

Wading Bird Nesting Success and Foraging Dispersion in Water  
Conservation Area 3A and Everglades National Park

1986 Interim Report

by

Dr. Michael Collopy, Principal Investigator  
Dr. Peter Frederick, Post-doctoral Associate

Dept. of Wildlife and Range Sciences  
118 Newins-Ziegler Hall  
University of Florida  
Gainesville, Florida 32611

Prepared for

U.S. Army Corps of Engineers  
400 West Bay St., P.O. Box 4970  
Jacksonville, Florida

under U.S. Fish and Wildlife  
Cooperative Research Unit  
Agreement # 14-16-0009-1544  
Work Order #39

November 1, 1986

## TABLE OF CONTENTS

|                                             |    |
|---------------------------------------------|----|
| ACKNOWLEDGMENTS.....                        | i  |
| INTRODUCTION.....                           | 1  |
| Background and Purpose.....                 | 1  |
| Causes of the Population Decline.....       | 2  |
| Purpose of the Present Study.....           | 6  |
| STUDY AREA AND SPECIES.....                 | 7  |
| METHODS.....                                | 8  |
| Reproductive Success.....                   | 8  |
| Foraging Dispersion.....                    | 16 |
| RESULTS.....                                | 18 |
| Nesting Population.....                     | 18 |
| Nesting Success.....                        | 29 |
| Causes of Nesting Failure.....              | 42 |
| Foraging Dispersion.....                    | 51 |
| DISCUSSION AND CONCLUSIONS.....             | 63 |
| Nesting Population and Nesting Success..... | 63 |
| Foraging Dispersion.....                    | 68 |
| FUTURE WORK.....                            | 69 |
| LITERATURE CITED.....                       | 72 |
| APPENDICES.....                             | 75 |

## ACKNOWLEDGMENTS

This research project would not have been possible without the cooperation of many persons and agencies. Reed Bowman was our field assistant; he provided valuable input to all aspects of the field research, and worked under trying conditions far beyond the requirements of his position. The project was funded by the U.S. Army Corps of Engineers, and has recieved continuous logistical support from both the Clewiston and Jacksonville offices of that agency. Jon Moulding and Lewis Hornung of the Jacksonville office have been invaluable to us in facilitating the project. Everglades National Park research staff (in particular Bill Robertson, Sonny Bass, and Gary Hendricks) have provided frequent and speedy logistical assistance despite budget cuts and administrative changes, and have provided essential physical and avian demographic data freely. All members of the National Audubon<sup>Dr.</sup> Society Research department have been of great help in many aspects of the research, frequently sharing information on methodologies and giving us access to past records as well as current results. The stimulation resulting from our frequent discussions has been of immeasurable value. Various staff members of the South Florida Water Management District have provided information on colony locations, physical data, and numerous maps and reports. The Florida Freshwater Fish and Game Commission generously donated the use of one of their vehicles exclusively for this project; their Game biologists and Law Enforcement officers have provided much-needed information on the locations of colonies in various parts of the Conservation areas. The Florida Cooperative Fish and Wildlife Research Unit has provided the use of

boats, vehicles, equipment and secretarial services. The Florida State Division of Forestry kindly allowed us space to park airboats at their facility on Tamiami Trail. Dr. Steven Beissinger took time to help us with initial orienteering, and gave valuable information on all aspects of the ecology and natural history of the Everglades. We thank S. Winterstein, G. Hensler, J. Nichols, K. Portier, and R. Bennetts for help in understanding and developing Mayfield method statistics. James Wyatt donated many hours of his time as a trained aircraft mechanic to service our airboats free of charge.

## INTRODUCTION

### Background and Purpose

Wading birds are species within the order Ciconiformes, which nest and feed in wetlands. This group includes the herons, egrets, storks, ibises, and spoonbills. The Everglades region is a vast wetland, which historically has supported very large numbers of both wintering and breeding wading birds (Robertson and Kushlan 1974). Wading birds are an essential ecological component of wetlands ecosystems, capable of moving many thousands of tons of nutrients in a single season (Kahl 1964, Kushlan 1977, Christy et al. 1981) and have important effects on prey populations, such as dampening population cycles and maintaining species diversity (Kushlan 1976a).

During this century there have been two major population declines of wading birds in the Everglades region. The first occurred at the turn of the century, when plume hunting nearly extirpated several species (Allen 1964). Most of those species increased dramatically following federal protection in 1910, to numbers that most authors agree were healthy in the 1930's (Allen 1964, Robertson and Kushlan 1974, Ogden 1978, Kushlan and Frohring 1986). Sometime between the late 1940's and the mid 1960's, populations of Wood Storks (Mycteria americana), Tricolored Herons (Egretta tricolor), Snowy Egrets (Egretta thula), Little Blue Herons (Egretta caerulea), Great Egrets (Casmerodius albus) and probably White Ibises (Eudocimus albus) again began a decline which led to losses of one to two orders of magnitude (Kushlan and White 1977, Ogden 1978, Kushlan and Frohring 1986).

The fact that wading bird populations recovered relatively quickly from the decline at the turn of the century suggests that a reversal of the present trend is possible; however, an understanding of the causes and actual extent of the second decline are essential to any efforts aimed at restoring current wading populations.

Because many population estimates from the 1930's are inaccurate and probably inflated (Ogden 1978, Kushlan and Frohring 1986), it is not obvious what healthy population levels should be. Although the Wood Stork population has by far the best historic documentation, Kushlan and Frohring (1986) found that most of the records from the 1930's were unsubstantiated or unrealistic, and concluded that those censuses probably overestimated populations by three to ten times. Even so, they categorized the decline of storks as drastic.

In the case of the herons, egrets, and ibises, the population decline has been less well documented. Taking into account the exaggeration of nesting numbers in the 1930's, Kushlan and White's (1977) censuses suggest that populations of smaller herons had been reduced by the mid-1970's to at best one quarter of the probable 1930's numbers.

#### Causes of the population decline

Since most important nesting areas for wading birds in the Everglades region (Corkscrew Swamp, Okaloacoochee Slough, Everglades National Park, and the Everglades Water Conservation Areas) have been protected since the 1930's, it is doubtful that population declines can be attributed to loss of nesting habitat or to rookery harassment. Wading birds are now hunted only rarely and there is no evidence of widespread losses due to disease or parasites. This implies that the

decline is related to loss or degradation of the feeding habitat.

Several important changes in wading bird feeding habitat have occurred in this century. First, a great deal of the Everglades has been converted into agricultural lands. In the area south of Lake Okeechobee, the acreage of five important wading bird feeding habitats has decreased by 35% since 1900 (Browder 1976, 1978). In addition, the vast majority of the undeveloped Everglades is now surrounded by a levee and canal system, which allows artificial changes of the natural hydrologic cycle. Large-scale water management became possible in 1962 with the completion of the S-12 control structures along Tamiami Trail. These gates control water flow between the vast Water Conservation Area 3 (WCA 3, including WCA 3A and 3B) and Everglades National Park (ENP). Water management practices resulted in pooling water in WCA 3 during the dry spring (when wading birds traditionally nest) and releasing water into ENP abruptly at the start of the rainy season.

