108 | 3063083 | Salix | 0 | 0 | |
| 541396 | 3062207 | Typha | 3 | 0 | |
| 540252 | 3061717 | Chrysob | 0 | 0 | |
| 539533 | 3060581 | Annona | 2 | 0 | |
| 534746 | 3061856 | Salix/Typha | 3 | 0 | |
| 534843 | 3057833 | Taxodium | 3 | 2 | |
| 534638 | 3059774 | Taxodium | 0 | 0 | |
| 534301 | 3059645 | Taxodium | 0 | 0 | |
| 534490 | 3057613 | Taxodium | 3 | 0 | |
| 534161 | 3057746 | Taxodium | 2 | 0 | |
| 534931 | 3058225 | Taxodium | 0 | 0 | |
| 534739 | 3057804 | Taxodium | 0 | 0 | |
| 534665 | 3061812 | Sabal | ? | ? | |

**Figure 1.** Study area, with the number indicating the area sampled during the surveys. The red rectangle indicates Blue Cypress Water Management Area (BCWMA). [1 = L. Toho; 2 = L. Kissimmee; 3 = BCWMA; 4 = L. Okeechoobee; 5 = Grassy Waters; 6 = WCA1A; 7 = WCA2A; 8 = WCA2B; 9= WCA3A; 10 = WCA3B; 11 = Big Cypress; 12 = ENP]

