

CONSEQUENCES OF NESTING DATE ON NESTING SUCCESS  
AND JUVENILE SURVIVAL IN WHITE IBIS

By

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Differences in temperate and tropical and/or subtropical avian reproductive parameters may exist, making it difficult to apply temperate models of life history strategies to tropical and subtropical species. It is unclear whether avian species breeding in subtropical or tropical regions suffer the same seasonal decline in nest success commonly associated with temperate birds. I designed a study to compare some of the reproductive parameters (timing of breeding, nesting success, and juvenile survival) of White Ibises (*Eudocimus albus*), a primarily subtropical and tropical-breeding bird, nesting early and late in the breeding season. I monitored the fates of marked nests and radio-marked juvenile ibises from the Florida Everglades in 2001 and 2002, two years of contrasting hydrological conditions in the region.

When comparing years using the Mayfield method, White Ibis nesting success varied inconsistently during the breeding season. In 2001, a very poor breeding year overall (5.4% nest success), early-nesters had greater nest success than late-nesters (4.6%

and 1.7%, respectively). However, I observed a reversal of this pattern in 2002, a more typical nesting year in the Everglades (44.5% overall nest success), as late-nesters had greater nest success (44.9%) compared to early-nesters (33.4%). Early-hatched juvenile ibises in both study years had greater survival compared to late-hatched ibises, at least until 90 days post-independence from the colony.

The evidence from this study indicates that White Ibis nesting success in the Everglades seems to vary inconsistently as the breeding season progresses. I suggest that this inconsistent pattern of White Ibis nesting success was due to the unpredictable timing of wetland ecological conditions and variability in the extent and magnitude of these conditions in general, regardless of latitude, as opposed to a greater variation and unpredictability in subtropical compared to temperate environmental conditions. In either explanation, environmental inconsistencies between breeding seasons could make it difficult for adult White Ibises to select the optimal time to initiate nesting attempts, therefore potentially compromising nest success and offspring survival.

## CHAPTER 1 INTRODUCTION

Many species of temperate breeding birds show a decline in nesting success and offspring survival as a breeding season progresses, due to deteriorating environmental conditions (Lack 1966, Perrins 1970, Verhulst and Tinbergen 1991, Norris 1993, Lepage et al. 1999) and/or degrading food sources (Frederick and Collopy 1989a, Ogden 1994, Martin 1996), poor experience in late-nesting birds (Verhulst and Tinbergen 1991, Brinkhof et al. 1993), or some combination of these factors (Perrins 1966, Martin 1987, 1996, Price et al. 1988, Tinbergen and Daan 1990, Daan et al. 1990, Norris 1993). Most research regarding breeding chronology and offspring survival in birds has been conducted in temperate regions. It is unclear whether avian species breeding in subtropical or tropical regions also suffer the same seasonal decline in nesting success commonly associated with temperate birds. The models that have been proposed to explain the phenomenon in temperate bird species may not be pertinent under the different ecological conditions experienced by subtropical and tropical species, and the mechanisms that influence life history evolution in temperate birds may not be present and/or important in the tropics and subtropics (Ricklefs and Bloom 1977).

### **Mechanisms for a Seasonal Decline in Nest Success**

Two mechanisms are more commonly suggested to explain why early-nesting temperate birds are generally more successful than late-nesters. First, early and late-nesters may experience differences in environmental conditions (Verhulst and Tinbergen 1991, Ogden 1994, Brinkhof 1997, Morrison 1999), possibly influencing reproductive

decision-making and life history optimization (Daan et al. 1990, Tinbergen and Daan 1990). These environmental constraints could include a decrease in food resources over the breeding season (Sydeman et al. 1991, Ogden 1994), changes in predation pressure (Lloyd et al. 2001, Gotmark 2002, Jobin and Picman 2002), the onset of winter (high latitude sites) or the wet season (Perrins 1966, Frederick and Collopy 1989a, Young 1994a, Ogden 1994, Morrison 1999), and late-winter storms (Perrins 1966).

Late-hatched young may miss the period of most abundant food resources (Perrins 1970, Martin 1987), potentially retarding development. Sydeman et al. (1991) observed a decline in fledging success over the breeding season in Western Gulls (*Larus occidentalis*) nesting on Southeast Farallon Island. They correlated this decline in fledging success with a seasonal decline in the abundance of rockfish (*Sebastodes jordani*), the primary food of chicks, though parental experience and individual quality may, in part, have contributed to the observed seasonal variation in fledging success (Sydeman et al. 1991).

In a clutch switching experiment delaying or advancing the hatch date of Blue Tits (*Parus caeruleus*), Norris (1993) found a decline in juvenile survival with hatching date. Perrins (1970) suggested that if the period of greatest food abundance for tits is sufficiently short, late-nesting tits might hatch chicks during sub-optimal periods of less abundant resources. Hatching outside this window of peak food abundance may have contributed to the observed decline in late-hatched juvenile success observed in Blue Tits. Yet, differences in the genetic composition of chicks and/or parents, and the quality of parental care also may have influenced the observed seasonal decline in Blue Tit juvenile success (Norris 1993).

In many birds, juvenile size at fledging is important in determining post-fledging survival (Perrins 1965). Lepage et al. (1999) found that the growth rates of Greater Snow Goose (*Anser caerulescens atlanticus*) goslings near fledging were slower later in the season compared to earlier in the season. This seasonal disparity in growth rates resulted in the larger size and mass of early versus late-hatched goslings near fledging. They attributed the differences in growth rates to environmental factors, most likely a seasonal decline in food supply and colder late-season temperatures. Since the growth of goslings hatched on the same date did not vary between control and manipulated clutches, it was not likely that the quality of parental care contributed to the cause of the observed seasonal variation in gosling growth rates. However, differences in parental care or genetic differences of both chicks and parents may have influenced gosling growth rates and, subsequently, survival. Although they did not find any differences in pre-fledging survival during their study, there was an overall trend of a seasonal decline in pre-fledging survival for this population (Lepage et al. 1999).

A second mechanism to explain late-season declines in nesting success and chick quality (chick quality includes aspects of genetic composition and overall chick health) involves a declining quality of parental care and parental quality (same as for chicks) during the breeding season (Perrins 1970, Price et al. 1988, Brinkhof et al. 1997). An association between early breeding and high nutritional state in adults has been established for some birds, and females in good nutritional condition typically have higher reproductive success (Lack 1968, Perrins 1970). In many species, older parents tend to nest earlier and achieve higher reproductive success than younger parents (Finney and Cooke 1978, Dow and Fredga 1984, Nisbet et al. 2002), although this observation

clearly does not separate age and nutritional state, since environmental factors could still generate or contribute to the phenomenon.

In the colonial nesting Common Guillemot (*Uria aalge*), the onset of nesting can be highly synchronous with other colony conspecifics, regardless of the date (Hatchwell 1991). This strategy may be advantageous because synchronous nesting could swamp local predators, thereby reducing individual predation rates. Common Guillemots nesting on Skomer Island, Wales, displayed a seasonal decline in nest success, partially explained by late breeders' use of poor nest sites, increased predation of later and less synchronous nesters, and partially by the poorer ability of late breeders to provision young, even though there was no seasonal difference in food availability (Hatchwell 1991).

In a study of post-fledging survival, early-fledged European Coots (*Fulica atra*) from cross-fostered clutches had increased first-year survival compared to late-fledged coots (Brinkhof et al. 1997). Individual pairs that differed by 10 days in laying had either the hatch date of their young advanced (late laying parents) or delayed (early laying parents) by switching clutches with a different lay-period during incubation. Survival of juveniles laid later in the season but cared for by early-laying parents increased to similar levels as control (non clutch-switching), early-laying parents. Only a slight difference was evident between the survival of juveniles cared for by advanced pairs and those of controls. The experimental results supported the idea that differences in first-year post-fledging coot survival were due to differences in the quality of parental care (parental hypothesis). Yet, it is interesting to note that previous cross-fostering experiments with European Coots (Brinkhof et al. 1993) found that a seasonal decline in coot nesting success resulted from a combination of differences in the quality of parental care of early

and late-nesters (parental hypothesis) and from potential effects due to the seasonal hatch date (date hypothesis).

Separating the mechanisms of seasonal variation in nest success and post-fledging survival, even in temperate regions, has proved difficult. While the date and parental hypotheses have been tested with avian species breeding in temperate zones, there is a lack of information regarding the general life histories and any potential within-season differences in nest success and juvenile survival of tropical and subtropical breeding birds. Very few tropical bird studies have differentiated between early and late-nesting periods within a season (Morrison 1999, Ramos 2001, Olmos and Silva e Silva 2001), and comparisons between temperate and tropical species generally report only the overall trends in nest success and chick survival (Martin 1995, 1996).

Differences in temperate and tropical/subtropical avian reproductive parameters may exist, making it difficult to apply temperate models of life history strategies to tropical and subtropical species. In temperate regions, much of the seasonal patterns of success are dependent upon seasonal differences in resource abundance (see next section). The timing of nesting events, the window of breeding opportunity available for successful nesting, and the magnitude and duration of changes in ecological conditions may be as important as factors in nesting success and juvenile survival for tropical/subtropical nesters as they are for temperate nesters.

However, the tropics may have a greater variation in the window(s) of nesting opportunity and less consistent timing of seasonal resources than temperate ecosystems. How and when such changes in ecological conditions (e.g. seasonally fluctuating food resources) occur during a breeding season could affect associated seasonal patterns of

nest success and offspring survival in the tropics. Quality of parental care in tropical birds also may have a significant affect on within-season nesting success. If this is true, one might expect to see variation in the timing of nesting and inconsistencies in nest/chick success rates throughout a breeding season. As good parents select the most opportune times to breed they may have greater nesting/offspring success compared to poor parents. However, we know little about the consequences of the timing of breeding on seasonal differences in tropical/subtropical nesting success and offspring survival. Therefore, studies of seasonal trends in avian success in the tropics may enable us to better address the date and parental hypotheses as they apply to tropical and subtropical nesting birds.

### **Differences in Temperate and Tropical Bird Reproductive Parameters**

Life histories of birds in tropical and subtropical regions are generally characterized by smaller clutch sizes, more nesting attempts per year, greater nest predation, better adult survival, and longer chick development times than temperate species (Lack 1968, Skutch 1985, Martin 1996). The windows of nesting opportunity also may be longer for tropical compared to temperate species (Ricklefs 1968, 1976, Martin 1996). Nesting periods may vary annually (both in duration and timing), depending on each species' reliance on seasonally available resources and/or their flexibility regarding other environmental constraints (e.g. excessive rainfall or drought, changes in wetland hydrology, predation pressures, prolonged winter, etc.). If tropical birds have increased nesting opportunities due to a prolonged breeding season, then the within-season timing of breeding may not be as important a factor in nest success and offspring survival as demonstrated in temperate birds.

The degree of environmental predictability and variation within the tropics may have consequences for the reproductive behavior and physiology of birds (Wikelski et al. 2000). Precision in the timing of nesting allows seasonally breeding birds to come into a physiological state of breeding at a specific time of year, facilitating a more conservative allocation of resources to somatic efforts during the remainder of the year (Wikelski et al. 2000, Hau 2001). The temporal control of reproduction in birds from seasonal, temperate latitudes is well understood (Murton and Westwood 1977, Cockrem 1995, Hau 2001). In general, temperate birds apparently time their breeding to coincide with the period of most abundant resources (Lack 1968, Perrins 1970, Martin 1987). If temperate environments are more predictable in the timing of appropriate ecological conditions for nesting than those of the tropics and subtropics, it would be beneficial for higher latitude birds to time their breeding efforts precisely for the window of high resource allocation.

This display of timed breeding is evident in the arctic-nesting Lapland Longspur (*Calcarius lapponicus*), in which the entire population arrives, establishes territories, courts, and nests within a few days (Hunt et al. 1995). Synchronizing breeding in this predictable, arctic environment with the period of high food availability may allow for greater nesting success and offspring survival in Lapland Longspurs.

In contrast, if the window of suitable breeding were narrow, but unpredictable in time, opportunistic breeders would need to maintain a state of reproductive readiness for prolonged periods of time (Hahn 1998, Wikelski et al. 2000). Maintaining a state of reproductive readiness may be energetically demanding (Murton and Westwood 1977), making this a costly strategy for birds breeding in unpredictable environments.

The tropics may be less seasonal than temperate zones (Ashmole 1963, Martin 1996). Decreased seasonality in tropical and subtropical areas may lower food productivity generally or extend the period of productivity. Food acquisition also may be more difficult for tropical and subtropical species compared to temperate ones because of reduced food density, or because of increased competition (Ashmole 1963). Ashmole (1963) hypothesized that a decreased seasonality in the tropics could lead to increased competition and niche specialization among birds. However, species in tropical areas that experience seasonality in the form of marked wet/dry periods have been shown to breed as seasonally as temperate species (Wikelski et al. 2000) and, in some cases, form non-competitive niches (Ahumada 2001).

In Panama, Wikelski et al. (2000) considered the consistent between-year breeding patterns of Spotted Antbirds (*Hylophylax n. naevioides*) an indication that tropical seasons are as predictable for birds in that region as for temperate birds. Indeed, the predictability of Spotted Antbirds' environment (~70%) was highly comparable to central California White-crowned Sparrows (*Zonotrichia leucophrys nuttalli*) (~72%) and for Song Sparrows (*Zonotrichia melodia morphna*) (~77%) in western Washington (Wikelski et al. 2000). Spotted Antbirds also displayed a similar seasonal pattern of gonad regression and recrudescence as many temperate bird species, suggesting that Spotted Antbirds may follow a similar seasonal breeding cycle.

Less is known about the factors that influence the predictability of tropical environments as they concern avian reproductive decisions (Hau 2001, Ahumada 2001). Food availability is probably important, especially in environments with pronounced wet/dry seasons, and there is evidence that some Neotropical species exhibit a distinct

breeding season (Poulin et al. 1992). However, in tropical habitats with less distinct wet/dry seasons, food (Skutch 1950), nest predation (Young 1994a), and climate (Skutch 1950) may be important in determining when birds breed, and some species in these environments have been shown to breed year-round (Skutch 1950, Ahumada 2001).