Prior to water management, water flowed slowly southward in a sheet across the entire Everglades region. During the dry season, the area covered gradually shrinks in size and forms shallow evaporating edges and pools (Kushlan et al. 1975). The dynamics of this natural cycle are essential to wading bird feeding and nesting success for several reasons.

First, some wading birds require quite shallow water in which to wade. Many of the smaller heron species are too short to wade in water deeper than 20 cm (Custer and Osborne 1978). Second, wading bird foraging techniques may become ineffective in anything but very shallow water (Jenni 1969, Kushlan 1976b). For example, Kushlan (1974) found that White Ibises avoided water deeper than 10 cm when foraging. Though

White Ibises are tall enough to wade in water up to 25 cm deep, they usually probe continuously for their food, and would have to submerge their head to forage in deeper water. Thus, pooling of deep water in large areas of feeding habitat effectively renders those areas unsuitable for most wading birds.

Third, wading birds may rely on concentrated food sources for reproduction, regardless of hunting technique. Rapidly shrinking areas of water in the Everglades are essential to creating such a supply, because fish and other prey are concentrated in shallow pools (Kushlan 1976a) or along drying edges (Kushlan et al. 1975). For the Wood Stork, this concentration is essential for any successful feeding (Kahl 1964).

Finally, the timing of optimal feeding conditions with nesting phenology is critical for successful reproduction. For most species, the production of eggs relies on the female's ability to collect and store nutrients prior to the nesting attempt (Ankney and MacInnes 1978, Winckler and Walters 1983). Excellent feeding conditions also must be available during the more protracted nestling period, when fast nestling growth is essential to survival (Werschkul 1979). Since fledglings usually forage far less efficiently than adults (Bildstein 1984), fledgling and juvenile survival also may be dependent on conditions which concentrate prey.

Thus a protracted period of shallow and shrinking water levels over a large areas appears to be essential to wading bird nesting success. This period can last as long as 110 days in the case of the Wood Stork (Kahl 1964).

Changes in water management implemented in 1962 completely altered the natural hydrologic cycle during the normal wading bird nesting

season and probably have contributed largely to the decline of wading bird populations. Kushlan and Frohring (1986) found that south Florida Wood Stork nesting populations probably were not much smaller during the early 1960's than during the 1930's. The decline of stork populations, then, seems to have coincided with the changes in water management made during the 1960's rather than being a gradual decline since the 1940's (Sprunt and Kahl 1960). Kushlan et al. (1975) demonstrated that Wood Stork nesting success in ENP decreased dramatically after 1962. They also found that after 1962, Wood Stork nesting attempts were initiated several months later in the winter, when too little time remained to raise a brood before the onset of the rainy season. Both of these patterns were attributed to the drastic man-induced change in the hydrologic cycle. While there were brief periods of low and shrinking water, these periods came at the wrong time in the stork's nesting season to cue nesting initiation and were too brief to support the entire nesting cycle.

Thus, there is good evidence that the wading bird population decline was tied closely to water management practices. This implies that a change in water management could forestall a complete collapse of the wading bird populations, or even reverse the declining trend. Extremely low wading bird populations increased dramatically following the ban on plume hunting, indicating they have the potential for rapid increase under good conditions. The Everglades also is a traditional wintering ground for many more wading birds than currently nest there (Robertson and Kushlan 1974) and attractive feeding conditions could induce many of these birds to nest instead of migrating. With the exception of Wood Storks (Ogden 1978), most wading birds are very opportunistic nesters,

and can be expected to take advantage of good nesting conditions fairly rapidly (Kushlan 1977, Ogden 1978, Frederick in press). Thus, any future increase in the nesting population is not necessarily limited to reproduction by the current depauperate cohort of breeders.

#### Purpose of the Present Study

In an effort to reverse the detrimental effects of the "old" water management practices, the U.S. Army Corps of Engineers implemented a new, rainfall-driven water management plan in the wet season of 1985. The new plan is expected to change both the timing and amount of water released from WCA 3 into ENP, and could have profound effects on wading bird nesting success and foraging dispersion within the two areas. The purpose of this project is to document wading bird nesting success and foraging dispersion during implementation of the new water management plan in both WCA 3 and ENP, and to investigate whether any changes in these parameters are attributable to the new water management plan. This study will be conducted during the 1986 and 1987 nesting seasons. This interim report presents the results of the first season's work.

### Study Area and Species

The study area includes all of the central grasslands within Everglades National Park, and all of WCA 3. The WCA 3 study area includes WCA 3A and 3B, and is bordered by Tamiami Trail on the south, L-28, L-4 and L-5 on the north, and Florida Route 27 on the east. In addition, the East Everglades (south of Tamiami Trail, east of L-67, north of Grossman's Hammock) was included in the aerial surveys since it was systematically overflown en route to both WCA 3 and ENP. Nesting success of the historical wading bird colonies within the coastal mangrove sections of ENP was monitored by ENP research staff and by National Audubon Society Research staff. Both organizations kindly supplied data and information on those colonies for this report.

Species monitored for nesting success included Wood Storks, Great Blue Herons (Ardea herodias), Great Egrets, Snowy Egrets, Tricolored Herons, Little Blue Herons, Green-backed Herons (Butorides striatus), Black-crowned Night-Herons (Nycticorax nycticorax), White Ibises, and Glossy Ibises (Plegadis falcinellus). Cattle Egrets (Bubulcus ibis) are common nesters in Everglades colonies but were not included since they are purely terrestrial feeders and therefore do not reflect wetland feeding conditions. Though Least Bitterns (Ixobrychus exilis) and Limpkins (Aramus guarauna) are common breeders in the Everglades, they are dispersed nesters. For this reason, monitoring their nesting success was considered infeasible.

## METHODS

### Reproductive Success

Colonies were located by systematic aerial overflights of both WCA 3 and ENP. These flights were flown at 350 m above ground level, with one observer on each side of a single-engined, high-wing aircraft (Cessna 180) at approximately 160 km/hr airspeed. During early morning hours, non-nesting birds are likely to be away from the colonies and roosts feeding. To avoid counting roosts as colonies or roosting birds in colonies as breeders, survey flights were only flown in early morning hours (0600 - 1030). Survey flights in each area always followed a predetermined set of transects (see Fig. 1), usually about 2.4 nautical miles apart. This ensured that even small colonies would be spotted if they formed anywhere in the study area. A minimum of six nests was established as our criterion for colony status. Nearly all colonies had some white-plumaged species nesting in them; however, a few contained only dark-colored Little Blue Herons. Although initially difficult to locate, these latter colonies became obvious as soon as their white-plumaged young hatched.