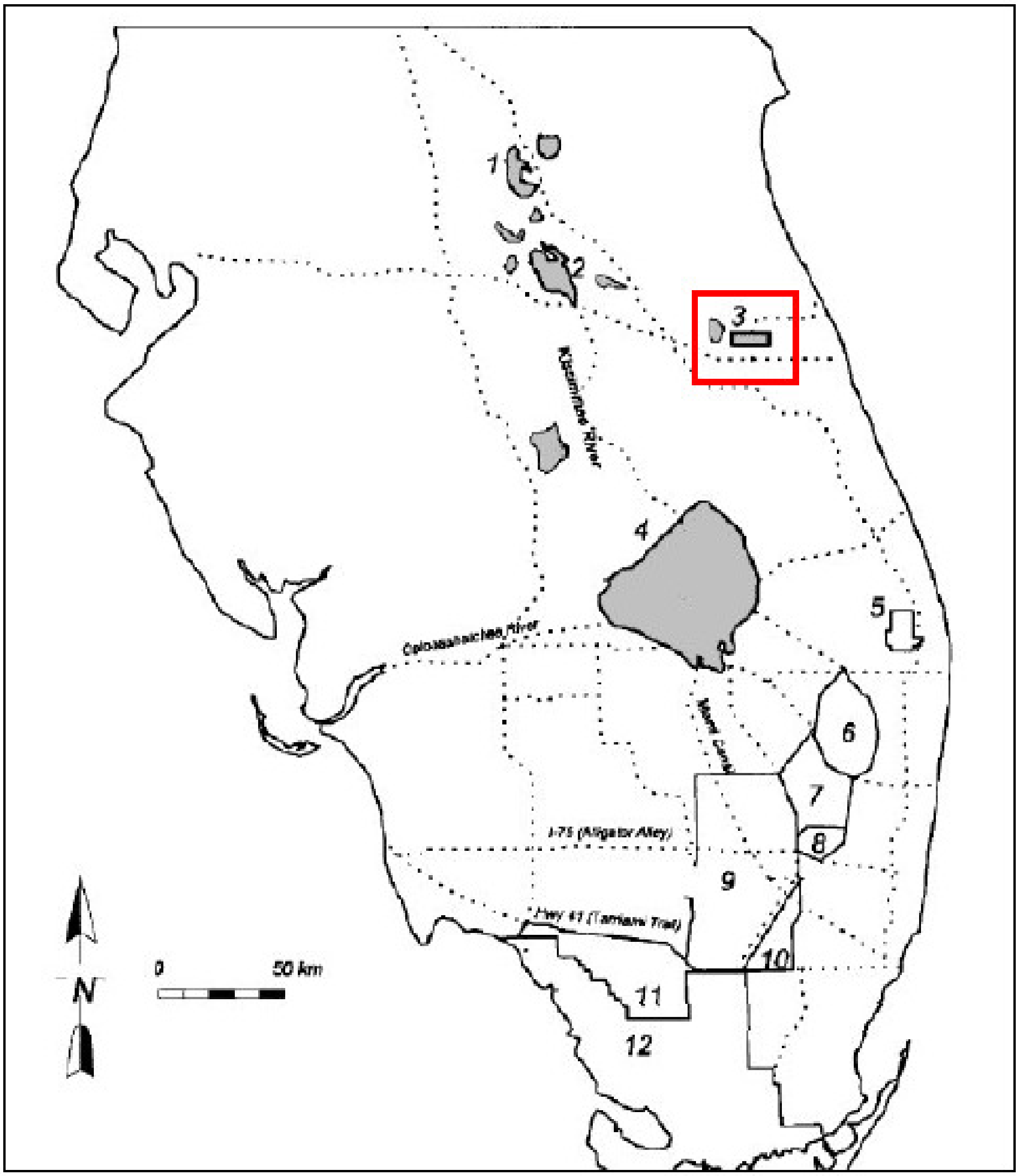


**Figure 2.** Comparison of nest success in BCWMA and all other wetlands combined between 1992 and 2006 (estimates from 1992 and 1997 were taken from Dreitz et al. 2001). Error bars correspond to 95% confidence intervals.

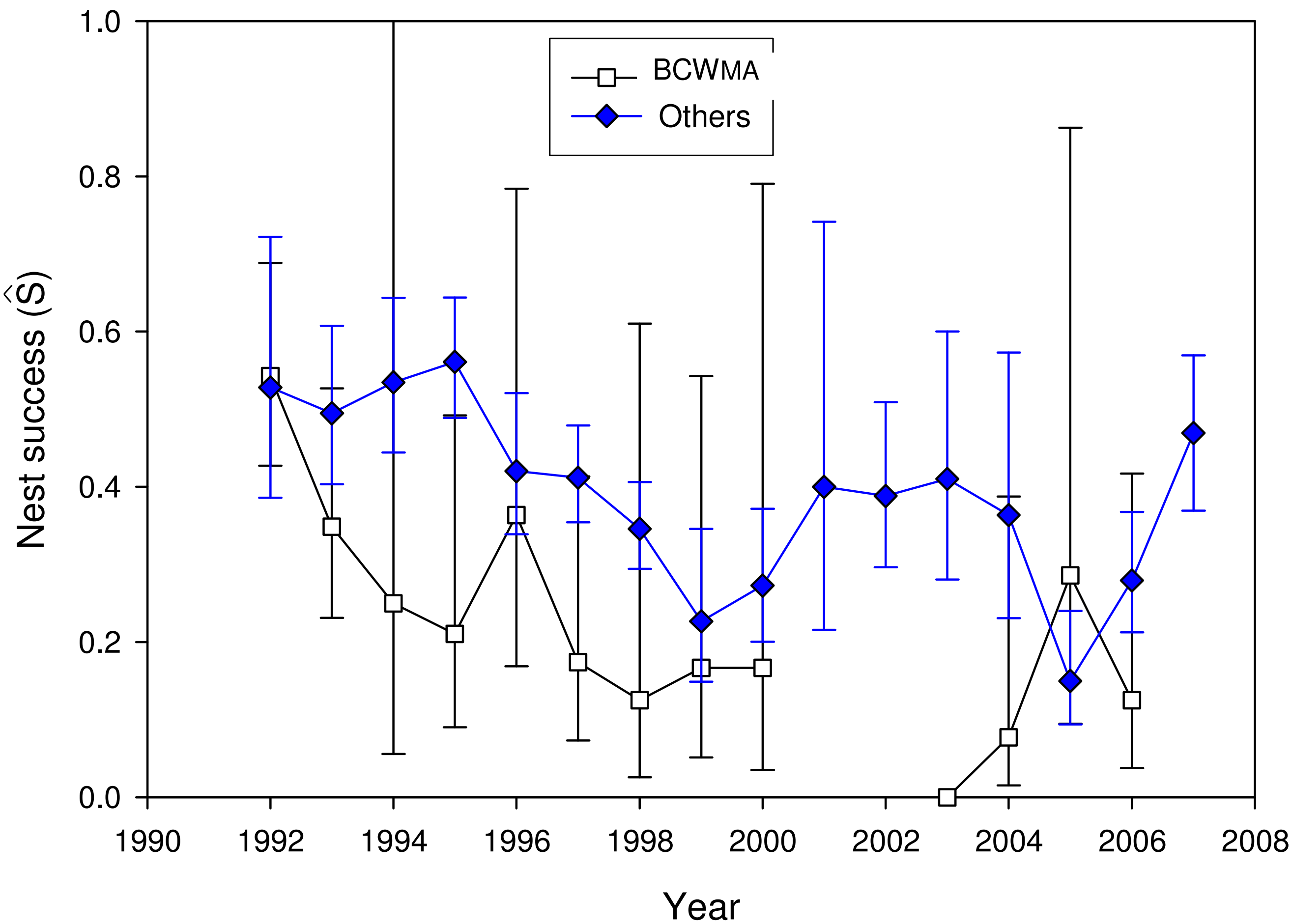


**Figure 3.** (a) Model averaged Estimates of adult and juvenile survival (phi-hat) between 1992 and 2005; (b) estimates of detection probability (p-hat) (from Martin et al. 2006). Error bars correspond to 95% confidence intervals