However, the breadth of the foraging niche also may influence the degree of dependence of nesting timing and success on seasonal food pulses. Congeneric Buff-breasted (*Thryothorus leucotis*) and Rufous-and-white (*Thryothorus rufalbus*) Wrens in a dry forest of northeast Colombia may both use seasonal rains as a cue for the timing of reproduction (Ahumada 2001). The dry Colombian forest is characterized by annual unpredictability in the onset of the rainy season and pulses of food abundance, conditions that could present consistent, annual uncertainties in the reproductive decisions of birds in the area. Rainfall levels influenced arthropod abundance from year-to-year and the two wrens differed in foraging heights and food choice. Buff-breasted Wrens foraged in the leaf-litter, which displayed no significant change in arthropod abundance between wet and dry seasons. Rufous-and-white Wrens foraged on understory arthropods, which varied in abundance between seasons. The less seasonal and more predictable food source for Buff-breasted Wrens may explain the shorter nesting period and later nest initiations observed in Buff-breasted Wrens than for Rufous-and-white Wrens (Ahumada 2001). Yet, some factor other than food abundance may be acting upon Buff-breasted Wrens to shorten their nesting period.

Currently, most evidence supports the hypothesis that temperate regions are characterized by more predictable and less variable seasonal environmental conditions that, in turn, may allow some birds breeding in these areas to time their reproductive

events precisely for the period of greatest resource abundance. Such generalizations are more difficult to discern for the tropics and subtropics. Ashmole (1963) may be correct in his assessment that a less seasonal tropical habitat leads to the increased niche specialization seen in the tropics. Some evidence suggests that species occupying individual niches within local tropical communities may display different reproductive strategies, even when exposed to the same environmental pressures (see Ahumada 2001). Therefore, the well-studied examples of temperate birds seem to represent only one end of the continuum of seasonality and predictability of nesting conditions.

It is possible that the tropics and subtropics may display a greater variation in seasonality and predictability in the timing of nesting events and ecological conditions, but few studies of seasonal change in tropical/subtropical avian reproductive parameters exist. To better understand the effects of environmental predictability on the productivity and nesting success of birds generally, we therefore need to study the seasonal nesting success of species from a diversity of locations, especially those that represent varying degrees of environmental predictability within the tropics.

### **Subtropical South Florida and the Everglades**

In the subtropical Everglades of south Florida, we know that this pattern of decreasing nest success over a season holds for Wood Storks (*Mycteria americana*) (Kushlan et al. 1975, Kushlan and Frohring 1986, Frederick and Collopy 1989a, Ogden 1994). In the case of storks, the primary mechanism is obvious—late-nesting storks must raise their young during the onset of the rainy season, when prey becomes dispersed and less available during rising water (Ogden 1994). This situation is similar to temperate nesting birds that face a sharp decline in availability of food with the approach of winter.

However, since wading birds vary in their foraging techniques and prey selection (Kahl 1972, Kushlan 1976, 1977, 1979) the stork model may not be relevant for other species of wading birds when considering the source of seasonal limitation. Different species of wading birds also can vary in their response to foraging conditions. Certain species (Wood Storks, White Ibises *Eudocimus albus*, and Snowy Egrets *Egretta thula*) of wading birds' feeding strategies show a higher dependence on high densities of prey in shallow water, giving up and searching for new foraging locations sooner than other species (Glossy Ibises *Plegadis falcinellus*, Great Egrets *Casmerodius alba*, Tricolored Herons *Egretta tricolor*, Great Blue Herons *Ardea herodias*, Little Blue Herons *Egretta caerulea*) (Gawlik 2002b). Wood Storks and White Ibises are primarily tactile feeders (Kushlan 1977, 1979) and dispersion of prey as water depth increases may have a more profound effect their foraging ecology compared to the more visual foraging methods utilized by other wading birds (Kushlan 1976). It follows from this difference in foraging ecology between species of wading birds that changes in hydrological regimes may affect some species' life history strategies (including reproductive parameters) to a greater degree than others.

Somewhat in contrast to Wood Storks, Morrison (1999) found that Crested Caracaras (*Caracara plancus*) breeding in south-central Florida experienced varied nest success throughout a breeding season, with the lowest nesting success associated with early and late-season nesters. The unpredictability of several environmental factors, especially rainfall, may have contributed to the observed nest success rates in Crested Caracaras. Winter storms, cold fronts, and variations in the timing and magnitude of seasonal rainfall may have affected nest success either directly (hypothermic chicks), or

indirectly as ephemeral wetland water levels varied, altering the concentration of available food resources (Morrison 1999).

Understanding the general nature and sources of declining success over the nesting season is relevant to the success of Everglades restoration, since the timing of nesting in several species of wading birds may be related to seasonal hydrology (Kushlan et al. 1975, Kushlan 1979, Frederick and Collopy 1989a, Ogden 1994). Changes in hydrology can affect water depth and the location, diversity and density of prey, which may affect the foraging success of specific wading bird species (Powell 1987, Bildstein et al. 1990, Gawlik 2002b). Kushlan (1979) posited that the temporal and spatial components of White Ibis nesting events in the Everglades were associated with swiftly receding water levels. In a study of five wading bird species in the Florida Everglades, Frederick and Collopy (1989a) associated Great Egret nesting failure with the amount of rainfall, and a rapid surface-water drying rate was associated with White Ibis nesting success.

White Ibises are of particular interest because they represent the majority of the avian biomass in the Everglades (Ogden 1994) and because they display very long reproductive windows (nest initiation ranges from January to September) (Kushlan and Bildstein 1992). This flexible breeding schedule, coupled with the nomadic movements of this species, may allow White Ibises to exploit favorable and spatially unpredictable breeding conditions (Frederick and Ogden 1997). The consequences of this flexibility on nest success, juvenile survival, and demographic recruitment in White Ibises are unknown.

Due to the lack of information on within-season patterns of tropical and subtropical nesting productivity and the unpredictability of tropical environments, I designed a study

to characterize nesting success in a particular subtropical niche, wading birds reproducing in the wetlands of the Everglades. In this thesis, I report findings of a study designed to compare the reproductive parameters of a primarily subtropical and tropical-breeding bird, the White Ibis, nesting early and late in the breeding season. I predicted that White Ibis nesting success and offspring survival would be lower in nests initiated late versus early in the season. I compared late and early nests within several colonies, and assumed all nests within a colony were equally affected by environmental constraints at any particular moment in time. I expected to see significantly more eggs surviving to hatching, higher survival rates of nestlings to fledging, higher survival rates of fledglings to independence, and higher first-year survival rates of juveniles for early compared to late-hatched chicks.

## CHAPTER 2 METHODS

### **Study Area**

I chose a subtropical site, south Florida, U.S.A. (Chen and Gerber 1990, Duever et al. 1994), in which to study ibis nesting productivity in relation to nest date, because the region is a known center of nesting abundance for the species (Kushlan and Bildstein 1992), and previous reproductive information was available for this area (Frederick and Collopy 1988, Frederick and Collopy 1989a, Frederick 1995, Heath 2002). The primary study area encompassed the freshwater marshes of southern Florida (Miami-Dade, Broward, Monroe, and Palm Beach counties; Water Conservation Areas [WCAs] 2B and 3A; Arthur R. Marshall Loxahatchee National Wildlife Refuge [WCA 1]; and Everglades National Park; see Figure 1).

The landscape is divided by a system of dikes and canals, with varying levels of water regulation and management goals within individual compartments (Light and Dineen 1994). These areas are seasonally inundated and dominated by extensive stands of sawgrass (*Cladium jamaicense*) and cattail (*Typha angustifolia*). Tree islands and open water sloughs sporadically interrupt the sawgrass mosaic (Gunderson 1994). The south Florida climate has a distinctive annual wet and dry season and is generally considered to have more in common with the tropics than the more temperate regions characterizing most of North America (Duever et al. 1994). Climate is highly variable in space and time over the south Florida ecosystem, particularly in amounts and timing of rainfall and the severity of wet/dry years.

After some juveniles emigrated from the primary study region late in the breeding season, I expanded the area covered by radio-telemetry flights to include the majority of peninsular Florida, from Key Largo north to Daytona Beach. The initiation and frequency of flights over this expanded region depended upon the pattern and timing of juvenile emigration and/or an increased loss of signal receptions in the primary study area. As the breeding season progressed and more marked birds from both early and late-hatched cohorts expanded their range, I made two flights per week in areas outside the south Florida ecosystem. In an attempt to locate juveniles marked in 2001 during their first winter, I flew two additional nighttime flights in February 2002 over portions of southern and central Louisiana. Combined, these flights included locations from Baton Rouge south to the coast and east to New Orleans (see later this section).

### **Reproductive Success**

To monitor nest success, I first located White Ibis colonies using systematic (100% coverage) survey flights in fixed wing aircraft and later confirmed nesting stage during ground visits. Survey flights were performed in a Cessna 182 at an altitude of 240 meters with east-west flight transects spaced ~ 2.6 km apart (see Frederick et al. 2001). Attempts were made to monitor nest success in the majority of active White Ibis colonies (2001: 6 of 9; 2002: 5 of 8) within the study area, regardless of size. However, I excluded colonies I could not access with an airboat or on foot, usually due to extremely low water levels. I conducted all colony monitoring activities during one-hour visits either in the early morning (0600-1000) or early evening (1600-2000) hours to avoid heat stress to the birds and the nests. Previous studies of wading bird nesting productivity used one-hour colony visits (Frederick and Collopy 1988, 1989b, Frederick 1995) and I

believe that this conservative amount of time inside a colony resulted in a minimal amount of disturbance in this study.

When a majority of nests within a colony contained two or more eggs, I marked nests individually with strips of numbered orange or pink surveyors flagging, usually tied to a branch below the nest. Nests too high to reach by hand were checked using a bicycle mirror attached to the end of a telescoping aluminum pole. In small colonies (< 100 nests), all nests were marked and monitored. If the colony was large, all nests within two meters of transects through the colony were marked. To avoid edge effects, the first transect began at the edge of the colony, progressed toward the area of densest nesting, and continued until it reached the center of the colony or a point at which the density of nests declined markedly. If time allowed, I marked nests along additional transects, each beginning ~10 meters away from the end of the previous transect (i.e. either inside the colony or along the edge) and parallel to the first transect. The one-hour visitation limit determined the total number of nests marked per colony.

Marked nests were monitored through repeated visits to a colony every five days during incubation and every three days after hatching. At 14 days of age White Ibis nestlings became highly mobile, and it was not possible for me to associate chicks with specific nest sites. My concern with colony disturbance at this time was that younger birds (< 14 days) in the colony might not be able to return to the nest on their own. Therefore, I stopped individual nest monitoring when, for each marked nest, at least one nestling reached 14 days of age or when the nest failed. Colony visits stopped once I determined the fate of all marked nests in a colony. Some colonies (5 of 9 over both

years of study) displayed multiple nesting pulses over a breeding season, and I marked and monitored nests associated with these pulses in nesting effort.

During every visit to each nest I recorded the nest contents and any evidence of abandonment or failure. I used the following criteria to determine nest abandonment: all eggs in the nest were cold when touched by bare hands, all eggs or nestlings were missing from the nest (with no evidence of predation), the eggs were intact on the ground or chicks were dead outside the nest (with no evidence of predation), or the nest was entirely missing or partially dismantled. Efforts were made to determine if nest contents had been scavenged (post-abandonment) or depredated based on the presence of mammalian feces and/or the destruction pattern of broken eggs.

To monitor chick growth I measured the mass, wing chord, tarsus, and bill length for as many first-hatched chicks (considered the largest chick if hatching order was unknown) in as many marked nests as could be monitored during the one-hour period allotted for colony visits. I marked first-hatched chicks on the leg above the carpal joint with a non-toxic red paint and efforts were made to obtain repeated measurements (see above) on these individuals during subsequent colony visits.

Hatchability of eggs (proportion of eggs hatching divided by proportion of eggs surviving to the date of hatch) is an indicator of eggs that fail to hatch due to embryonic death, infertility, or poor attendance by adults. Only nests that hatched at least one chick were used in estimating hatchability.

I estimated clutch size data from nests found during the first six days after the laying of the first egg in order to minimize error associated with partial clutch losses early in the incubation stage. The nest initiation date was often unknown due to the

spacing of colony visits. Therefore, the initiation date for nests found while eggs were still being laid were backdated using a two-day interval between egg depositions. Nests found after the completion of egg laying were backdated using the hatch date of the nest's first young. I did not attempt to estimate the initiation date at nests for which neither the egg laying or hatch dates were known.

I considered nest success as the probability of any initiated nest producing at least one young to 14 days of age, at which point young were capable of escape by walking. I estimated nest success using Mayfield's (Mayfield 1961, 1975) method. Because survival rates may change with behavior of parents and nest content type, I estimated nest survival rates separately for the incubation (lay date of the first egg to 20 days after the laying of the first egg, 21 days total) and nestling (1-14 days of chick age) periods. The spacing of colony visits generally precluded determination of the actual day on which a nest failed. In the absence of evidence (freshly preyed upon or scavenged eggs, stage of chick decay) to accurately date a nest failure between visits, I used the midpoint of the interval between visits (including half-days) as the point of failure. An overall nest success probability was calculated by combining the period-specific rates (Hensler and Nichols 1981). Nest success estimates given are only through the period that the young spent in the nest since I could not monitor success after 14 days of age for juveniles not radio-marked.

### **Defining Early and Late Parts of the Season**

To investigate the effect of date of nesting on nest success, I compared the success of nests initiated early with the success of those initiated late in the nesting season. For each year, I obtained the median nest initiation date for all marked nests for which I could determine an accurate initiation date (see above). I placed a two-week buffer around

each year's median nest initiation date, creating a minimum 15-day buffer period between early and late-initiated nests. I considered early-season nests to be any nest initiated at least one week prior to the median nest initiation date (pre-buffer), and late-season nests to be any nest initiated at least one week after the median nest initiation date (post-buffer). "Middle" nests were any nests initiated during the 15 day buffer period. I used a Z-test to compare Mayfield nest success rates between time periods and between years (Hensler 1981, Hensler and Nichols 1985).

### **Juvenile Survival**

To monitor the survival of fledged juveniles (> 14 days of age) I re-entered study colonies when the majority of first-hatched young in a colony were at least 18 – 22 days of age. At this age they were considered large enough to return safely to the nest by themselves and to carry a radio transmitter. My goal was to annually capture and radio-mark 70 juveniles, 35 early-hatched and 35 late-hatched. Radio-marked juveniles were selected from any colony included in the nest success portion of the study that year, and I attempted to mark juveniles from all monitored colonies that fledged juveniles (7 of 13 colonies over both years of study). Up to twelve people entered a colony simultaneously and captured juveniles by corralling them in trees and hand-grabbing individuals. Radio-marked juveniles were from the same colony in which nests were marked, but were not necessarily associated with any marked nests in that colony.