When colonies were spotted, their position was recorded using latitude/longitude coordinates given by an aviation-grade LORAN-C unit accurate to 0.18 nautical miles. Survey flights were flown on a biweekly basis in both areas from early January 1986 to late April 1986, and on a weekly basis from late April 1986 through late July 1986.

The size and species composition of each colony was estimated by averaging successive counts made at 30 - 60 m above the colony. All colony counts given in this report are of nests, not of breeding birds (total numbers of breeders would be the number of nests times two).

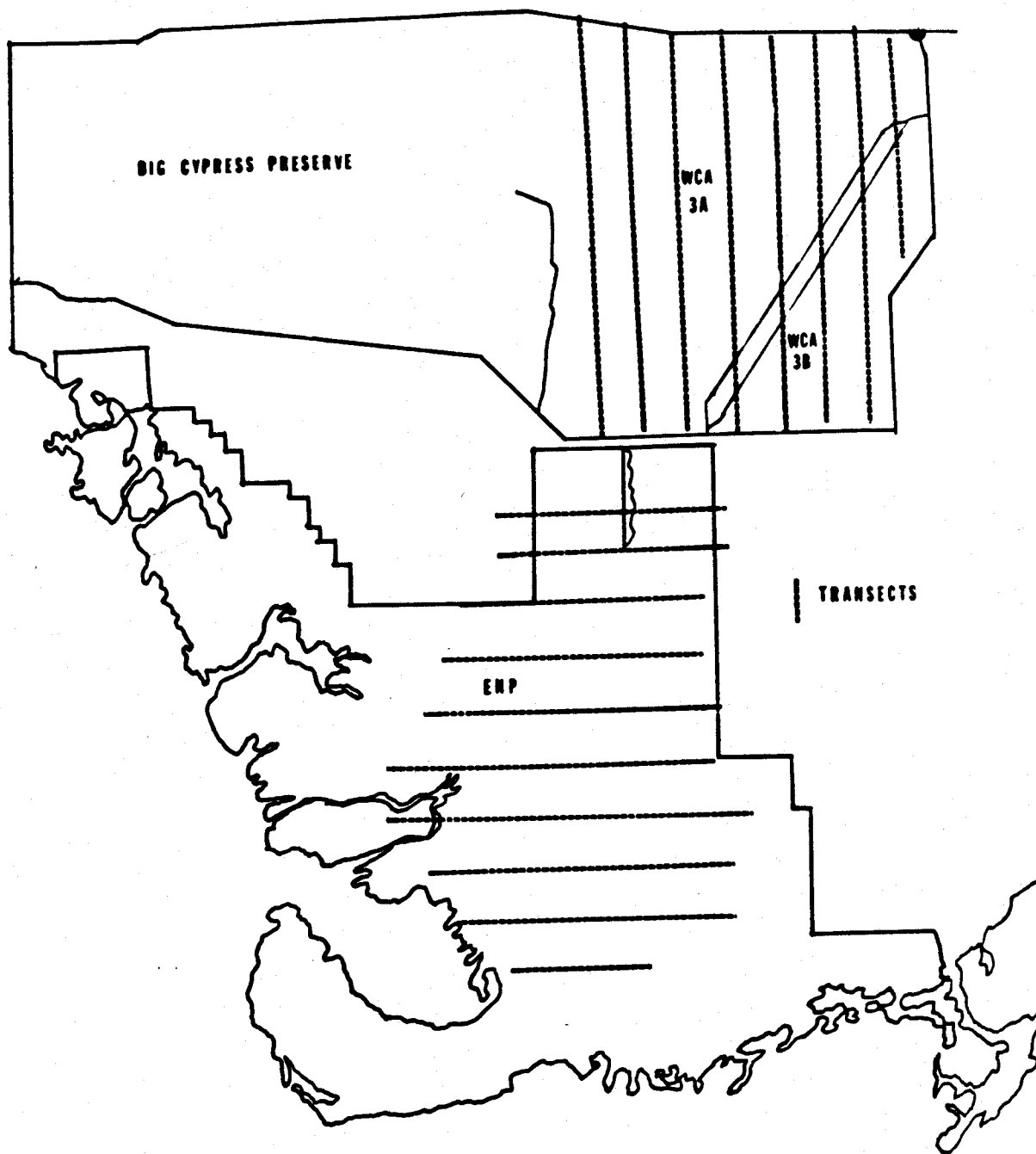


Figure 1. Fixed-wing survey transects.

Numbers of nests were estimated by counting birds in the colony only when the majority of the breeders were known to be in incubation stage. At this time, only one member of each pair is usually on the nest at a time and a count of birds reflects the number of nests. When colonies were located only after young had hatched (as in the case of several of the Little Blue Heron colonies), numbers of nesting starts were estimated crudely by dividing the number of young by two. Colonies were considered active with the laying of the first egg in any nest. Laying dates were determined during ground visits. If nests were in advanced stages, the initiation date of the colony was estimated by backdating the oldest young, whose age was estimated.

Counts of nests in the traditional coastal colonies within ENP were made by Sonny Bass of ENP Research Center, and by Tom Bancroft and John Ogden of the National Audubon Society Research Center. Their counting methods were very similar to those described here.

Reproductive success was measured by following the fate of marked nests in specific colonies. Colonies were selected for detailed study on the basis of several criterion. An effort was made to study colonies that were large, that had mixed species composition, that were accessible by airboat, and that did not have endangered Snail Kites (Rostrahamus sociabilis) nesting in or near them. Finally, an effort was made to collect reproductive success data from colonies that were geographically distant from each other, so that all parts of the large study area were represented.

Colony visitation and nest marking protocol were standardized across colonies to control for human disturbance effects on reproductive performance. Colonies were visited once every 4 days, though inclement

weather, vehicle failure, and fluctuating water levels sometimes extended the interval to 6 days. Nearly all colonies were reached using an airboat; the airboat was usually driven up to the edge of the colony. Three colonies in ENP (Lost, Stix, Nicks) were visited by helicopter because they were in rocky areas inaccessible by airboat. Colonies visited by helicopter were approached no closer than 200 meters by the helicopter, and the helicopter was shut down during the visit. Colonies were visited only during early morning hours (0630 - 0900) to avoid overheating eggs and young. To standardize the duration of human disturbance and to avoid lengthy exposure of eggs and young to the elements or bold avian predators, colony visits were always limited to one hour.

When the colony was small, all nests were marked and their fates followed. If large, all nests within 1 meter of 2 transects within the colony were similarly studied. Transects were oriented towards the densest nesting locations, but started at the edge of the colony to control for edge and density effects. The total number of nests marked was determined by the one hour limit on our visitation.