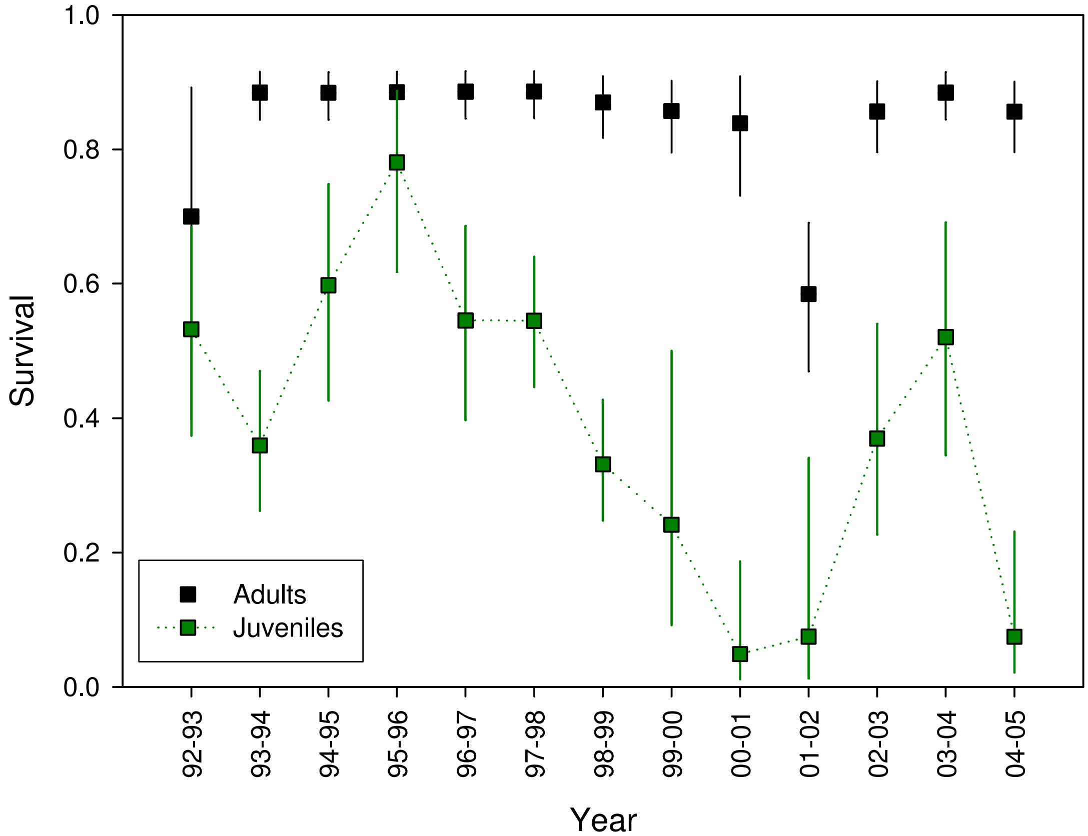


**Figure 4.** Population size of snail kites estimated for 1997 – 2007 using the superpopulation approach (Dreitz et al. 2002).