I initially inspected captured birds to determine if they had sufficient mid-back feather growth to allow for transmitter attachment and whether they had a large enough mass to carry the transmitter safely. For each bird selected for radio-marking, I recorded mass and length of tarsus, bill and wing chord; collected scapular feather samples (5-8 feathers, including growing feathers if necessary) for analysis of mercury content, and

blood samples for sexing; and fitted each individual with a 17 gram, 6-volt radio transmitter (American Wildlife Enterprises, Monticello, FL; see description below). I attached a wrap-around, plastic, uniquely numbered colorband (National Band and Tag Co., Newport, KY) to the leg (above the carpal joint) of radio-marked juveniles for easy identification during subsequent visits to the colony.

I collected blood samples from a prick to the brachial vein with a 27-gauge needle. One drop of blood was collected with a capillary tube and the tube transferred to a vial pre-filled with ~70% ethanol. Samples were sexed by PE Celera AgGen (Palo Alto, CA). Radio transmitters were within 3-5% of a juvenile's total body mass and contained a mortality sensor that activated if the transmitter remained motionless for approximately 18 hours. I monitored radio-tagged juveniles through both aerial and ground telemetry tracking (see description below) until a bird either died (N = 25), prematurely dropped its transmitter (N = 1), or the study ended.

### **Transmitter Harness Design and Attachment**

Heath (2002) used a figure-8 leg-loop Teflon ribbon harness to attach transmitters to adult White Ibises. In order to monitor the survival of fledged juvenile White Ibises I needed a method of transmitter attachment that would allow for the continued growth of the birds. Juvenile White Ibises reach 90% of their final weight by 30 days of age (Kushlan 1977) and walk away from the nest for extended periods of time at approximately 28 days of age (nest fledge date, juveniles are not independent from their parents or the colony at this age) (Kushlan and Bildstein 1992). However, I could not capture juveniles after about 21 days of age, a point at which the birds were still growing.

I modified the harness used with adult White Ibises and designed an expandable figure-8 leg loop harness to attach 122 transmitters to juvenile ibises. Teflon ribbon (6.4

mm width) leg loops were precut to the average adult ibis harness setting (Heath, unpublished data). I loosely stitched a 6.5 mm knit polyester elastic (56% polyester, 44% rubber) thread into the middle of each entire leg loop. Before securing the elastic thread with a knot, I pulled it taut enough to form the Teflon ribbon into small bundles, “accordion style,” formed by holding onto the free end of the elastic and pushing the Teflon loop up against the body of the transmitter. This significantly reduced each leg loop’s size, actually pulling the loops closer into the body when placed on a juvenile bird, therefore reducing the chance of a bill or leg becoming entangled in the harness. The low tension in the elastic allowed for the expansion of the harness to the average adult White Ibis setting as the juvenile grew.

I cut a chiffon patch into the shape of the bottom of the transmitter leaving an extra 2-3 mm around the edges. Using a fast-drying epoxy, I attached the chiffon patch to the bottom of the transmitter. The Teflon ribbon loops were sewn together with cotton thread at the point of the adult setting, providing a weak link that would allow the transmitter to eventually detach when the cotton thread rotted through. Transmitters placed on adult White Ibises have been retained for over 18 months (Heath 2002).

To attach the transmitter I looped the harness around each leg and across the bird’s back, allowing the transmitter to rest anterior to the preen gland. I used fast-drying epoxy to attach the chiffon patch on the transmitter to the juvenile’s back feathers. Care was taken not to place epoxy directly on the bird’s skin. This method of attachment successfully kept the transmitter fixed in place on the bird’s back until the juvenile grew into the adult setting of the leg loops.

### Tracking Radio-Tagged Birds

I attempted to locate all radio-tagged birds through aerial and ground telemetry tracking on a regular basis, dependent on the stage of the colony (majority of marked birds pre-independence or independent from the natal colony). Once located, I recorded the bird's status (either alive or dead according to the mortality sensor), marked its location using a GPS unit (Garmin GPS 12), and tried to visually locate the bird. In order to determine cause of death, I attempted to recover all birds (or transmitters) broadcasting a mortality code as soon as possible after receiving a mortality signal.

When possible, I located marked juveniles from the ground until they were independent from the natal colony. I considered a marked bird fledged from its natal colony if I did not receive any signals from that individual within the colony on two successive visits. Until all birds were independent from a colony I monitored for signals at least bi-weekly. Once all marked birds were independent from a colony, I only flew over that colony if the transect route crossed that area.

To estimate the age at which birds became independent from the colony, I considered each radio-tagged juvenile to be 20 days of age when radio-marked. I added to this age the additional number of days until that particular bird was not found on a telemetry monitoring flight over its respective colony (see description above). I then used the midpoint between first date missing and the last day found in the colony as the independence date, unless the actual independence date was known (e.g. via daily ground telemetry monitoring of a colony).

I performed systematic aerial searches for marked birds using radio-telemetry flight transects spaced 7-9 km apart and flown at an altitude of 900-950 m above ground with a ground speed of 161 km/h. Most telemetry flights were 4-5 hours in duration and

consisted of flying directly over all colonies containing marked birds, followed by flying transects over selected areas in all Water Conservation Areas, Everglades National Park, Big Cypress National Preserve, and the Everglades Agricultural Area south of Lake Okeechobee. Once juveniles began dispersing from a colony I made at least two telemetry flights per week, often in addition to continued ground monitoring of a colony. Efforts were made to fly over all of the mentioned areas every two weeks; however, I concentrated the majority of flights over areas with standing water or that were known areas of dense wading bird foraging activities. As the season progressed and marked birds began leaving the south Florida ecosystem, I flew along the coastal zones as far north as Cedar Key and Daytona Beach, Florida, and in central Florida from Avon Park to the southern tip of Lake Okeechobee.

From December 2001 to March 2002, I attempted to locate radio-marked individuals by monitoring large ( $> 100$  birds) White Ibis winter roost sites within peninsular Florida. Roost monitoring occurred from one hour before sunset until 30 minutes to one hour after sunset and included both inland and coastal roosting locations. In addition, I conducted two aerial nighttime roost-monitoring flights over portions of southern and central Louisiana, from Baton Rouge south to the coast and east to New Orleans. I selected flight areas in Louisiana based on high-density ( $> 1000$  individuals) locations of White Ibises counted during the Audubon Christmas bird counts in December 2001 (National Audubon Society 2002).

### **Statistical Analyses**

Statistical tests were conducted using SPSS software version 10.1 and SAS software version 8. I report descriptive statistics as mean  $\pm$  standard error unless otherwise noted. Nonparametric tests were used (Hollander and Wolfe 1999) if

requirements for parametric tests could not be met. Comparisons of clutch sizes and nest abandonment between early and late-nesting ibises were made using a Wilcoxon-Mann Whitney test. I used a chi-square test of independence to compare the hatchability of eggs between early and late nest periods.

I estimated survival of radio-tagged juveniles using the Kaplan-Meier product limit estimator (Kaplan and Meier 1958) with a staggered entry design (Pollock et al. 1989). Birds were censored from the study if I did not locate that individual at least once during every 30-day period post-independence. Censored birds found later in the study were re-entered as new additions to the population (not “back-logged” to the individual’s last known resight point). I divided juvenile survival into four distinct time periods: survival until independence from the colony and 30, 60, and 90 days post-independence. A two-sample test for censored data (Mantel log-rank) was used to compare survival probabilities between early and late nesting periods for each year (Pollock et al. 1989, Hollander and Wolfe 1999).

## CHAPTER 3 RESULTS

I marked and monitored 570 White Ibis nests between 2 March and 7 June 2001 and 790 nests between 20 March and 11 June 2002 (Table 1). These nests represented approximately 3.3% of the total White Ibis nests initiated in the Everglades as estimated by aerial surveys in 2001 (Gawlik 2001) and 2.4% of the total in 2002 (Gawlik 2002). The difference in marked nest initiations between early and late-nesting ibises ranged from 19 days (number of days between the latest, early-period nest and the first, late-period nest) and 83 days (number of days between the first, early-period nest and the latest, late-period nest) in 2001 and from 15–62 days in 2002 (Figure 2). Differences in the observed range of nest initiation dates were due to the earlier onset of nesting in 2001 compared to 2002 (see Figure 2) and the prolonged 2001 nesting season compared to 2002.

### **Comparison of Reproductive Parameters In Early and Late Nests**

Mean clutch size was significantly larger in late compared to early-nesting ibises in 2002 ( $U = 21706$ ,  $Z = -2.106$ ,  $P = 0.035$ ) (Table 2). The observed mean clutch size for each year (2001:  $2.50 \pm 0.04$  and 2002:  $2.56 \pm 0.03$ ) was near the middle of the range for the species (Table 3). Hatchability (the percent of available eggs at the time of hatching that actually hatched) of eggs from monitored nests (all clutch sizes combined) was not significantly different for early and late-nesting birds in either study year (2001:  $X^2 = 0.90$ ,  $P = 0.344$  and 2002:  $X^2 = 2.21$ ,  $P = 0.137$ , Table 2). The overall hatchability in

2001 (0.854) and 2002 (0.856) for White Ibises in the Everglades system was the lowest recorded since 1986 (Table 4).

Table 1. Numbers of White Ibis nests marked by nest period and colony in 2001 and 2002.

Colony	Nest Period	2001	2002
Alley North <sup>a</sup>	Early	0	246
Big Pond <sup>a</sup>	Late	42	0
Hidden <sup>a</sup>	Middle	0	21
	Late	0	92
L-67 <sup>a</sup>	Late	78	0
Lox 70 <sup>b</sup>	Early	150	85
	Middle	0	53
Lox 99 <sup>b</sup>	Middle	0	57
	Late	0	88
Lox 111 <sup>b</sup>	Early	203	0
Tamiami West <sup>c</sup>	Early	28	0
	Late	0	148
2B Melaleuca <sup>d</sup>	Early	4	0
	Middle	33	0
	Late	32	0

a) Water Conservation Area 3A

b) A.R.M. Loxahatchee National Wildlife Refuge

c) Everglades National Park

d) Water Conservation Area 2B

Table 2. Mean clutch size and hatchability (the percent of available eggs at the time of hatching that actually hatched) comparisons from marked White Ibis nests. Error is standard error.

	2001		2002	
	Early	Late	Early	Late
Clutch	$2.52 \pm 0.04$	$2.59 \pm 0.08$	$2.49 \pm 0.04^*$	$2.62 \pm 0.04^*$
N	197	49	183	265
Hatchability	$0.82 \pm 0.03$	$0.90 \pm 0.05$	$0.88 \pm 0.02$	$0.83 \pm 0.02$
N	53	10	176	212

\*Mann-Whitney U = 21706, Z = -2.106, P = 0.035.

Table 3. Comparison of mean White Ibis clutch sizes and Mayfield nesting success estimates in this study with those from studies in other years and locations.

Study	Location	Year	Clutch Size			Mayfield Nest Success (%)
			Mean	S.D.	N	
Frederick 1993 <sup>b</sup>	Loxahatchee N.W.R.	1992	2.20			
Kushlan 1977	Coastal Everglades	1972-73	2.20	0.640	290	
Allen-Grimes 1982 <sup>a</sup>	Coastal North Carolina	1981	2.23		312	59
Frederick 1993 <sup>b</sup>	WCA 3	1992	2.24	0.572	68	16
Frederick 1995 <sup>b</sup>	WCA 3	1995	2.36	0.771	11	12.6
Kushlan 1977	Interior Everglades	1972-73	2.45	0.670	51	
Kushlan 1977	South Florida Lakes	1972-73	2.49	0.560	202	
<b>This study</b>	<b>Interior Everglades</b>	<b>2001</b>	<b>2.50</b>	<b>0.601</b>	<b>274</b>	<b>5.4</b>
<b>This study</b>	<b>Interior Everglades</b>	<b>2002</b>	<b>2.56</b>	<b>0.650</b>	<b>571</b>	<b>44.5</b>
Smith 1994 <sup>b</sup>	Lake Okeechobee	1991	2.50	0.570	96	34
Frederick and Collopy 1988	Interior Everglades	1987	2.53	0.527	162	48.9
Rudegeair 1975	Interior Central Florida	1973-74	2.53		74	
Frederick 1987 <sup>a</sup>	Coastal South Carolina	1984	2.55		380	
Smith 1994 <sup>b</sup>	Lake Okeechobee	1990	2.60	0.620	85	47.8
Smith 1994 <sup>b</sup>	Lake Okeechobee	1989	2.70	0.480	46	40.5
Frederick and Collopy 1988	Interior Everglades	1986	2.72	0.534	94	20.4

a) Frederick and Collopy (1988)

b) Frederick (1995)

Table 4. Comparison of White Ibis hatchability from marked nests in 2001 and 2002 with marked nests from WCA 3 in previous years.

Year	Hatchability
2001	0.854
2002	0.856
1986 <sup>a</sup>	0.888
1992 <sup>b</sup>	0.916
1995 <sup>b</sup>	0.931
1987 <sup>a</sup>	0.972

a) Frederick and Collopy (1988)

b) Frederick (1995)

### **Mayfield Nest Success Estimates**

Overall nest success estimates (probability of a nest producing at least one chick to fledging, 14 days old) were significantly higher in 2002 compared to 2001 ( $Z = -19.159$ ,  $P << 0.0002$ ) (Table 5). Early-nesters had significantly higher nesting success compared to late-nesters in 2001 ( $Z = 2.64$ ,  $P = 0.004$ , Table 5), while in 2002, late-nesters had significantly higher nesting success compared to early-nesters ( $Z = -2.91$ ,  $P = 0.002$ , Table 5). Middle-nesting ibises displayed significantly higher nest success rates compared to either early or late-nesting ibises in both years of study (Table 5).