Study nests were marked with strips of numbered orange or pink surveyor's flagging tied to a branch, usually underneath the nest. Nest contents were recorded, and each egg within a nest marked with a different letter using a felt-tipped permanent marking pen. Length and width of all eggs in a clutch were measured with vernier calipers to the nearest 0.5 mm.

Nests that were too high to reach by climbing were examined using a convex mirror attached to the end of an extendable aluminum pole. These poles also had a wide-tipped magic marker filled with India Ink attached

to an adjustable sidearm near the tip. When used in conjunction with the mirror, this device allowed recognizable marking of the eggs in the elevated nests. Eggs in the high nests were not measured.

A nest was considered active with the laying of the first egg. For many nests, the exact date of the laying of the first egg was not known, since visits were usually four days apart. The initiation date was therefore estimated, using a two-day inter-egg interval. For nests that were not discovered until after egg-laying was over, the first egg date was estimated by backdating the hatching of the first young. The incubation periods used for each species are given below. No attempt was made to date nests for which neither egg-laying dates nor hatching dates were available.

The disappearance of marked eggs was obvious even when replacement eggs were laid between visits. Assigning a cause for the egg loss, however, was more difficult. The disappearance of single eggs from a still-warm clutch was considered evidence of predation of that missing egg. More often, entire clutches were missing or clutches were partially depleted and cold. Loss of entire clutches was enigmatic, since this could have resulted either from complete predation followed by abandonment, or abandonment for other reasons (loss of mate, poor feeding conditions, water level fluctuation, weather, nest usurpation, etc.) followed by scavenging of the nest contents. Abandonment not induced by nest predation was assigned as a cause of failure only when a complete set of cold eggs were found in the nest during the incubation period. Similarly, abandonment also was assigned when all young in a nest were dead, cold or moribund. When obviously predated eggs were found in nests or on the ground beneath nests, we could not necessarily

attribute the nesting failure to predation, since predators could have scavenged the eggs after the parents had deserted the nest for other reasons.

Traditional reproductive success studies have used the proportion of all nests found that produced young as the unit of comparison. But as first pointed out by Mayfield (1961, 1975), this method only measures nesting success for a part of the nesting cycle, and does not take into account nests that were never found because they failed earlier in the cycle. Nests that survive are much more likely to be found, and the resulting bias of the traditional method is therefore to overestimate nesting success, in some cases by a very large amount. Mayfield's solution was to measure survival during a period of observation of a group of marked and repeatedly visited nests, and then pro-rate that estimate for the entire reproductive cycle, thus avoiding the above bias. Various refinements of Mayfield's method (Hensler and Nichols 1981, Hensler 1985) now allow the researcher to estimate variances and confidence limits for Mayfield nesting success estimates, to combine estimates and variances across periods within the nesting cycle, and to apply statistical hypothesis testing to these results. Because of these advantages, the Mayfield method was selected for use in this study. All formulae used in nest-success calculations are given and referenced in Appendix 1.

Because nest survival rates often are very different during different stages of the nesting cycle (Mayfield 1961, 1975, Black et al. 1984, Shields 1985), the nesting cycle was divided into three periods: early incubation, incubation, and nestling. The laying and incubation periods for different species were derived from the literature (Bent 1926,

Palmer 1962, Hancock and Kushlan 1984, Rudegeair 1975, Shields 1985). The end of the nestling period was arbitrarily defined for each species as the time when nestlings were capable of moving from the nest to denser foliage or taller branches, at which time locating them becomes unreliable. For Great Blue Herons, Black-crowned Night-Herons, and Great Egrets, early incubation, incubation, and nestling periods were considered to be 6, 27, and 21 days, respectively. For Snowy Egrets, Little Blue Herons, Tricolored Herons, and Green-backed Herons, the periods were 6, 22, and 14 days, respectively. For White Ibises and Glossy Ibises, the periods were 6, 21, and 14 days, respectively. Nest success estimates for the three nesting periods were combined (Hensler 1985, see Appendix 1) to give an overall nesting success figure for each species within a colony or across colonies within regions. All formulae used in computing nesting success figures, variances, and for combining variances across nesting periods are given in Appendix 1.

Most nesting losses during the laying and incubation periods of wading birds are of entire clutches and partial loss of clutches is usually negligible (Black et al. 1984, Shields and Parnell 1986). Consequently, measuring the success of entire nests is sufficient to estimate production. During the nestling period, however, partial loss of broods without nest failure is common. This brood reduction usually is due to starvation and has been considered a mechanism for adjusting brood sizes to available local food supply (Lack 1968, O'Connor 1978). Assuming the latter is true, the degree of this nestling mortality might vary widely even when nest mortality does not. Therefore, nestling mortality also might be used as an indicator of local feeding conditions.

To measure the degree of brood reduction, the Mayfield method can be applied to nestlings as well as eggs, provided the probability of each unit (nests or nestlings) surviving is independent. Since the degree of brood reduction usually depends on size of brood (Werschkul 1979, Fujioka 1985) nestling success was analyzed only within broods of equal size. The estimates for different brood sizes were then combined by means of a weighted average, and their variances combined by a similar method (Hensler and Nichols, pers. comm., Appendix 1).

Nests and eggs of three of the smaller herons (Little Blue Heron, Tricolored Heron, and Snowy Egret) are impossible to reliably tell apart using appearance, color or measurements. Consequently, only rare circumstances allow the observer to identify the nest (in some cases, a particularly small colony can be identified as monospecific because only one species was ever seen in or around the colony or the observer may occasionally see the bird incubating a nest before it leaves). In general, the nests of these species can be identified only after the eggs have hatched, when they can be reliably identified by plumage of the nestlings. Thus, if a small heron nest fails before hatching for any reason, the nest cannot be assigned to species, and in this study was labeled "small heron".

If nesting success for any of the three small heron species were calculated only from data from identifiable nests, then those data would not include any of the nests that failed before hatching. This would result in a gross over-estimation of nesting success. To avoid this problem, nesting success data from all identifiable and unidentifiable small heron nests were pooled to estimate nesting success during incubation in any one colony or area. For the nestling period, data for

the three different species were kept separate. Overall nesting success figures for the small heron species, then, were compiled in the normal fashion (Appendix 1) from both genus-wide incubation period estimates and species-specific nestling period estimates.

#### Foraging Dispersion

After most of the nests in a colony had hatched young, adult birds were followed from the colony to feeding locations using fixed-wing aircraft. Colonies from which birds were followed were selected on the basis of size, species composition, and location. As with the colonies selected for nesting success study, an attempt was made to follow birds from both large and small colonies, and those representing different parts of the study area.