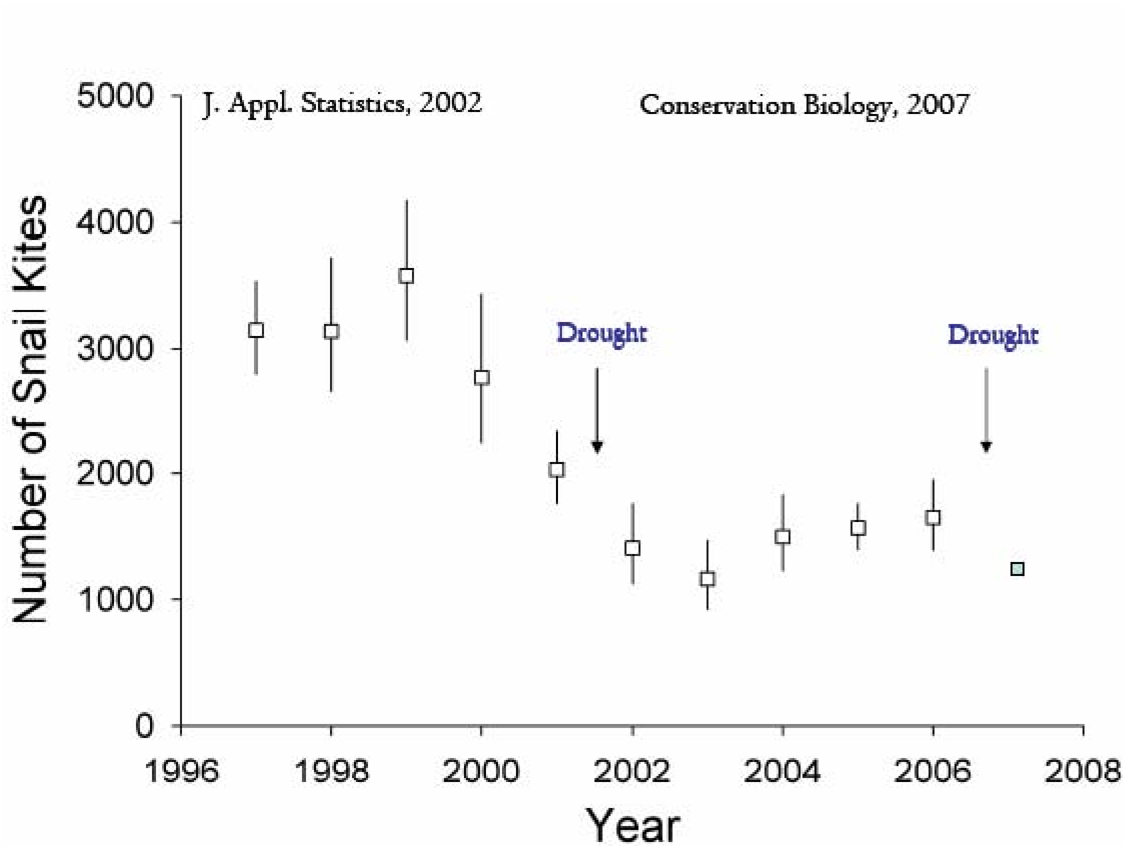


**Figure 5.** Number of young detected and banded: in the BCWMA (St. Johns), Water Conservation Areas (WCA), Kissimmee Chain of Lakes (KCL), Lake Okeechobee, and all areas combined (total), between 1992 and 2006.