Using data from two previous White Ibis nesting success studies in WCA 3 (1986 and 1987, see Frederick and Collopy 1988) I determined the early and late-nesting demarcation dates for each year and computed Mayfield success estimates for all marked nests. In both 1986 and 1987, early-nesters had significantly greater nesting success than late-nesters (1986:  $Z = 13.231$ ,  $P << 0.0002$  and 1987:  $Z = 13.577$ ,  $P << 0.0002$ ; Figure 3). Late-nesting ibises in both years showed particularly low nesting success versus early nesting ibises when compared to nest success patterns in 2001-2002 (Figure 3). The

Table 5. Mayfield estimates of nest success rates for White Ibis nests monitored in 2001 and 2002. Number of young fledged is from actual observations.

	2001				2002			
	Early	Late	Overall	Middle	Early	Late	Overall	Middle
N	371	152	556	33	331	329	790	130
<u>Incubation Period</u>								
Number of Successful Nests	99	30	155	26	175	212	509	122
Number of Incubation Nest Days	3490	819	4528	219	3678.5	4216	9613.5	1719
Survival for Incubation Period	0.182	0.034	0.143	0.506	0.403	0.554	0.536	0.907
SE	0.001	0.001	0.001	0.023	0.002	0.002	0.001	0.003
<u>Nestling Period</u>								
Number of Successful Nests	33	21	76	22	146	172	424	106
Number of Nestling Nest Days	707	182	1171	282	2201.5	2683.5	6403.5	1518.5
Survival for Nestling Period	0.254	0.492	0.376	0.819	0.831	0.810	0.829	0.862
SE	0.004	0.021	0.003	0.016	0.002	0.002	0.001	0.003
Overall Nesting Success	0.046	0.017	0.054	0.414	0.334	0.449	0.445	0.782
SE	0.000	0.001	0.000	0.020	0.001	0.002	0.001	0.003
Number of Young Fledged	58	36	131	37	256	273	723	194
Early versus Late	Z = 2.641	P = 0.0041			Z = -2.907	P = 0.0019		
Early versus Middle	Z = -3.202	P = 0.0007			Z = -9.331	P < 0.0002		
Late versus Middle	Z = -3.465	P = 0.0003			Z = -6.801	P < 0.0002		
2001 versus 2002	Z = -19.159	P << 0.0002						

median nest initiation date for 1986 and 1987 occurred during the last week of May (26 May and 29 May, respectively, Figure 2) compared to the middle of April in 2001 and 2002 (12 April and 8 April, respectively, Figure 2). The late-May start of late-nesting ibises observed in 1986 resulted in the majority of late-nesters starting and/or incubating nests during the onset of the rainy season for that year (1<sup>st</sup> week of June). While it is likely that the increased number of large storms (> 2.54 cm of rain/day) associated with the beginning of the rainy season and the subsequent rise in water levels surrounding the colony caused the large-scale abandonment observed in 1986 (Frederick and Collopy 1988), I observed high nest success (> 63.5%) from late-nesters in 2002 even after the start of the rainy season (last week of May) in that year (Figure 4). When compared to nesting success from previous years in WCA 3, 2001 was at the extreme low end of the scale for the species, while 2002 was more representative of previous years (Figure 5, Table 3).

### **Nest Abandonment and Predation**

I observed some degree of nest abandonment in all the locations within all study colonies in both years. Abandonment appeared to be independent of island structure, density of nesting ibises, or frequency of researcher visits. Very few nests showed evidence of mammalian predation (Table 6). Therefore, I considered the majority nests found empty during a colony visit to have been abandoned by one or both parental birds.

Many abandoned nests were often associated with post-abandonment scavenging (primarily from Boat-tailed Grackels *Quiscalus major*). Nest failure frequently occurred in localized areas within a colony, with several nests in close proximity to one another failing simultaneously. Nest abandonment ranged from 33.3% (2B Melaleuca) to 100% (L-67) in 2001 and from 37.6% (Hidden) to 69.4% (Lox 70) in 2002 (Figures 6 and 7).

In 2002, late-nesters displayed significantly less nest abandonment compared to early-nesters ( $U = 50000.5$ ,  $Z = -2.099$ ,  $P = 0.036$ , Figure 8).

Table 6. Causes of nest failure in early and late-initiated nests monitored in 2001 and 2002.

	2001		2002	
	Early	Late	Early	Late
Abandoned			266	146
Mammalian Predation			2	4
Other (wind damage, researcher handling, etc.)			4	0
Total			272	150
			208	96

There were no complete failures of all nests within any White Ibis colonies in 2000 (Frederick et al. 2001) or 2002 (including those in which I did not monitor nests, data obtained through aerial surveys), compared with the complete abandonment of some (2 of 6) marked colonies in 2001. Through aerial surveys in 2001, I observed repeated initiation of large-scale ibis nesting events ( $N = 9$  colonies > 450 nests) followed by complete or nearly compete abandonment (> 75%) in several colonies ( $N = 6$ ).

### **Survival of Young Post-Fledging**

I radio-tagged a total of 122 juvenile White Ibises from six colonies in 2001 and 2002 (Table 7). Age of independence for marked birds ranged from 51–70 days of age, and the mean age at independence was about 61 days for both years (Table 7).

Table 7. Distribution of radio-marked juveniles by nest period and mean age (in days) at independence for all marked birds that survived to independence.

	2001			2002		
	Early	Late	Combined	Early	Late	Combined
N	29	24	53	35	34	69
Age	$60.8 \pm 1.5$	$60.1 \pm 1.3$	$60.5 \pm 1.0$	$62.2 \pm 0.8$	$58.4 \pm 0.7$	$60.7 \pm 0.6$

I experienced very different location-rates of radio-marked birds' signals between 2001 and 2002. In 2001, only 16 of 46 (34.7%) birds that survived to independence were located at least once outside their natal colony compared to 43 of 57 (75.4%) juveniles in 2002 (Appendix B). Several reasons may partially account for this difference in the location-rates of transmitter signals including transmitter and/or receiver malfunctions, a poor ability to receive mortality signals, and faster emigration rates of juveniles to areas outside central and southern Florida in 2001 compared to 2002.

Due to the simultaneous use of two receivers on numerous telemetry flights in both years of the study and my ability to locate birds' signals during these flights, it seems unlikely that receiver malfunction caused such a large discrepancy in resight rates. A transmitter's frequency can shift or change, especially during its first six weeks in use, potentially altering the frequency enough to mask detection. To avoid this problem I activated transmitters a minimum of two weeks prior to attachment and tuned each transmitter on every receiver the night before deployment. This allowed me to obtain a transmitter's stable frequency before attachment. During the first month post-attachment, all birds carrying transmitters remained in their natal colony, giving me the opportunity to further tune transmitter frequencies if they continued to shift during this period. It is therefore unlikely that the changing of transmitter frequencies caused the discrepancy in resight rates; however, I could not entirely rule out the possibility of complete transmitter failures.

Mortality signals can be difficult to receive if they are not located soon after death occurs. Carcasses, along with the transmitter, can be deposited in trees, on open or densely covered ground, under ground, or under water. Depending on the final location,

it is possible for signals to become blocked by the surrounding environment, with transmitters underwater and/or underground more difficult to locate than those in more open environments (see Table 8). Scavengers also may move the radio, thus resetting it to normal mode and possibly preventing the detection of actual mortality some of the time.

I conducted an experiment to determine the best flight altitude and transect spacing during telemetry flights and my ability to receive signals from the ground. I spaced four pairs of transmitters two meters apart in each of four positions: suspended 1.5 m above ground on a wooden post out in the open, suspended 1.5 m above ground on a wooden post in dense vegetation, buried ~5 cm underground, and ~0.5 m underwater.

To test reception distance from the ground I gradually moved further away (directly out into the wetland with an unimpeded view) from the transmitters until I lost reception. Aerial reception consisted of testing signals from 300 m to 1200 m in elevation (in ~150 m intervals) at increasing distances away from the point of origin (from 0 m – 9.5 km). Receptions distances varied depending on both elevation and direct distance from the transmitter (Table 8). Based on these estimations and previous experience, I believe that our transect spacing and altitude were sufficient for locating live birds. No possible coverage, however, could guarantee successful location of all mortality signals every time.

Table 8. Maximum reception distances (km) of transmitter signals from both ground and aerial testing.

Altitude (m)	Transmitter Locations			
	Suspended, unblocked	Suspended, blocked	Underground	Underwater
300	4.8	4.8	1.6	3.2
460	5.6	5.6	1.6	3.2
610	8.8	7.2	1.6	3.2
760	9.6	8.8	1.6	3.2
915	9.6	9.6	1.6	3.2
1070	9.6	8.8	1.6	3.2
1220	11.2	8	1.6	3.2
<b>Ground</b>	<b>6.4</b>	<b>4</b>	<b>1.2</b>	<b>2.4</b>

In both years of the study my telemetry tracking efforts covered the same areas (see Methods section) with approximately the same intensity and at similar times in the respective breeding cycles, using the exact same methods. The only exception was more intense coverage of southeast Florida landfills, including the Palm Beach County Waste Facility where I located birds marked in both study years in 2002. In addition, I found an increased number of mortalities outside the colonies in 2002 (7 of 19 mortalities) compared to 2001 (0 of 4 mortalities) using these same methods, weakening the hypothesis that I could not locate mortalities. However, this does not preclude the fact that there may be mortalities within the study area in both years that went undetected. Therefore, the difference in signal location rates between years is probably best explained by a combination of a higher rate of undetectable mortalities and a faster emigration rate of juveniles out of central and southern Florida in 2001 compared to 2002.

While some juveniles flew only a short distance (< 5 km) upon independence from a colony, there was also the potential for long distance emigration (> 120 km) within the first week post-independence. The majority of marked birds' locations were fairly evenly

spread between wetland, landfill, and agricultural sites in 2001 and wetland and agricultural areas in 2002 (Appendix B).

In both study years, early-hatched juvenile ibises displayed significantly higher survival rates compared to late-hatched juveniles at least until independence from the colony (2001: Mantel = 2.33, P = 0.0087 and 2002: Mantel = 3.48, P < 0.0002; Figures 9 and 10). Due to the low resight rates of marked individuals in 2001 I did not estimate survival beyond independence for that year. Juvenile survival rates remained significantly higher in 2002 for early-hatched compared to late-hatched birds at 30, 60, and 90 days post-independence (Figure 10).

I found no significant differences between the survival to independence of early-hatched birds in 2001 (96.6 %) compared to early-hatched birds in 2002 (97.1%) (Mantel = 0.78, P = 0.2177). However, late-hatched juveniles in 2001 (79.2%) showed significantly higher survival rates compared to late-hatched juveniles in 2002 (67.7%) (Mantel = 2.40, P = 0.0082), at least until independence. When comparing the overall survival to independence of all marked birds in 2001 (88.7%) to those in 2002 (82.6%), birds hatched in 2001 had a significantly higher survival rate compared to those hatched in 2002 (Mantel = 2.53, P = 0.0057).

## CHAPTER 4 DISCUSSION

The 2001 and 2002 White Ibis breeding seasons occurred under somewhat different environmental conditions that may have resulted in the observed reversal in the pattern of ibis nesting success between years. In particular, the very different breeding season hydrology patterns that existed over large portions of the WCAs may have influenced the timing of available food resources and access by mammalian predators, thus potentially affecting ibis reproductive success. Nearly twice the number of White Ibis nests were initiated in the Everglades in 2002 (32,573) compared to 2001 (17,262) (Gawlik 2001, 2002a). Numbers of nesting White Ibises in the Everglades are known to vary widely during extremely wet or dry years, partially due to regional shifts in nesting locations (Ogden et al. 1980, Ogden 1994) and partially due to an association of “supernormal” wading bird nesting events closely following a drought year (Frederick and Ogden 2001).

The drying of the marsh surface in the nesting season of 2001 was much more pronounced than in 2002, resulting in the loss of surface water surrounding all study colonies. The more rapidly drying surface water in 2001 may have influenced the availability of White Ibis food resources by increasing the concentration of prey as ephemeral pools of water shrank and grew shallower (Kushlan et al. 1975, Frederick and Collopy 1989a, Bildstein et al. 1990). In many parts of the ecosystem however, the drying may have been so rapid that it caused large-scale die-offs of prey that were left without any water (personal observations from WCAs 1, 2B, and 3B in 2001). Under such stressed environmental conditions ibises may have experienced greater difficulty

foraging for both themselves and their young as prey became more difficult to locate and obtain. If breeding ibises did experience such harsh foraging conditions in 2001, the result of these difficult conditions could have been one factor causing nest abandonment in that year.

Other factors such as an increased exposure to mercury contamination may have affected ibis nesting efforts in 2001 (Frederick et al. 2001, Heath 2002). Wetlands are at risk to high levels of mercury contamination (Eisler 1987, Zillioux et al. 1993). Inorganic mercury may become bound in wetland soils, converting to the more toxic organic methyl-mercury as environmental conditions change (i.e. drought, decreased water levels, increasing anoxia) (Zillioux et al. 1993). Bioaccumulation of mercury in wetlands is a known potential threat to wildlife, including predatory birds (Scheuhammer 1987, Wolfe et al. 1998). Mercury's ability to increase in concentration by several orders of magnitude from surface waters to fish is well documented (Scheuhammer 1987, Driscoll et al. 1994) and it follows that piscivorous species, such as wading birds, feeding on small fish and invertebrates are at a high risk of accumulating toxic levels of methylated mercury (Jurczyk 1993). Thus, during the pronounced low water levels in 2001, an increase in mercury's conversion to methyl-mercury and a subsequent increase in the uptake of methyl-mercury by foraging wading birds may have been expected compared to the conditions associated with the 2002 breeding season.

Chronic levels of mercury exposure in White Ibises may interfere with the hormonal mechanisms associated with nest attendance (Heath 2002), which could cause nest abandonment, especially during rapidly occurring, short-term changes in environmental conditions similar to those observed in the Everglades in 2001. However,

without evidence that mercury levels in 2001 were high enough to lead to the abandonment of nests and significantly higher than 2002 levels, exposure to mercury does not appear to be a likely cause of ibis nest abandonment during this study.

### **Reproductive Parameters**

I am uncertain as to the cause of the lower hatchability observed in both study years compared to previous years in the interior Everglades. While mercury contamination is a possible explanation for low hatchability, it appears unlikely since mercury levels in the Everglades have decreased considerably since 1994 (> 75% in Great Egrets) and hatchability rates in earlier, higher-exposure years have not been as low as during the years of my study (Frederick et al. 2001).