Dark-colored species were nearly impossible to follow visually from an aircraft, so only Great Egrets, Snowy Egrets, White Ibises, and Wood Storks were followed. The foraging flights that we monitored usually were constrained to the morning hours by weather. The colony was circled slowly at about 155 m above ground level, and the first white wading bird to leave the colony in any direction was followed. The flight ended when the bird landed, even if the bird subsequently moved. Total flight time was recorded and the location determined using an aviation-grade LORAN-C unit which gave latitude and longitude to within 0.18 km. The location of the feeding bird was subjectively characterized on the basis of vegetation type, apparent recent burn status, number of wading birds nearby, and relative amount of open water.

Water level and rainfall information was obtained from Everglades

National Park Research Center, and from the U.S. Army Corps of Engineers office in Jacksonville. Water levels usually are given as heights above mean sea level (MSL); water depths were derived by subtracting ground level (height of ground around the recording station in feet above MSL) from water levels. In ENP, water levels were estimated at specific colonies from levels at the nearest staff gauge or water recording station. Though staff gauges are no longer monitored, predictive equations (with 95% confidence intervals of  $\pm 0.20$  feet) exist for most of them using permanent water recording stations as references (Probst and Rosendahl 1981).

Abbreviations used for wading bird species in this report are as follows:

|                               |                                  |
|-------------------------------|----------------------------------|
| GE = Great Egret              | BCNH = Black-Crowned Night-Heron |
| WI = White Ibis               | TC = Tricolored Heron            |
| GBH = Great Blue Heron        | SE = Snowy Egret                 |
| GBA = Green-backed Heron      | LB = Little Blue Heron           |
| SH = Unidentified small heron | GI = Glossy Ibis                 |
| WS = Wood Stork               |                                  |

## RESULTS

### Nesting Population

From 10 January through 14 July 1986, a total of 35 colonies of wading birds were located: 20 in WCA 3, 12 in ENP, and 3 in East Everglades (Tables 1, 2, 3, Fig. 2). Colony initiation began in early January (Mud Canal colony in WCA 3) and ended in late June (Coopertown Ibis in East Everglades), and peaked throughout the area sometime in early May (Fig. 3). Colony initiations in ENP, however, appeared to end somewhat earlier than in WCA 3 and East Everglades. In ENP, no new colonies formed after the end of April.

Colonies in all study areas varied widely in size and species composition (Fig. 4, Tables 4, 5, 6). The majority of the colonies were quite small, often less than 50 nests. Only 9 colonies (25.7% of all colonies; 5 in WCA 3, 3 in ENP, and 1 in East Everglades) had more than 100 nesting starts. Thus, the vast majority of the nesting wading birds were found in a very few locations; 84% of all the nests were found in 25% of the colonies. The western side of WCA 3A showed a concentration of smaller colonies, which were composed primarily of Little Blue Herons and Tricolored Herons.

Great Egrets, Tricolored Herons, and Little Blue Herons were common nesting species in both WCA 3, ENP, and East Everglades. Wood Storks only nested at Cuthbert Lake, in ENP. Although White Ibises nested in all three areas, less than 5% of their nesting starts were in ENP. Glossy Ibises only nested at one colony in the area (Alley North Colony). Snowy Egrets were much more common in ENP (94.8% of nests) than elsewhere in the study area. Great Blue Herons and Green-backed

Table 1

Colonies Located in WCA 3  
(\* indicates nests were  
marked to study nesting success)

| Colony Name           | Approximate<br>Date of<br>initiation | Map# | Coordinates              | Success(S)<br>Failure(S)<br>Heavy Losses(L) |
|-----------------------|--------------------------------------|------|--------------------------|---------------------------------------------|
| Alley North*          | 4/10                                 | 1    | 26°11.25'N<br>80°31.08'W | L                                           |
| Alley North<br>Camp   | 4/12                                 | 2    | 25°11.35'N<br>80°27.56'W | S                                           |
| Andytown*             | 2/8/86                               | 3    | 26°06.87'N<br>80°29.48'W | L                                           |
| JW1                   | 5/14                                 | 4    | 26°05.07'N<br>80°42.80'W | S                                           |
| JW2                   | 5/20                                 | 5    | 26°06.50'N<br>80°43.15'W | S                                           |
| Big Melaleuca<br>West | 5/7                                  | 6    | 26°04.50'N<br>80°39.50'W | S                                           |
| Big Melaleuca 1*      | 3/1                                  | 7    | 26°02.80'N<br>80°37.50'W | L                                           |
| Big Melaleuca 2*      | 5/27                                 | 7    | 26°02.80'N<br>80°37.50'W | F                                           |
| Mud Canal             | 2/6                                  | 8    | 26°00.60'N<br>80°27.65'W | S                                           |
| Mickey Mouse*         | 5/3                                  | 9    | 26°00.05'N<br>80°37.50'W | S                                           |
| LBH*                  | 4/17                                 | 10   | 25°58.15'N<br>80°48.16'W | S                                           |
| LBH East              | 4/15                                 | 11   | 25°58.30'N<br>80°47.99'W | S                                           |
| L-67                  | 2/13                                 | 12   | 25°57.33'N<br>80°33.92'W | S                                           |
| Cypress Dome          | 4/18                                 | 13   | 25°53.78'N<br>80°46.59'W | S                                           |
| Outer Trail           | 4/20                                 | 14   | 25°55.00'N<br>80°49.18'W | S                                           |

Table 1 (cont'd)

Colonies Located in WCA 3  
(\* indicates nests were  
marked to study nesting success)

| Colony Name  | Approximate<br>Date of<br>initiation | Map# | Coordinates              | Success(S)<br>Failure(S)<br>Heavy Losses(L) |
|--------------|--------------------------------------|------|--------------------------|---------------------------------------------|
| Rob's        | 4/18                                 | 15   | 25°52.61'N<br>80°47.60'W | S                                           |
| Rob's South  | 5/9                                  | 16   | 25°51.20'N<br>80°47.75'W | S                                           |
| Rob's SW     | 5/14                                 | 17   | 25°50.70'N<br>80°48.25'W | S                                           |
| L-28 Plug    | 4/18                                 | 18   | 25°48.48'N<br>80°50.79'W | S                                           |
| L-28 Cypress | 3/7                                  | 19   | 25°48.50'N<br>80°51.30'W | S                                           |
| Frog City*   | 2/12                                 | 20   | 25°45.70'N<br>80°35.20'W | S                                           |

Table 2

Colonies Located in Everglades National Park  
(\* indicates nests were  
marked to study nesting success)