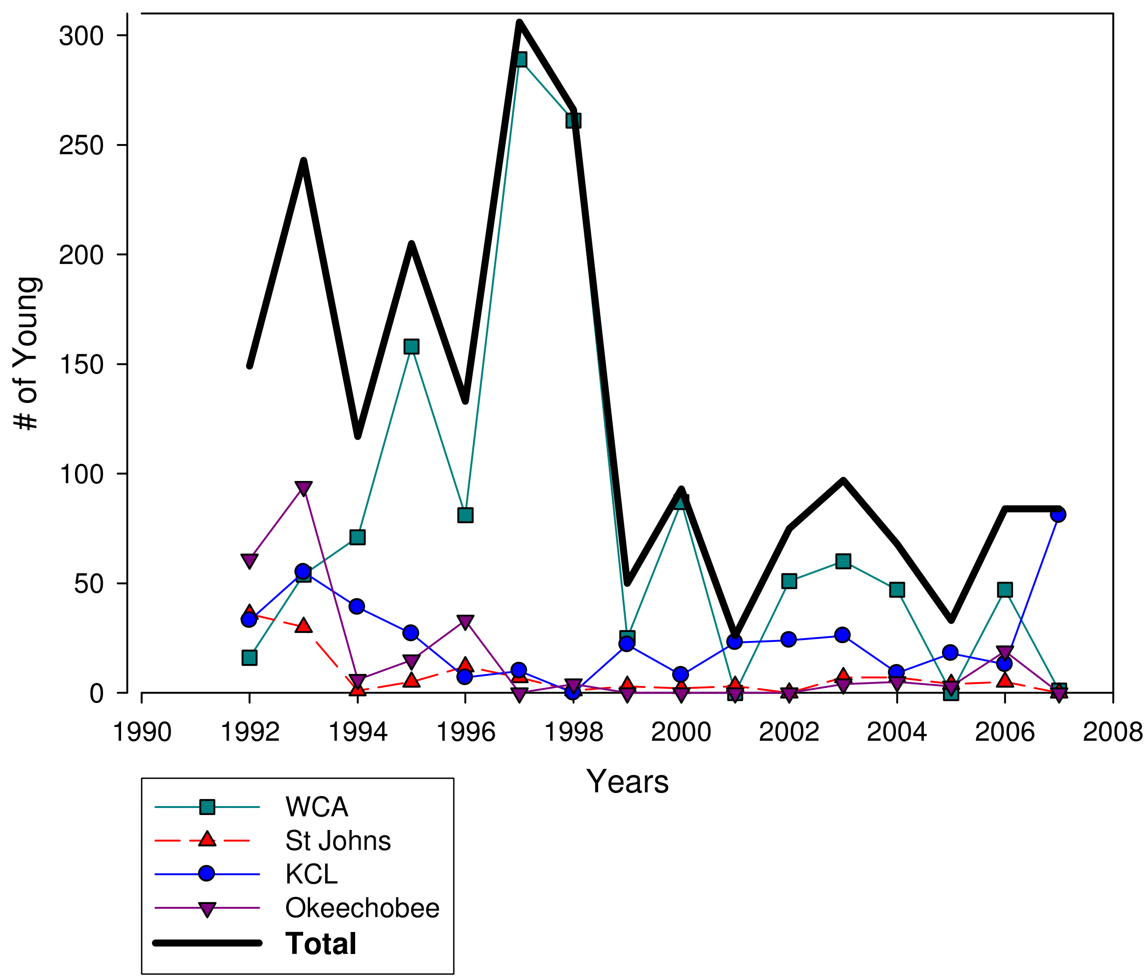
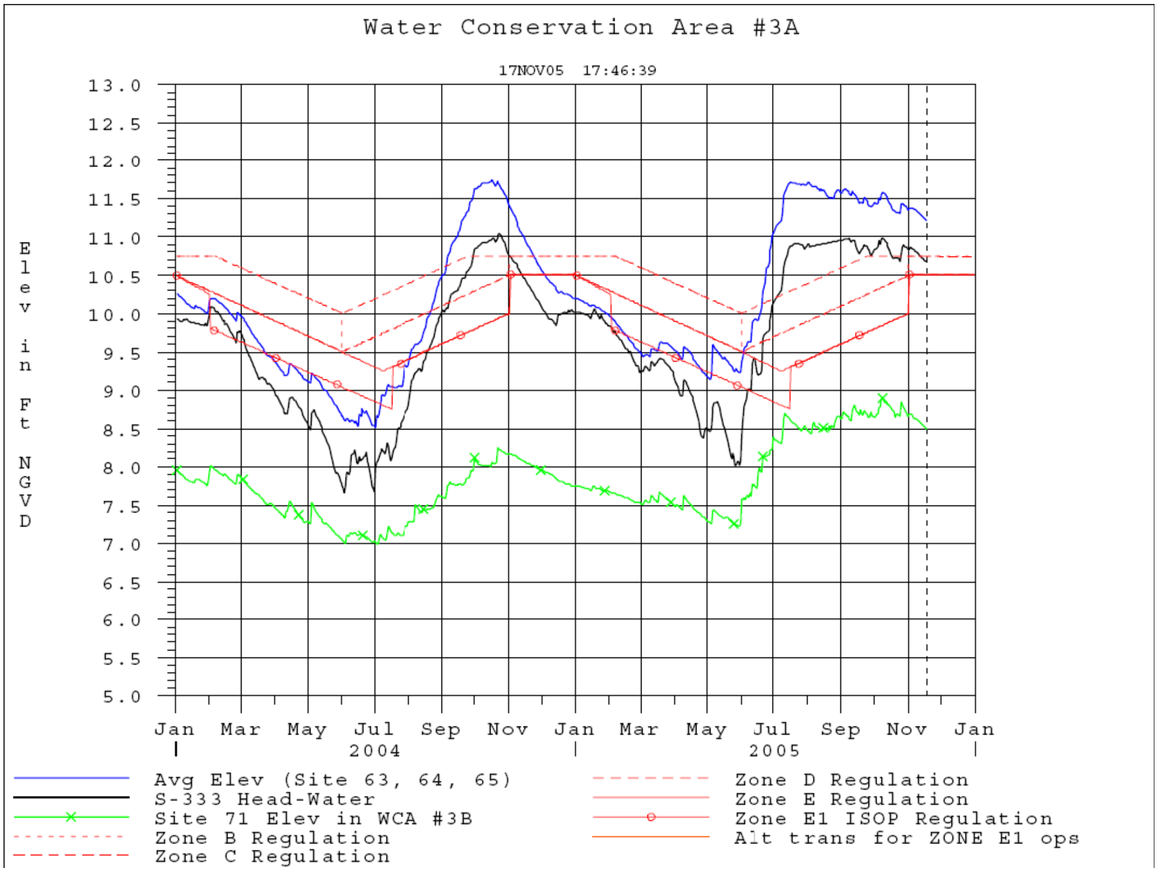