### **Mayfield Nest Success Estimates**

The evidence from this study indicates that White Ibis nesting success in the Everglades seems to vary unpredictably as the breeding season progresses, contrary to my predictions and different from the typical pattern of nesting success observed in most temperate breeding species of birds. It is interesting to note that ibis nests initiated during the “middle” of the nesting period in 2001 and 2002 (early/mid-April) showed the highest nesting success rates. In comparison, those ibises initiating “early” relative to the nesting season in 1986 and 1987 (late-April/early-May) resulted in extremely high nesting success (75.6% and 88.8%, respectively) compared to the same time period in 2001 and 2002 (4.6% and 33.4%, respectively). This pattern of high variation in nesting success at the same time of season may be expected in an environment with conditions similar to those typically experienced in the south Florida ecosystem. The within-season variability in the annual timing of environmental conditions in the Everglades may have contributed to the extreme annual differences in nest success.

It is tempting to consider the evidence presented in this study as partial confirmation that tropical/subtropical environments have a greater degree of variability in the timing and extent of environmental phenomena (i.e. onset of wet season, period of greatest resource abundance). I do not believe however, that enough evidence is available to generalize whether tropical and/or subtropical ecosystems are either as predictable or less predictable in the timing of environmental events than temperate systems. We also lack information regarding differences in the variability in magnitude of ecological conditions and seasonal weather patterns between temperate and tropical regions.

Current evidence suggests that in some tropical locations and with some species, tropical systems can be as predictable in the timing of ecological conditions as temperate areas (Stiles 1980, Wikelski 2000). Therefore, the tropical/temperate dichotomy may be a poor example for predicting variation in nest productivity. Our efforts may be better spent focusing on the difference in the magnitude of variation and predictability in the ecological conditions supporting successful breeding events as opposed to attempts in locating where areas with different magnitudes of variation in the timing of ecological phenomena are located.

Even less evidence is available correlating either a seasonal or unpredictable breeding pattern in the tropics with patterns of nesting success since few studies exist detailing nest and post-fledging success rates in tropical and subtropical bird species. One previous study of avian nesting success in Florida's subtropical zone found a similar variability in nesting success as White Ibises' in this study (Morrison 1999). Morrison suggested that the highly unpredictable environmental conditions in the central and

southern Florida ecosystem might have influenced the observed survival rates in Crested Caracaras.

I suggest that the varied patterns of White Ibis nesting success observed in this study are due to the unpredictability associated with wetlands in general, regardless of latitude, and do not represent evidence that there is greater unpredictability in subtropical/tropical, compared to temperate environmental conditions. Like many freshwater wetlands, the Everglades is characterized by periodic fluctuations in hydrology which can dramatically alter plant and animal communities, fire regimes, and ecosystem functions on an annual basis (DeAngelis and White 1994, Gunderson and Snyder 1994, Mitsch and Gosselink 2000). Varying hydrologic patterns can also affect wading bird use of foraging habitat directly through water depth changes (Kushlan 1977, Kushlan 1986, Bancroft et al. 1991), which affect food availability (Powell 1987, Bildstein et al. 1990). I suggest that, particularly in the Everglades, these hydrologic patterns are hypervariable among years, which makes it very difficult for adult wading birds to predict the timing of most opportune nesting and the best colony location (Frederick and Spalding 1994).

Consistent with some other studies of avian reproductive success (Sydeman et al. 1991, Morrison 1999, Lepage et al. 2000), I found a peak in nesting success during the middle of the nesting period in both years. However, late-nesting White Ibises' success varied between years. In contrast, late-season declines in nesting success have been observed in both tropical/subtropical (Morrison 1999, Ramos 2001, Olmos and Silva e Silva 2001) and temperate (Perrins 1970, Sydeman et al. 1991, Norris 1993, Brinkhof et al. 1993, Burger et al. 1996) studies. In both 2001 and 2002, water levels in the WCAs

approached their lowest point of the year when middle-nesting birds began hatching chicks (1<sup>st</sup> week of May). If prey concentrations increased due to the lower water levels at this time, middle-nesting ibises may have been able to feed their young better, resulting in the observed higher fledging rates. The comparison of temperate and tropical studies that considered seasonal variation in reproductive success, therefore, appears to indicate that there is no overall pattern regarding success outside of the higher latitudes.

### **Nest Abandonment and Predation**

Large scale nest abandonment and subsequent low nesting success have been attributed to fast increases in the water level surrounding colonies of White Ibises (Frederick and Collopy 1989a, Frederick and Spalding 1994), which can disperse concentrations of prey, leading to reduced prey availability. In 1999, Frederick et al. (2001) observed some abandonment of late-nesting White Ibises after the onset of the rainy season; however, the majority of ibises were successful. In mid-April 2000, a strong pulse of rains (3-day total: 159.51 mm of 164.59 mm monthly total) is believed to have caused the widespread abandonment observed in Loxahatchee N.W.R. that year (Frederick et al. 2001). Therefore, it is likely that the rapid rise of water levels in June 2001, which inundated ibis nests located at ground level in the L-67 colony, precipitated the eventual complete abandonment of that colony. However, heavy rainfall and fast-rising water levels are not necessarily a precursor to colony failure. In 2002, two late-nesting colonies (Tamiami West and Hidden) successfully fledged a majority (TW: 76%; Hidden: 85%) of the remaining active nest attempts in those colonies, even after the onset of the rainy season in late May of that year.

In addition to acting as a potential cause of food dispersal through rising water levels, the varying intensity and timing of rainfall events during the nesting stage also

may impact White Ibis nest success. Heavy or prolonged rainfall may have a greater impact on reproductive success if associated with young (nestling) chicks compared to chicks closer to becoming independent from the colony. Younger chicks may have an increased vulnerability to rains and could subsequently suffer from hypothermia if they are unable to maintain a constant body temperature. Pulses of rains in the early stages of nesting (including young chicks) may affect a parent's choice of whether or not food will continue to be available in sufficient quantities for the duration of the breeding cycle. If rains early in the nesting cycle are heavy and prolonged, parents may choose to abandon that particular nest attempt.

Human disturbance, via entering colonies, can affect nesting success, with nesters in certain stages (i.e. courtship and egg-laying) more sensitive to disturbance than others (Tremblay and Ellison 1979). In a study of Tricolored herons (*Egretta tricolor*), Frederick and Collopy (1989b) found no difference in the effect of the frequency of visits on five different measures of reproductive success. In my study, I entered colonies on a regular basis only after the majority of nests were near the completion of egg-laying, and the frequency of my visits was less than that in other studies of reproductive success (Frederick and Collopy 1989a, 1989b, Sydeman et al. 1991, Erwin et al. 1999). Using the same methods in both study years, I found large differences in abandonment rates between the two years of study. This suggests at the very least that my own disturbance was unlikely to have been the sole source of the variation between years. In addition, I observed the greatest abandonment in 2001, a year in which a number of colonies (see earlier) that I did not visit were abandoned. Disturbance therefore seems to be a weak predictor of variation in nest success in my study.

While checking marked nests I did observe several nest scavenging events in Lox 70 in 2001 and in Lox 70, Lox 99, and Alley North in 2002. I believe, however, that the majority of this scavenging occurred post-abandonment (again, primarily due to Boat-tailed Grackles). Human disturbance has been associated with increased predation and scavenging of nest contents (Frederick and Spalding 1994). Yet, increases in scavenging usually occurred while researchers were in the colony. To minimize this effect, I immediately stopped colony visits when it appeared that our presence affected the behavior of scavengers. Because of the precautionary measures taken to avoid human disturbances inside and outside the colony, I do not believe that my activities significantly affected predation or scavenging rates.

Previous studies of wading birds in the Everglades (Frederick and Collopy 1989c, Frederick and Spalding 1994) found little evidence of nest predation, especially by mammals. In the interior wetlands of the Florida Everglades, predation accounted for only 2.5% of nest failures among colonially nesting wading birds ( $N = 826$ ) (Frederick and Collopy 1989c). Mammalian predators may be deterred from wading bird colonies by the presence of alligators (*Alligator mississippiensis*). Surprisingly low water depths (5–10 cm) may be sufficient to severely limit mammalian predator movements and access to wading bird colonies (Frederick and Collopy 1989c). Individual or group nest-defense behavior is not commonly observed among Ciconiiformes, and large-scale abandonment of nests may be the result of a few individual predators (Shields and Parnell 1986, Frederick and Collopy 1989c). The extremely low levels of predation observed in this study support the idea that, during my study, predation was not a significant contributor to nest failures.

### **Post-Fledging Survival of Young**

In spite of high survival during the nestling stage for late-hatched ibises in both years (relative to overall survival in those years), the majority of late-hatched ibis' mortality occurred during the nestling stage, while birds were still in their natal colony. Some (~26%) of these pre-independence mortalities occurred during the time period when I expected the juveniles to leave the colony (defined by age of nestling in relation to mean age-at-independence). Considering the lower post-fledging survival of late-hatched ibises compared to early-hatched birds in this analysis, it is possible that an increased proportion of late-hatched ibises in both years were not fully fit to make the transition to independence and survive the challenges of life outside parental support. However, visual inspection of nestling growth data does not appear to support this idea. This pattern of lower survival in late-hatched birds may have been due to poorer food availability later in the breeding season, inattention by parents, disease, or some combination of these factors. This transition period (prefledging to fledging) is generally when juvenile birds of many species tend to die (Gill 2000) and the affects of this period of increased juvenile mortality could be exacerbated by any harsh environmental conditions that late-hatched ibises may face compared to early-hatched birds.

Based on my predictions, greater nesting success should be associated with greater juvenile survival post-independence. However, in 2002, even though late-nesting ibises showed significantly greater nesting success compared to early nesters, juveniles from the early-hatched cohort displayed significantly higher post-independence survival rates compared to late-hatched ibises. Brinkhof et al. (1997) found a seasonal decline in the post-fledging success of European Coots, attributed to the smaller size of late-hatched young. Other studies (e.g. Verhulst and Tinbergen 1991) suggest that competition

between early and late-hatched young may account for the observed seasonal decline in post-fledging survival. Several explanations for the pattern of post-fledging success in this study are possible. An abundance of available food for early-hatched ibises may have been depleted or dispersed by the time late juveniles were independent. Another possibility is that the increased amount of time early juveniles have to learn life skills (such as foraging, predator avoidance, etc.), grow and increase their body mass before the onset of the rainy season when prey become more difficult to obtain may give them an advantage in first-year survival compared to late juveniles.

Marked juveniles appeared to favor the mosaic of wetland, agricultural, grove land, and ranchland that dominates the non-coastal landscape southwest and west of Lake Okeechobee. Habitat use by post-fledging ibises varied between the two years. The smaller than expected number of signal locations of marked birds in any coastal area and/or inland wetland areas in 2001 (30% in 2001, 48% in 2002, when only considering signal locations >5 km from natal colony; see Appendix B) is interesting as it suggests that juveniles were inconsistently using these locations as post-independence habitat in those years. Anecdotal aerial observations through September of both years confirmed low numbers of foraging wading birds in south and central Florida in 2001, while large (> 200 individuals) groups were spread across the same area in 2002. Water levels in 2002 were visibly higher than 2001 levels throughout south and central Florida, with large tracts of land that were dry in 2001 containing standing water in 2002 (personal observations). This may help to explain why I observed more foraging birds in 2002 compared to 2001, and why more birds remained in these areas until later in year in 2002.

## CHAPTER 5

### CONCLUSIONS AND FUTURE DIRECTIONS

White Ibis nesting success in the Everglades varied inconsistently with respect to timing during the breeding season. Early-hatched juvenile ibises had a greater survival compared to late-hatched ibises, at least until independence from the colony, and this appeared to remain true through 90 days post-independence. Finally, contrary to my predictions, nesting success was not necessarily a predictor of post-independence juvenile survival.

Greater unpredictability in the timing of annual and within-season environmental conditions in subtropical compared to temperate zones may cause the increased inconsistency in both the timing of nesting events and the trends in nest success observed in ibis nesting success rates. I suggest, however, that the varied patterns of White Ibis nesting success observed in this study are due to the unpredictability associated with wetland ecological conditions in general, regardless of latitude, not necessarily the sole result of greater unpredictability in subtropical/tropical, compared to temperate, environmental conditions. In either situation, environmental inconsistencies between breeding seasons could make it difficult for adult White Ibises to select the optimal time to initiate nesting attempts, therefore potentially compromising nest success and offspring survival.

Direct comparisons of this research with a study of similar Ciconiiform species from the temperate zone were not possible. In order to better elucidate any differences in temperate and tropical/subtropical nesting success rates, more research is necessary on

species with comparable phylogeny and life histories. Especially lacking are long-term studies monitoring the post-independence survival of juveniles. A comparison of ibis nesting data from the northern part of their breeding range could help determine patterns of within season nest success for this species. An in-depth study of the local climatic differences between temperate and tropical species, how this may affect the formation of local niches within communities, and monitoring of nesting success rates in these locales would help determine whether tropical and subtropical areas experience greater annual and within-season environmental predictability or if inconsistencies in reproductive parameters are the result of adaptation to specific, local habitat constraints.