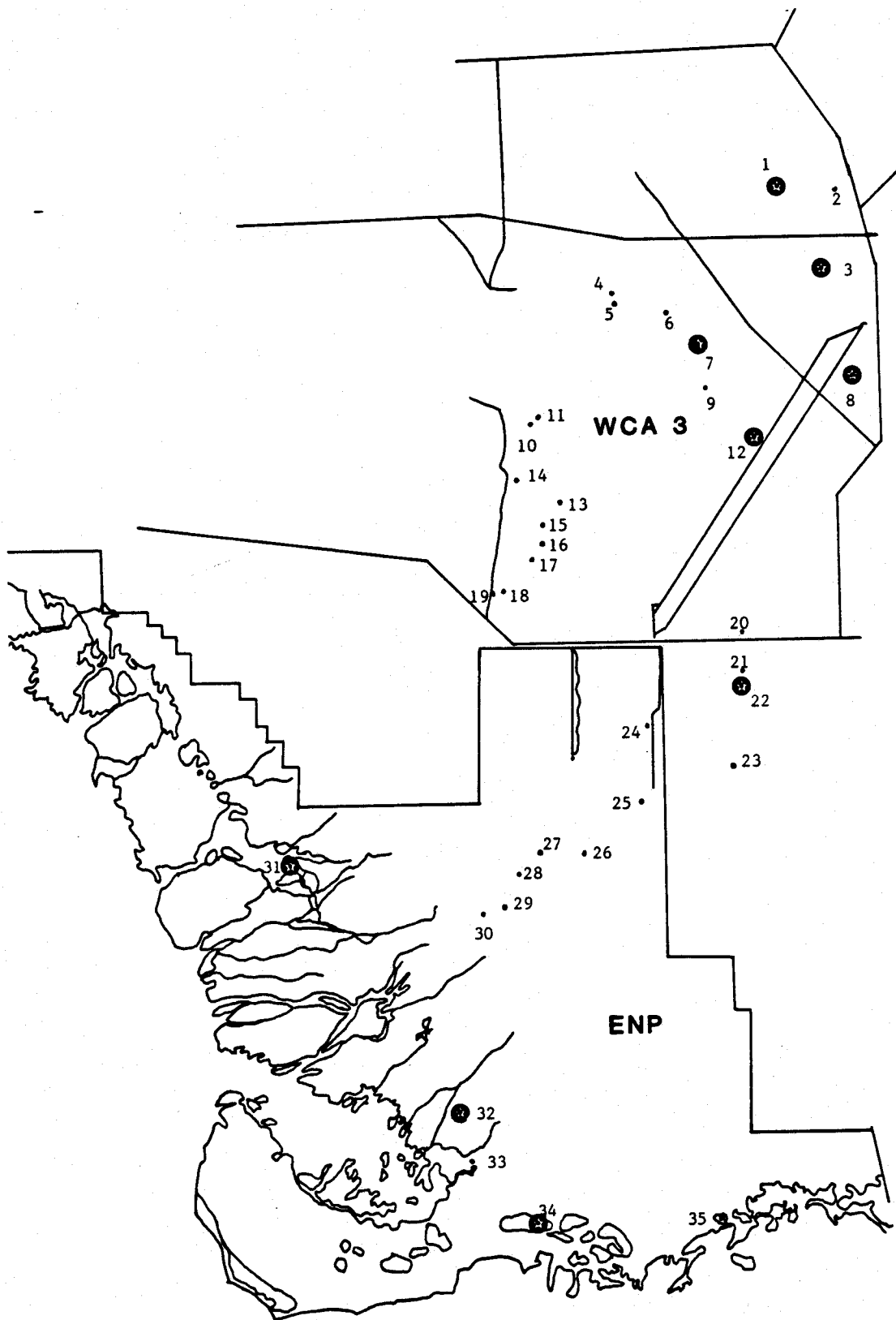
| Colony Name                       | Approximate<br>Date of<br>initiation | Map# | Coordinates              | Success(S)<br>Failure(S)<br>Heavy Losses(L) |
|-----------------------------------|--------------------------------------|------|--------------------------|---------------------------------------------|
| L-67 North<br>LBH                 | 4/19                                 | 24   | 25°40.85'N<br>80°40.90'W | S                                           |
| L-67                              | 4/26                                 | 25   | 25°36.42'N<br>80°41.39'W | S                                           |
| Panther Mound*                    | 2/23                                 | 26   | 25°33.60'N<br>80°45.50'W | F                                           |
| Nick's*                           | 3/20                                 | 27   | 25°33.80'N<br>80°48.25'W | F                                           |
| Stix*                             | 3/12                                 | 28   | 25°32.66'N<br>80°49.86'W | L                                           |
| Lost*                             | 2/19                                 | 29   | 25°30.70'N<br>80°50.50'W | F                                           |
| Park LBH                          | 4/29                                 | 30   | 25°30.20'N<br>80°51.71'W | S                                           |
| Rodger's River<br>Bay             | 2/11                                 | 31   | 25°32.80'N<br>80°03.40'W | S                                           |
| Lane River*<br>(Audubon)          | 3/20                                 | 32   | 25°19.00'N<br>80°53.10'W | L                                           |
| East River                        | 2/21                                 | 33   | 25°15.63'N<br>80°51.72'W | S                                           |
| Cuthbert Lake<br>(Egrets earlier) | 2/21                                 | 34   | 25°12.14'N<br>80°46.30'W | S                                           |
| Madeira Bay                       | 4/28                                 | 35   | 25°12.14'N<br>80°36.86'W | /                                           |

Table 3

Colonies Located in East Everglades Area (\* indicates nests were marked to study nesting success)

| - Colony Name    | Approximate Date of initiation | Map# | Coordinates              | Success(S)<br>Failure(S)<br>Heavy Losses(L) |
|------------------|--------------------------------|------|--------------------------|---------------------------------------------|
| Coopertown North | 5/1                            | 21   | 25°44.10'N<br>80°35.30'W | S                                           |
| Coopertown Ibis* | 6/21                           | 22   | 25°43.00'N<br>80°35.40'W | F                                           |
| East Everglades* | 3/11                           | 23   | 25°38.47'N<br>80°36.04'W | F                                           |

Figure 2. Locations of all wading bird colonies found in 1986.  
Colonies of greater than 100 nests are shown with stars.