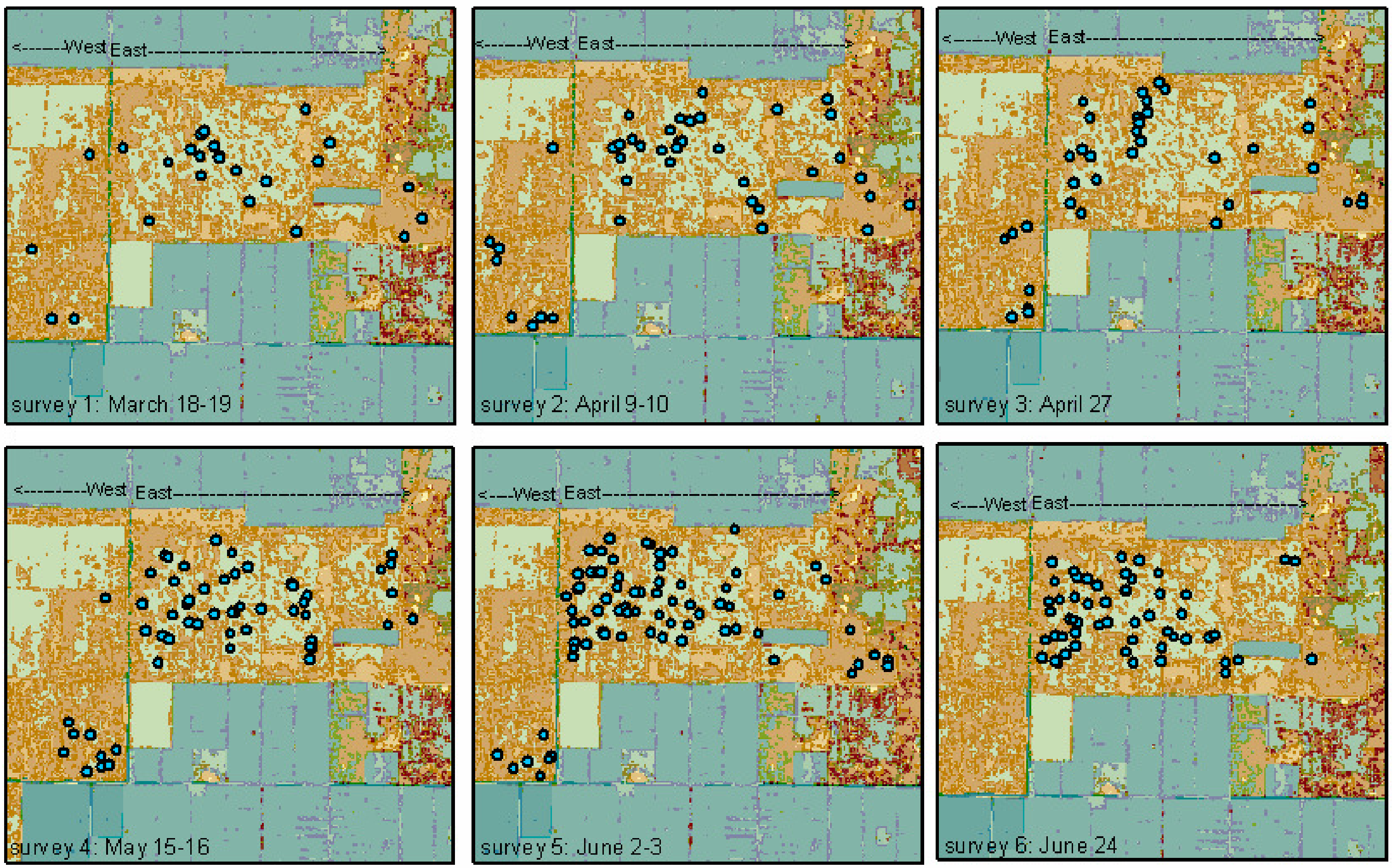