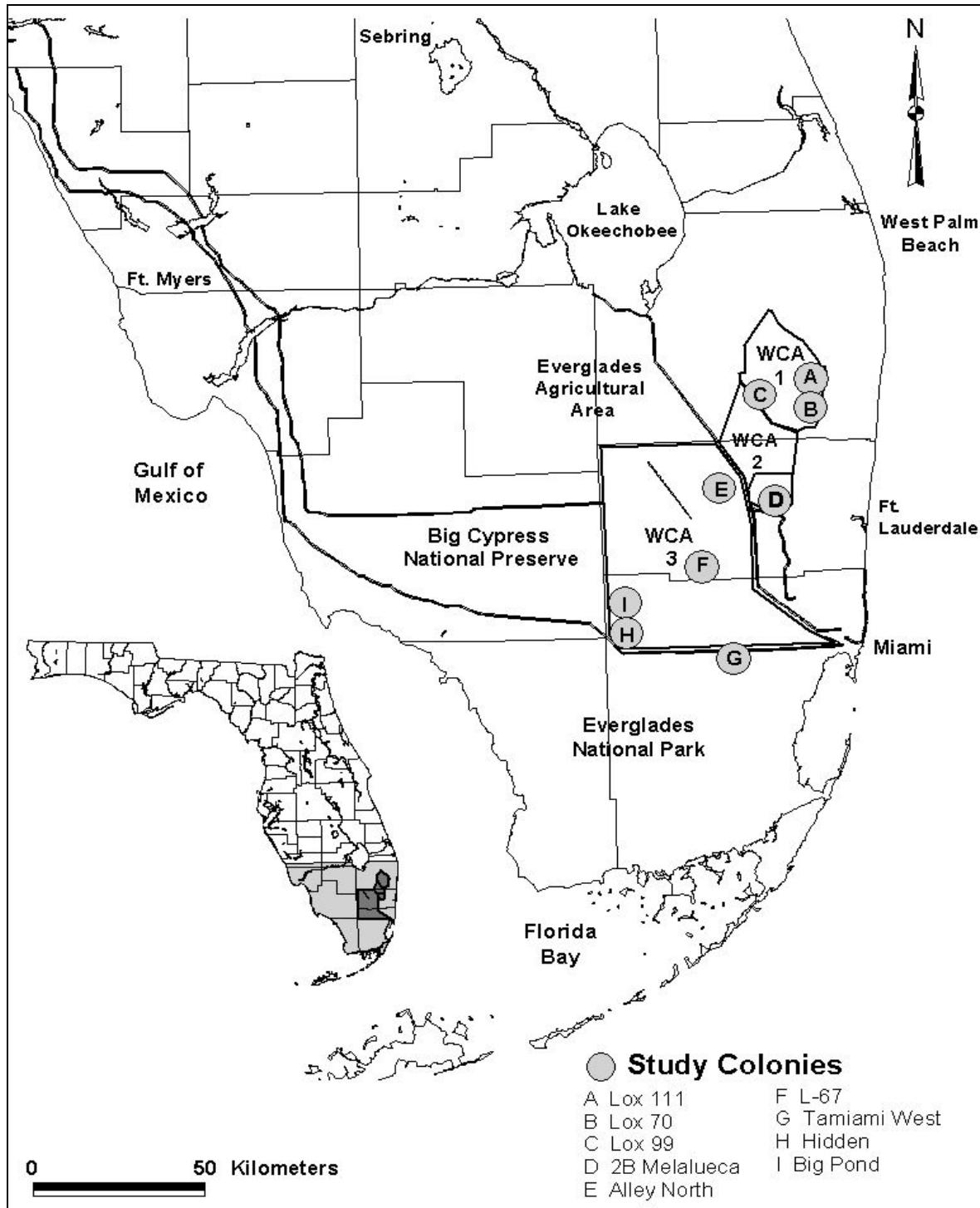


Figure 1. Location of monitored White Ibis colonies in 2001 and 2002. The primary study area (monitored colonies) is darker (inset) and the area of intense aerial telemetry monitoring is lighter shaded (inset).

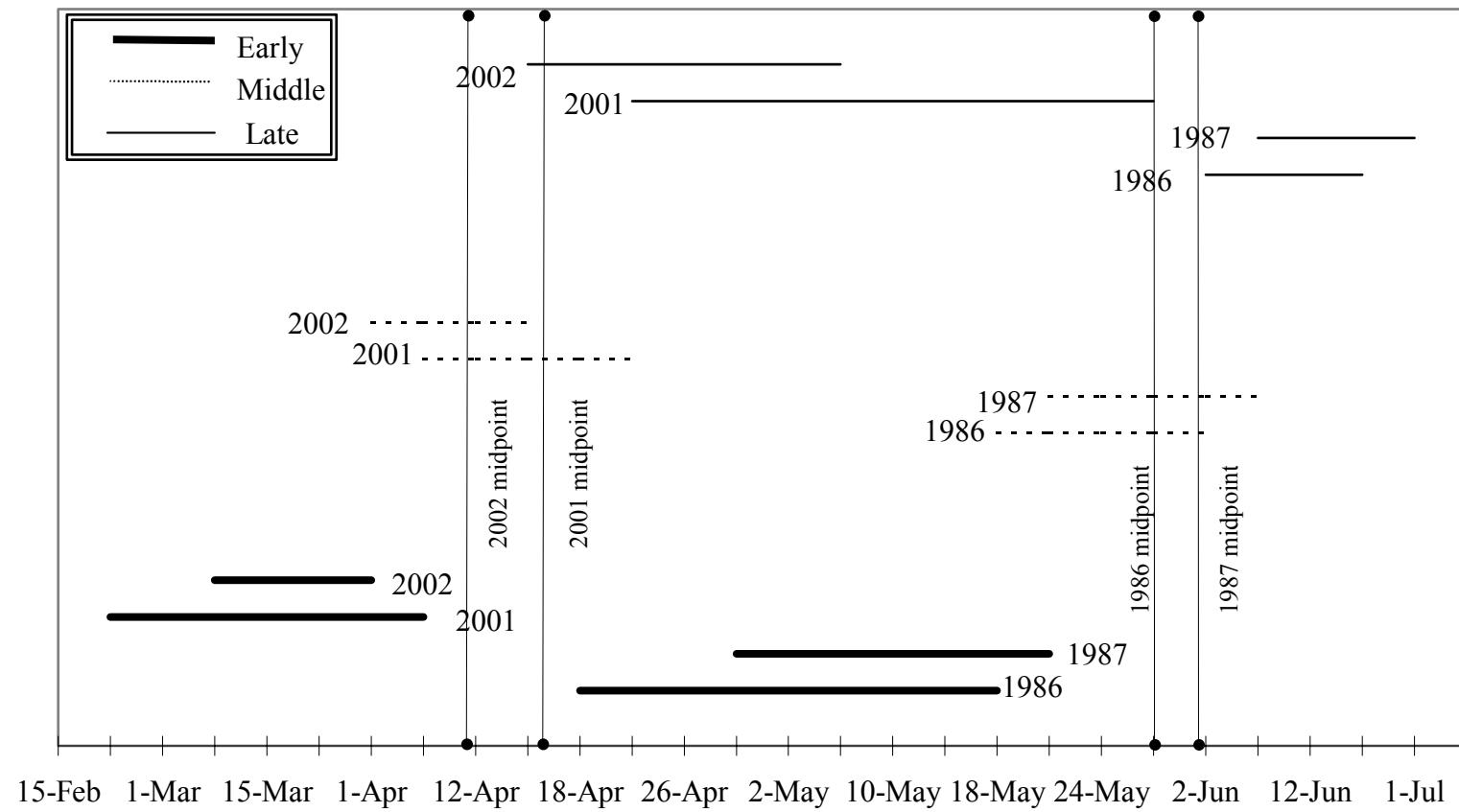


Figure 2. Nest initiation ranges by nesting period for marked White Ibis nests in 1986, 1987, 2001 and 2002. Vertical lines designate seasonal midpoints.

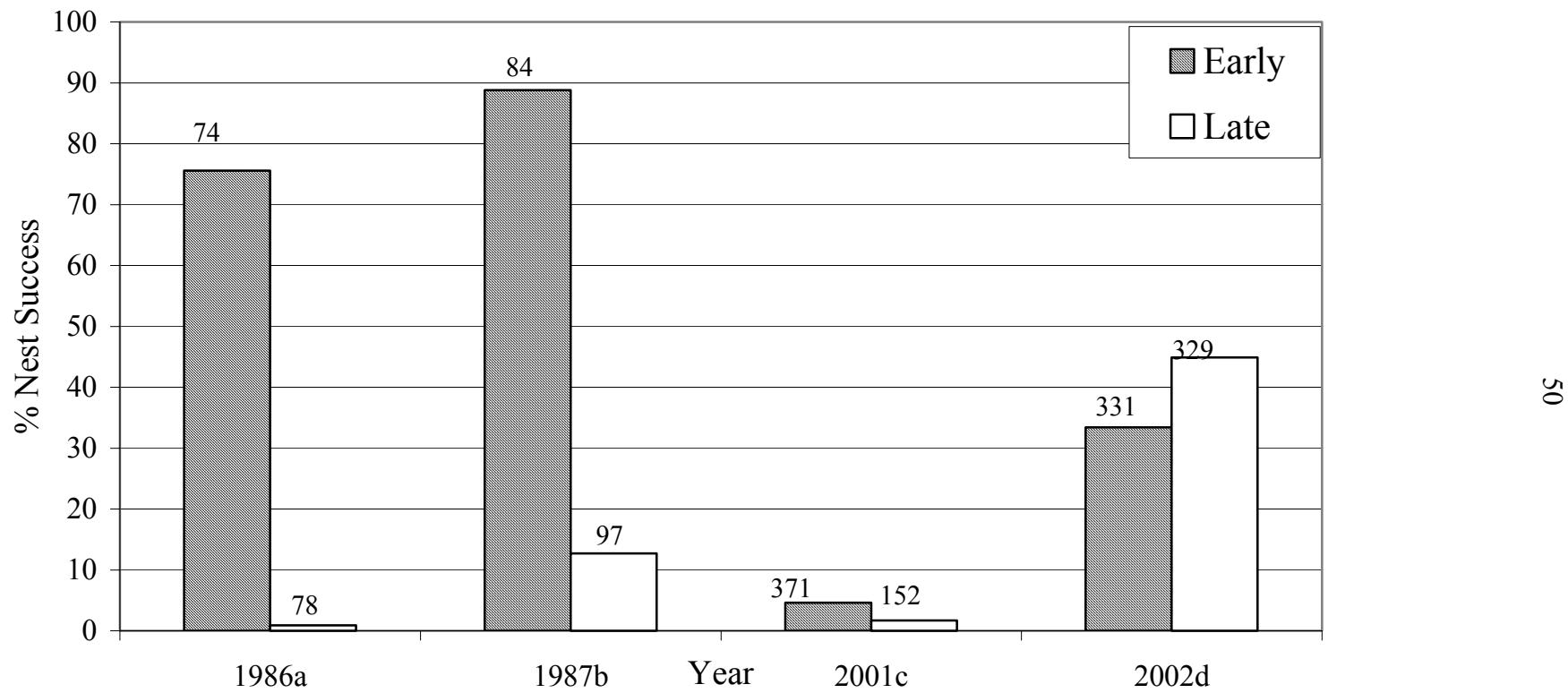


Figure 3. Four year comparison of Mayfield nest success estimates of White Ibises nesting early and late in the season. Sample sizes are denoted at the upper left corner of bar. Letters beside years indicate a significant difference between early and late-nesting ibises in that year. a)  $Z = 13.231$ ,  $P << 0.0002$ ; b)  $Z = 13.577$ ,  $P << 0.0002$ ; c)  $Z = 2.641$ ,  $P = 0.004$ ; d)  $Z = -2.907$ ,  $P = 0.002$ . 1986 and 1987 data from Frederick and Collopy 1988.

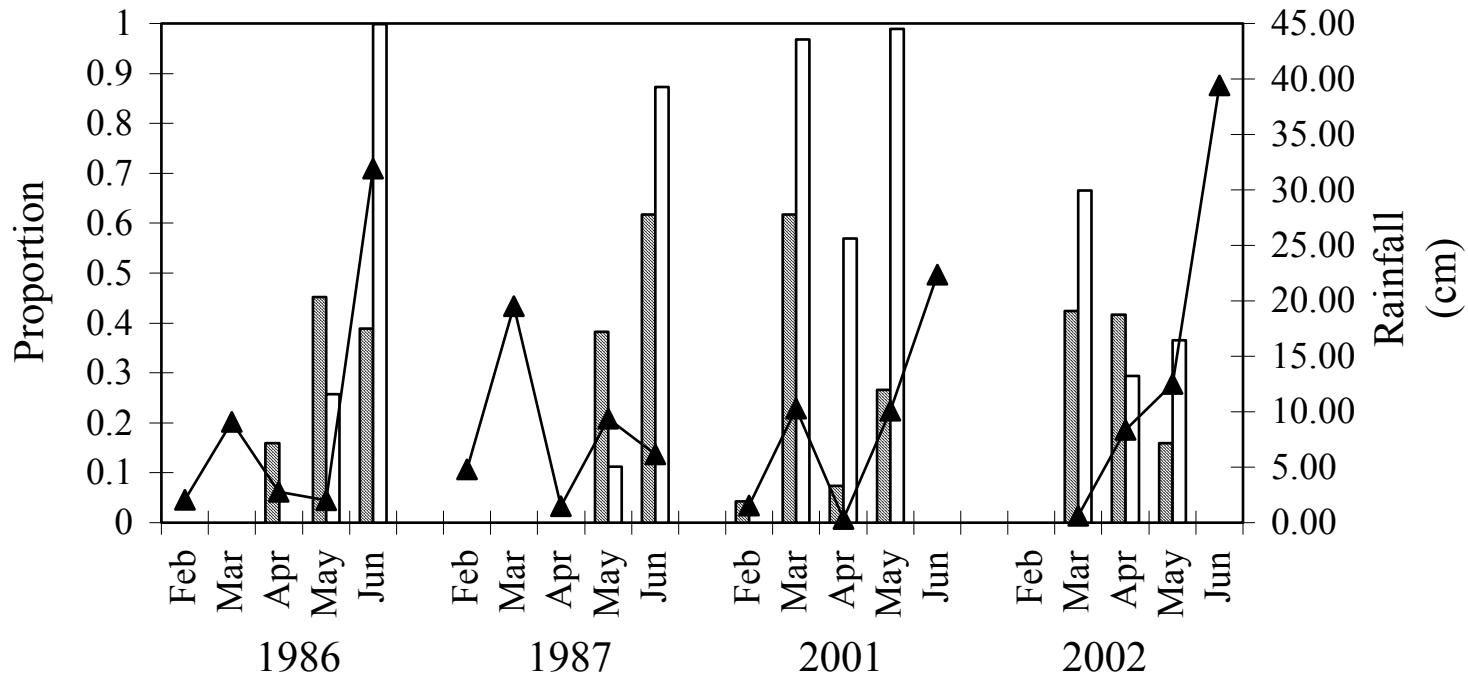


Figure 4. Monthly rainfall (solid line), breeding chronology (proportion of marked nests initiated each month; striped bars), and nest failures (proportion of nest attempts that failed; empty bars) of monitored White Ibis nests in the interior Everglades. Rainfall data was obtained from the Tamiami Trail Ranger Station (40 mile bend) rain gauge.