# DATE OF COLONY INITIATIONS

ALL COLONIES

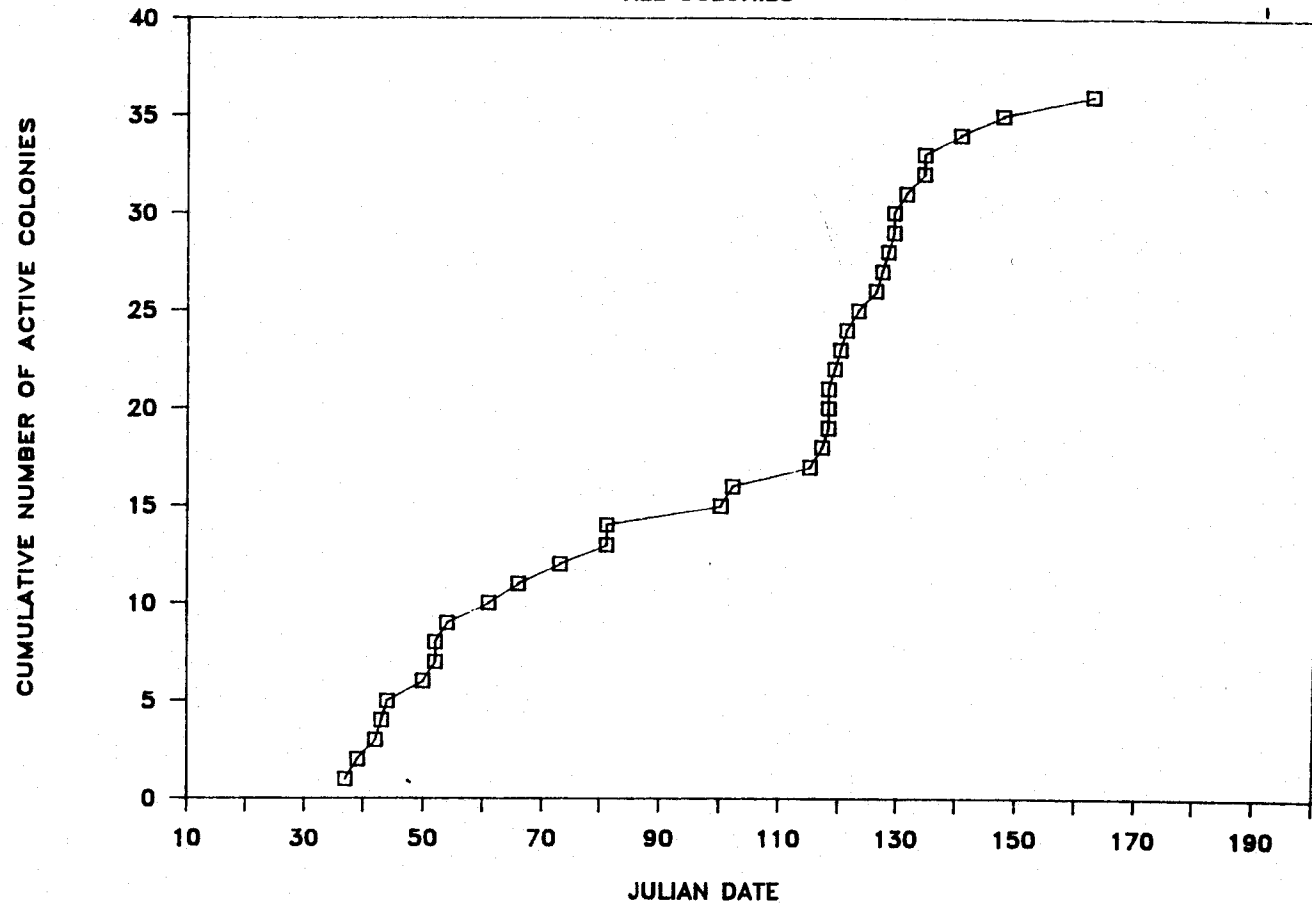


Figure 3. Date of colony initiations in the entire study area.

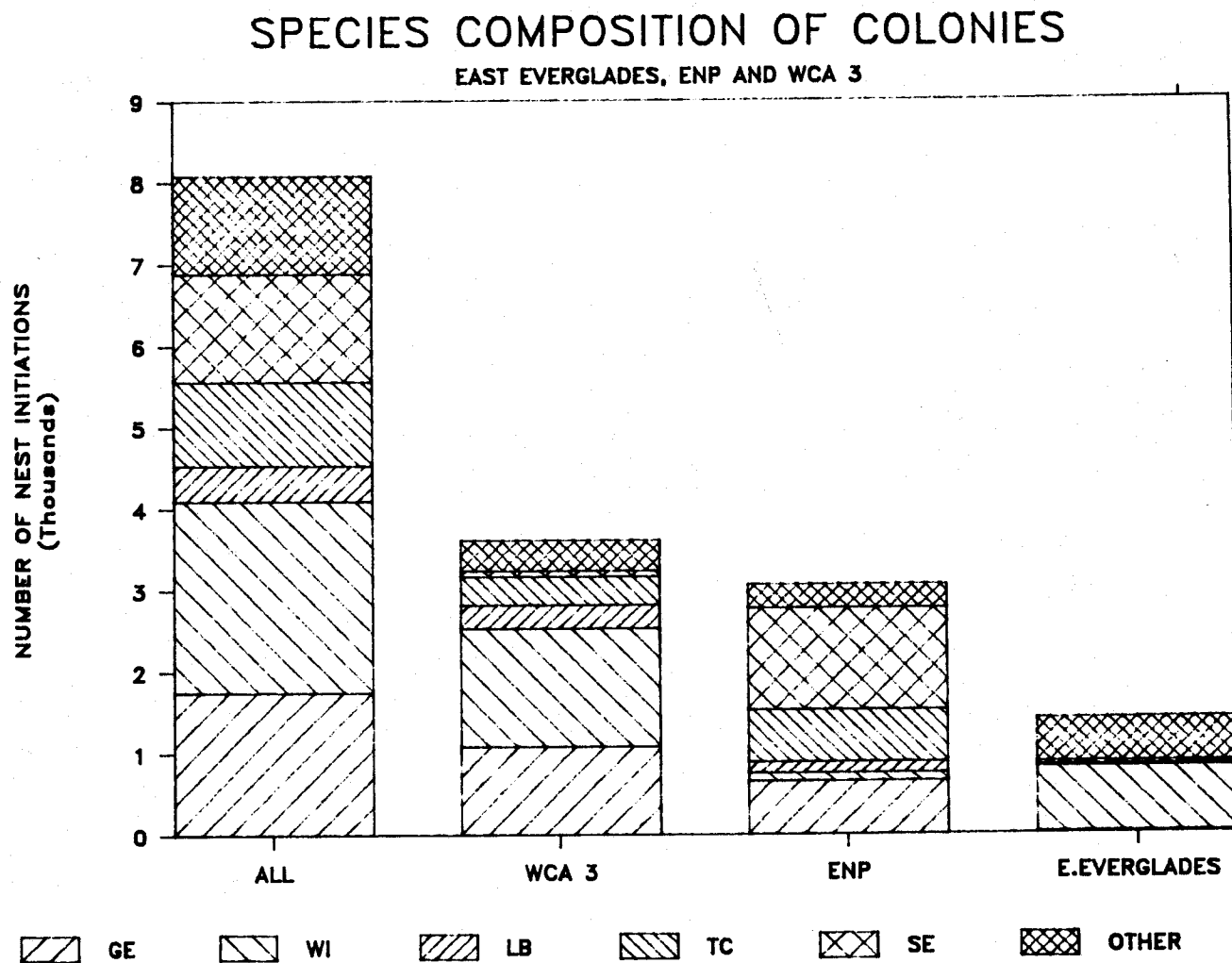


Figure 4. Species composition of all colonies found in 1986.