**Figure 6.** Water regulation schedule for WCA3A.

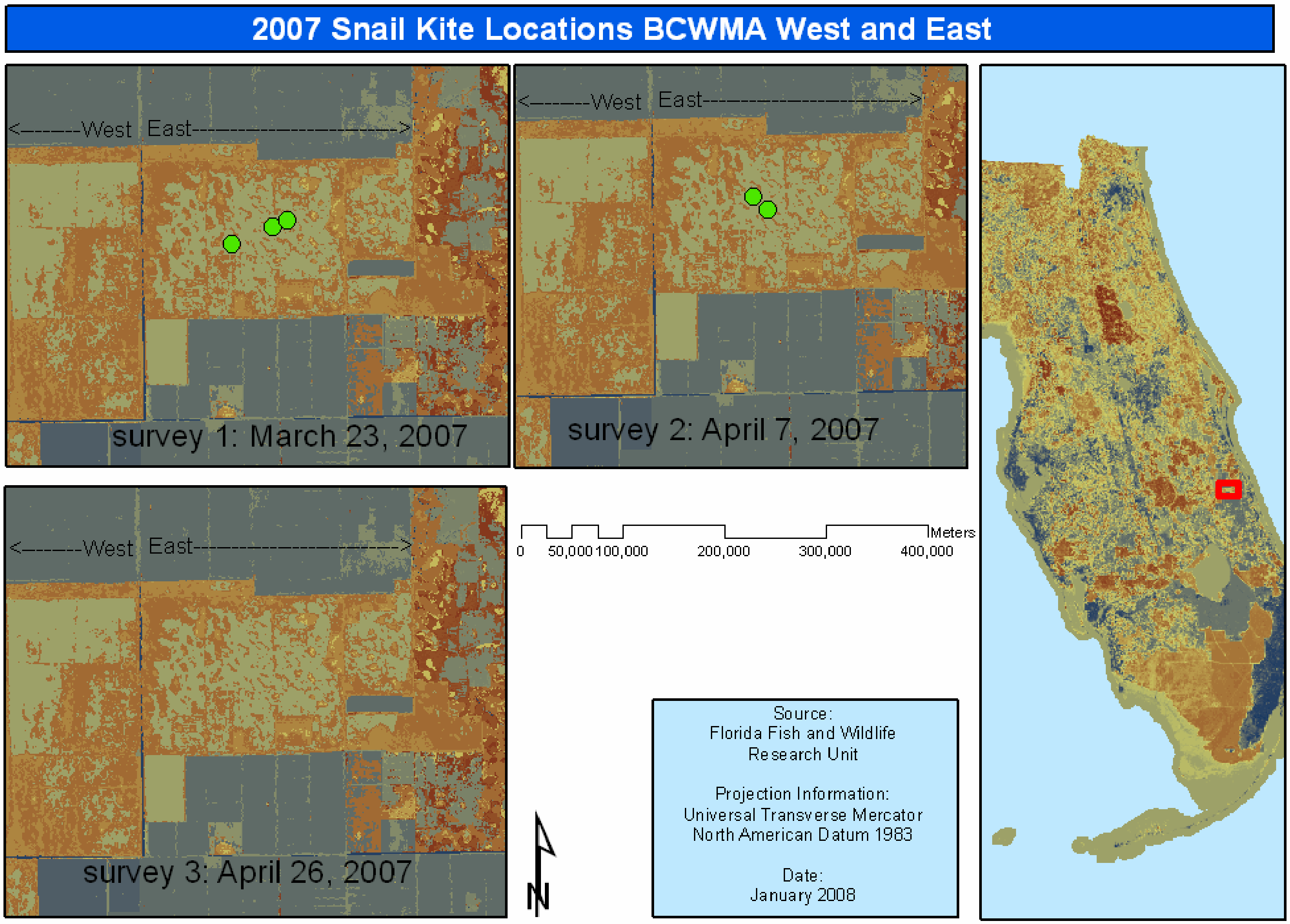


**Appendix 1.**

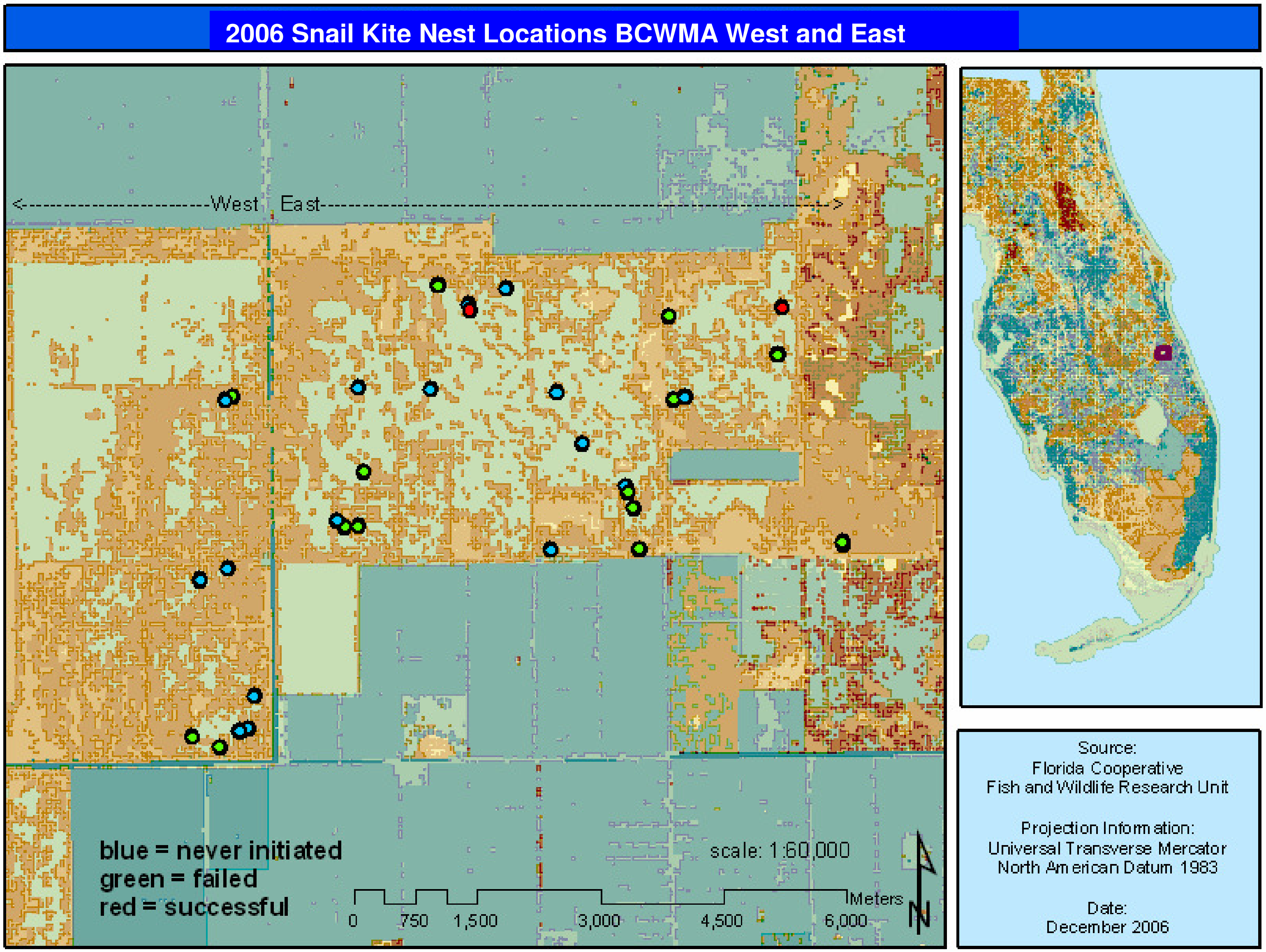
**Locations of Snail Kites in BCWMA (west and east) 2006 surveys 1 - 6**




Source: Florida Cooperative Fish and Wildlife Research Unit
Projection Information: Universal Transverse Mercator, North American Datum 1983
Date: December 2006


2007 Snail Kite Locations BCWMA West and East
<-------West East------------------------->
survey 1: March 23, 2007
<-------West East------------------------->
survey 2: April 7, 2007
<-------West East------------------------->
survey 3: April 26, 2007
0 50,000 100,000 200,000 300,000 400,000 Meters
N
Source:
Florida Fish and Wildlife
Research Unit
Projection Information:
Universal Transverse Mercator
North American Datum 1983
Date:
January 2008

**Appendix 2.**



2006 Snail Kite Nest Locations BCWMA West and East
<-------------------------West East------------------------------------>
blue = never initiated
green = failed
red = successful
scale: 1:60,000
0 750 1,500 3,000 4,500 6,000
Meters
N
Source:
Florida Cooperative
Fish and Wildlife Research Unit
Projection Information:
Universal Transverse Mercator
North American Datum 1983
Date:
December 2006

**Appendix 3.** Count of snail kites during surveys of the East and West parts of BCWMA between 2001 and 2007.

| 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 |