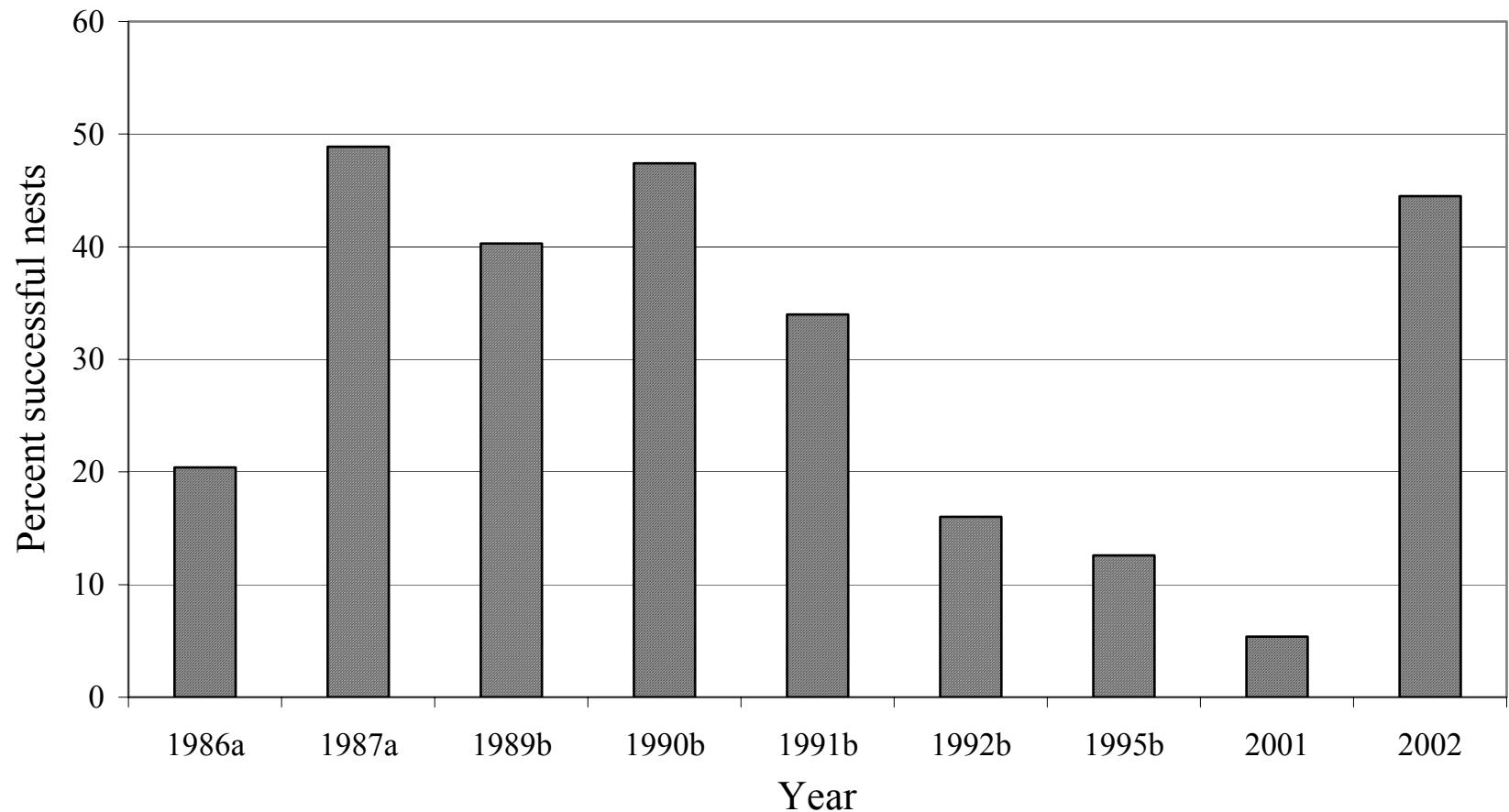


Figure 5. Multi-year comparison of Mayfield nesting success estimates for White Ibises in the interior Everglades. Includes censored (middle) nests for 2001 and 2002. a) Frederick and Collopy 1988. b) Frederick 1995.

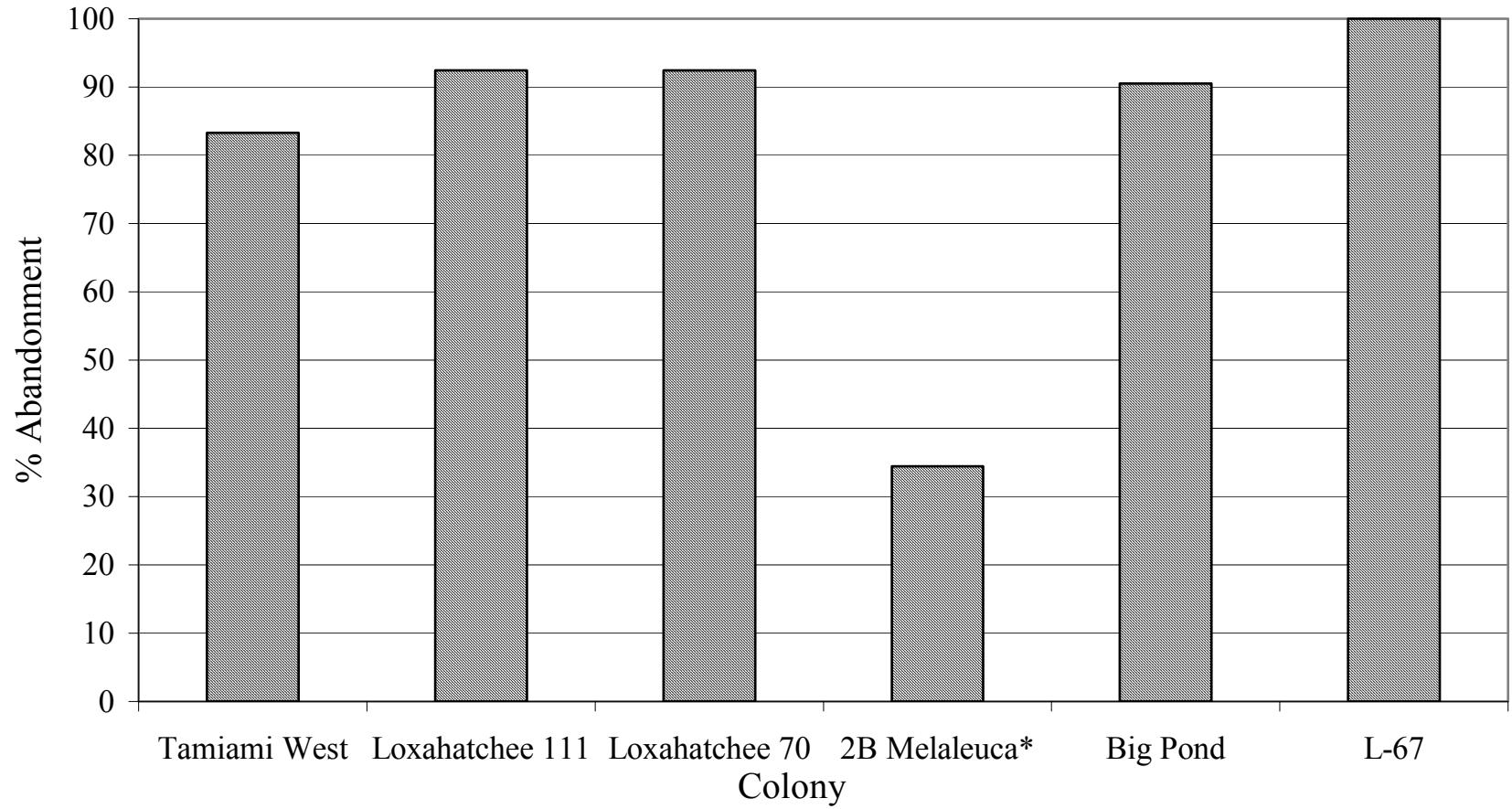


Figure 6. Percent nest abandonment of White Ibis nest attempts (marked nests) in 2001. Asterisks denote colony includes both early, middle, and late marked nests.

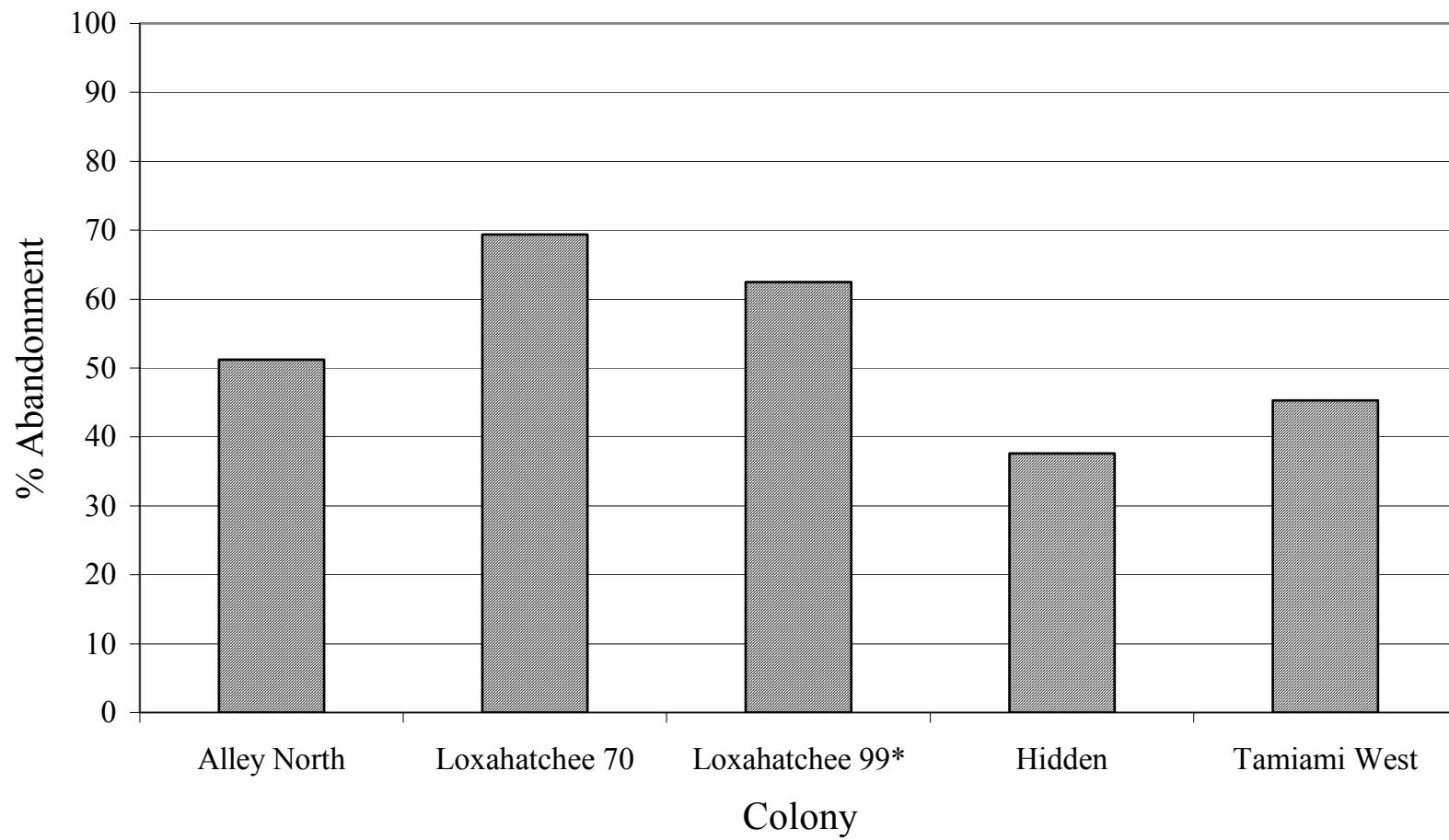


Figure 7. Percent of White Ibis nest initiations (marked nests) that were abandoned in 2002. Asterisks denote colony includes both early and middle marked nests.

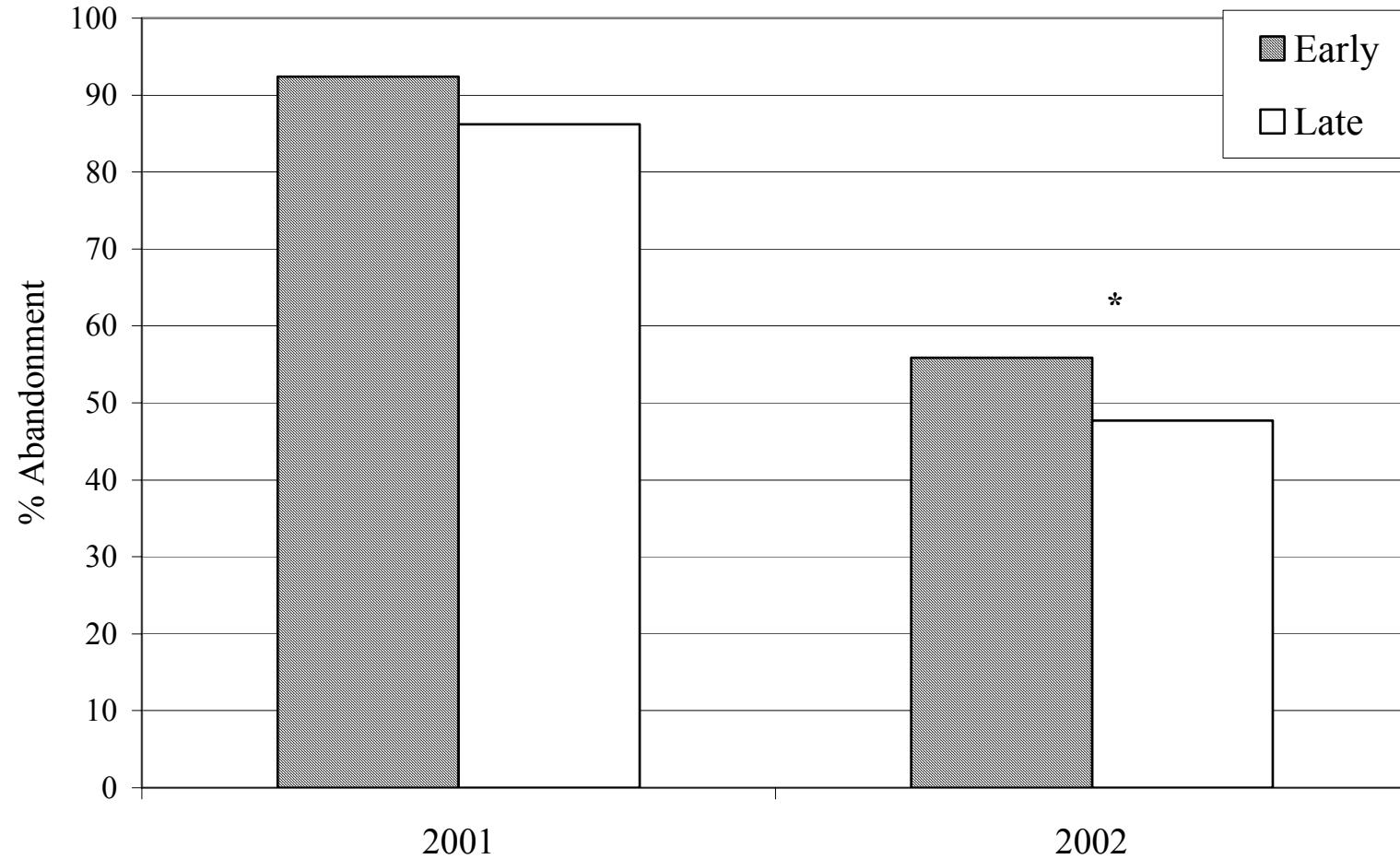


Figure 8. Comparison of overall nest abandonment rates at marked White Ibis nests for early and late-nesting pairs in both study years (all colonies inclusive). Asterisks indicates significance at  $P = 0.036$ .

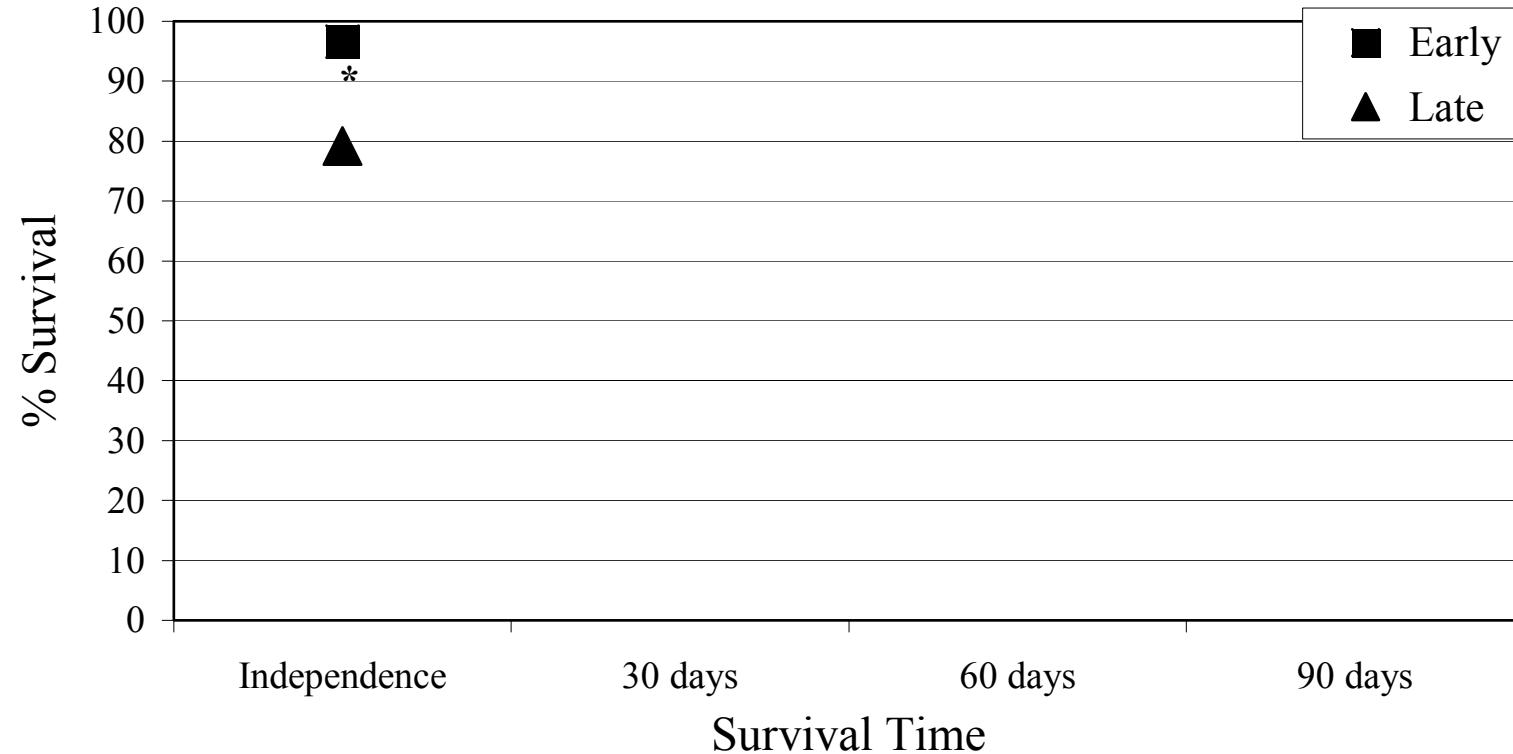


Figure 9. Kaplan-Meier survival estimates for marked juvenile ibises in 2001. Asterisks indicate a significant difference between early and late-hatched birds (Log Rank:  $P = 0.01$ ).

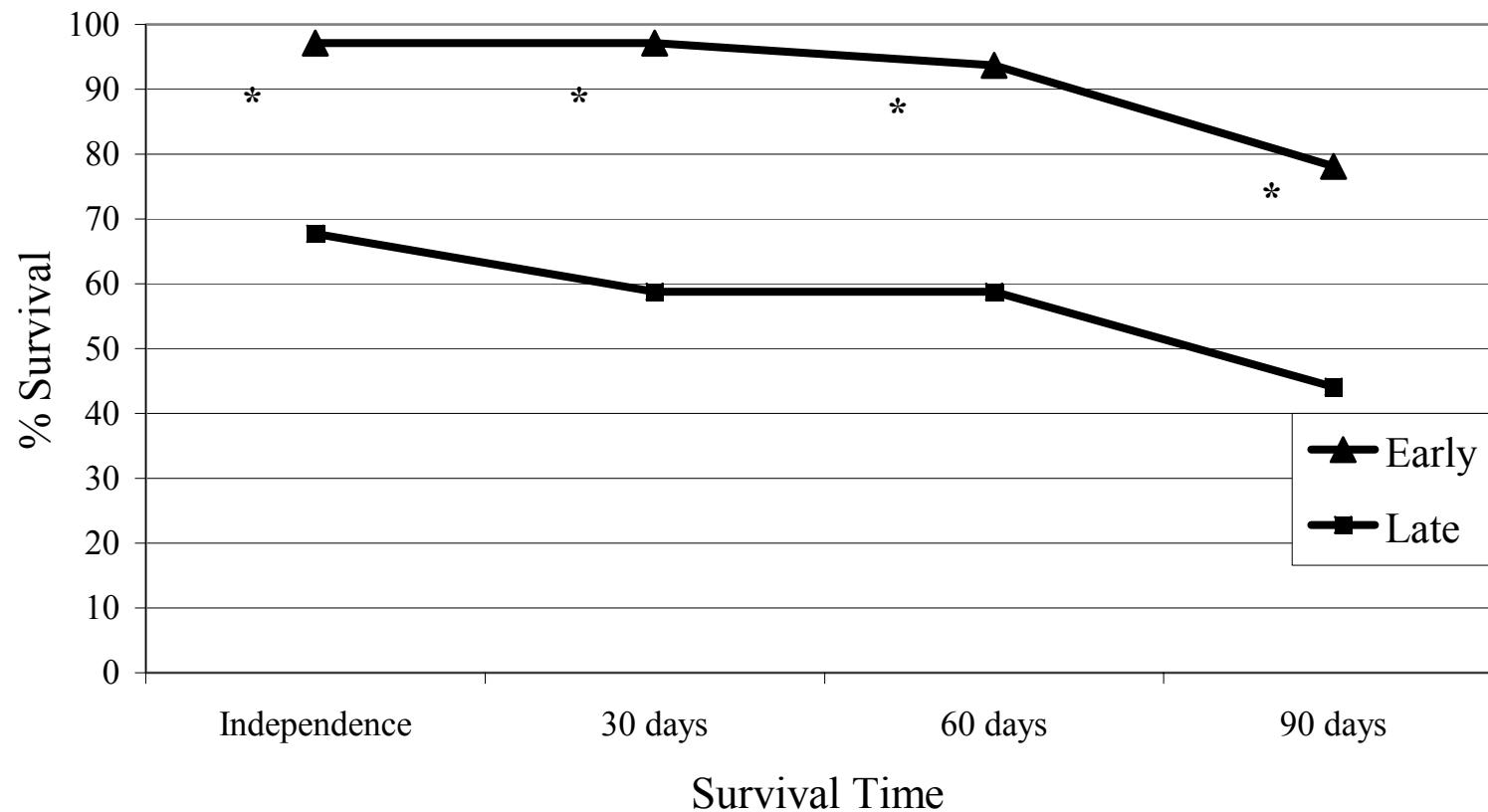


Figure 10. Kaplan-Meier survival estimates for marked juvenile ibises in 2002. Asterisks indicate a significant difference between early and late-hatched birds (Log Rank: all  $P < 0.0002$ ).

**APPENDIX A**  
**LOCATIONS OF COLONIES WITH MARKED NESTS IN THIS STUDY**

<b>Colony</b>	<b>Latitude</b>	<b>Longitude</b>
2B Melaleuca	26.510	-80.257
Alley North	26.196	-80.529
Big Pond	26.423	-80.243
Hidden	26.168	-80.351
L 67	26.440	-80.391
Lox 111	25.868	-80.801
Lox 70	25.767	-80.834
Lox 99	25.951	-80.567
Tamiami West	25.751	-80.518

APPENDIX B  
RADIO-TRACKING RESIGHT DATA FOR ALL MARKED BIRDS IN 2001 AND  
2002

	2001					
	Lox 111	Lox 70	2B Melaleuca	Early	Late	Combined
N	13	16	24	29	24	53
Mean Age-at-Independence (days)	56.5	64.5	60.1	60.8	60.1	60.5
SE	1.5	1.9	1.3	1.5	1.3	1.0
Range of Age-at-Independence	49-62	56-84	50-71	49-84	50-71	49-84
Total Surviving to Independence	13	15	18	18	18*	36*
Total Juveniles Located At Least Once Post-Independence	3	9	4	12	4	16
Total Mortalities	0	1	5	1	5	6
Mean Age at Mortality	-	23	36	23	36	34
Range of Mortality ages	-	-	34-37	-	34-37	23-37
<b>Resight Locations</b>						
Wetlands	3	5	1	8	1	9
Agricultural	0	9	3	9	3	12
Urban	0	1	0	1	0	1
Landfill	0	7	1	7	1	8
Coastal	0	0	0	0	0	0
Uncertain	0	0	0	0	0	0
% Located Post-Independence	0.231	0.600	0.222	0.429	0.222	0.348
% Located in Wetland Areas	1.000	0.227	0.200	0.320	0.200	0.300
% Located in Agricultural Areas	0.000	0.409	0.600	0.360	0.600	0.400
% Located in Urban Areas	0.000	0.045	0.000	0.040	0.000	0.033
% Located in Coastal Areas	0.000	0.000	0.000	0.000	0.000	0.000
% Located in Landfill Areas	0.000	0.318	0.200	0.280	0.200	0.267
Total resights (all birds)	3	22	5	25	5	30

Appendix B. Continued

	2002						
	Alley North	Lox 70	Tamiami West	Hidden	Early	Late	Combined
N	26	9	9	25	35	25	60
Mean Age-at-Independence (days)	62.5	61.3	58.6	58.3	62.2	58.4	60.7
SE	0.8	1.9	0.8	1.0	0.8	0.7	0.6
Range of Age-at-Independence	52-70	54-68	55-60	51-66	52-70	51-68	51-70
Total Surviving to Independence	26	8	9	14	34	14	48
Total Juveniles Located At Least Once Post-Independence	20	8	5	9	28	9	37
Total Mortalities	2	2	0	15	4	15	19
Mean Age at Mortality	113	96	0	55	105	55	66
Range of Mortality ages	101-126	51-142	0	22-125	51-142	22-125	22-142
<b>Resight Locations</b>							
Wetlands	31	9	4	5	40	5	45
Agricultural	18	12	5	12	30	12	42
Urban	0	1	0	0	1	0	1
Landfill	2	1	0	0	3	0	3
Coastal	0	0	0	0	0	0	0
Uncertain	0	1	0	0	1	0	1
% Located Post-Independence	0.769	1.000	0.556	0.643	0.824	0.643	0.771
% Located in Wetland Areas	0.596	0.375	0.444	0.294	0.526	0.294	0.484
% Located in Agricultural Areas	0.346	0.500	0.556	0.706	0.395	0.706	0.452
% Located in Urban Areas	0.000	0.042	0.000	0.000	0.013	0.000	0.011
% Located in Coastal Areas	0.000	0.000	0.000	0.000	0.000	0.000	0.000
% Located in Landfill Areas	0.038	0.042	0.000	0.000	0.039	0.000	0.032
Total resights (all birds)	52	24	9	17	76	17	93

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## BIOGRAPHICAL SKETCH

John David Semones began his environmental research and conservation advocacy career during the summer of 1994 as a Student Conservation Association volunteer in the Olympic National Forest, Washington. Work with Northern Spotted Owls and Marbled Murrelets began an ongoing concentration in endangered bird research, conservation, education, and recovery. He received a Bachelor of Science in biology from Davidson College, Davidson, North Carolina, in 1995. John David spent his first year post-undergraduate as an environmental educator, designing and teaching hands-on ecological classes for the Honey Creek Environmental Education Center on the southeast coast of Georgia. In the summer of 1996 he left Georgia for migratory bird work in Alaska, initiating a nearly four-year stretch of field biological work in various ecosystems across the country. He spent a year in Arizona working with the endangered Southwestern Willow Flycatcher and 2.5 years on the Big Island of Hawaii with the Palila Restoration Project. John David began his Master of Science degree with the University of Florida in the fall of 2000, concentrating on wading bird reproductive success in the Everglades. Upon completion of his degree John David plans on attending law school, focusing on environmental and natural resources law.