Table 4

Approximate size and species composition of colonies in WCA 3  
 (\*indicates colony was studied for nest success)

| Colony           | GE  | WI    | LB | TC  | SN | SH | CE | WS | GB | NH | GLI | TOTAL<br>(maximum) |
|------------------|-----|-------|----|-----|----|----|----|----|----|----|-----|--------------------|
| Alley North*     | 645 | 642   | 67 | 209 | 65 |    | 48 |    | 8  | 40 | 30  | 1,724              |
| L-67             | 108 |       |    |     |    |    |    |    | 14 |    |     | 122                |
| Big Melaleuca*   | 38  | 3-800 |    |     |    |    |    |    |    | 10 |     | 848                |
| Frog City*       | 50  |       | 1  | 24  | 1  |    |    |    |    | 16 |     | 92                 |
| Andytown*        | 120 |       |    |     |    | 3  |    |    | 10 |    |     | 123                |
| LBH*             |     |       | 50 | 8   |    | 13 |    |    |    |    |     | 71                 |
| Mickey Mouse*    |     |       | 44 | 4   |    | 5  |    |    |    |    |     | 53                 |
| Alley North Camp | 30  |       |    |     |    |    |    |    | 10 |    |     | 40                 |
| Mud Canal        | 50  |       |    |     | 3  |    | 60 |    |    |    |     | 113                |
| Rob's            |     |       | 26 | 60  |    |    |    |    |    |    |     | 86                 |
| Rob's South      |     |       | 1  | 1   |    | 7  |    |    |    |    |     | 9                  |
| Rob's SW         |     |       | 10 | 5   |    |    |    | 1  |    |    |     | 15                 |
| LBH East         |     |       | 50 |     |    |    |    |    |    |    |     | 50                 |
| L-28 Plug        | 28  |       |    |     |    |    |    |    |    |    |     | 28                 |
| L-28 Cypress     | 10  |       |    | 10  |    | 10 |    |    |    |    |     | 30                 |
| Cypress Dome     |     |       |    | 4   |    |    |    |    | 6  |    |     | 10                 |
| Outer Trail      |     |       | 11 | 10  |    |    |    |    |    |    |     | 21                 |

Table 5

Approximate size and species composition of wading bird colonies in ENP  
 (\*indicates colony was studied for nest success)

| Colony                      | GE    | WI  | LB  | TC  | SN     | SH | WS                      | Spoonbill | TOTAL<br>(maximum) |
|-----------------------------|-------|-----|-----|-----|--------|----|-------------------------|-----------|--------------------|
| Cuthbert Lake               | 1-200 |     | 30  |     |        |    | 275<br>(150 fledglings) |           | 475                |
| Lane River*<br>(AUDUBON)    | 20    | 50  | 30  | 200 | 50     |    |                         |           | 350                |
| East River                  | 40    |     |     | 15  |        |    |                         | 15        | 70                 |
| Rodgers River Bay           | 1-300 |     |     | 300 | 3-1200 |    |                         |           | 1800               |
| Madeira Bay                 |       | 50  |     |     |        |    |                         |           | 50                 |
| Lost*                       | 30    |     |     |     |        |    |                         |           | 30                 |
| Panther Mound*              | 12    |     |     |     |        |    |                         |           | 12                 |
| Nick's*                     | 23    |     |     | 72  |        |    |                         |           | 95                 |
| Stix*                       | 29    |     |     | 14  |        | 14 |                         |           | 57                 |
| L-67 LBH North<br>L-67 LBH  |       |     | 20  | 16  |        |    |                         |           | 36                 |
| Park LBH<br>(2 subcolonies) |       |     | 50  | 25  |        |    |                         |           | 75                 |
| TOTALS                      | 654   | 100 | 130 | 642 | 1250   | 14 | 275                     | 15        | 3,050              |

Table 6      Approximate size and species composition of wading bird colonies in  
 East Everglades  
 (\*indicates colony was studied for nest success)

| Colony             | GE | WI    | LB | TC | SN | SH | CE    | WS | GB | NH | GLI | TOTAL<br>(maximum) |
|--------------------|----|-------|----|----|----|----|-------|----|----|----|-----|--------------------|
| East Everglades    | 16 |       |    | 13 |    | 38 |       |    |    |    |     | 67                 |
| Coopertown Ibis*   |    | 3-800 |    |    |    |    | 3-500 |    |    |    |     | 1,300              |
| Coopertown North * |    |       | 21 | 28 |    |    |       |    |    |    |     | 49                 |
| TOTALS (maximum)   | 16 | 800   | 21 | 41 |    | 38 | 500   |    |    |    |     | 1,416              |

Hérons were probably under-represented by our sampling methods, since both species frequently nested solitarily or in very small, dispersed groups.

Total numbers of nesting attempts by various species are shown in Table 7. An estimated 8,090 nests were initiated in the entire area, 3,486 in WCA 3, 3,050 in ENP, and 1,416 in East Everglades.

Great Egrets, Tricolored Herons, Little Blue Herons, and Snowy Egrets appeared to have a normal distribution of nest initiation dates (see Figs. 5 - 8). White Ibises, however, started nesting much later than has been reported previously for this area during the spring season (see Fig. 9, and Kushlan 1974, 1977). Wood Storks at Cuthbert Lake also began nesting late (mid-February) compared to reported initiation dates in successful years (November through early January, Kushlan et al. 1975).

### Nesting Success

Five colonies failed completely (no young fledged of any species), 5 had heavy losses of one or more species, and 25 were successful (appreciable numbers of nests produced fledging young; see Tables 1-3). Complete failure was limited to colonies in the central part of ENP and to one late colony in East Everglades, though several other colonies in WCA 3 had heavy losses during the nesting period.

Eleven colonies were selected for detailed study of nesting success (Table 8). A total of 866 nests were marked and their fate monitored for all or part of the nesting cycle. These 866 nests represented 11.7% of all the nest initiations (excluding Cattle Egrets) in the area, and in general, are probably reliable indicators of nest success for the

Table 7

Estimated numbers of wading bird nesting attempts--all colonies studied.\*

| <u>Species</u>                | <u>Total number of<br/>nesting initiations</u> |
|-------------------------------|------------------------------------------------|
| Wood Storks                   | 275                                            |
| Great Egrets                  | 1,751                                          |
| White Ibis                    | 2,353                                          |
| Little Blue<br>Hérons         | 437                                            |
| Tricolored<br>Hérons          | 1,033                                          |
| Snowy Egrets                  | 1,319                                          |
| Unknown Small<br>Hérons       | 90                                             |
| Cattle Egrets                 | 688                                            |
| Great Blue<br>Hérons          | 48                                             |
| Black-Crowned<br>Night Herons | 66                                             |
| Glossy Ibis                   | 30                                             |
| Total                         | <u>8,090</u>                                   |

\*Highest estimates for all colonies were used--estimates are therefore generous.

# DATE OF NEST INITIATION

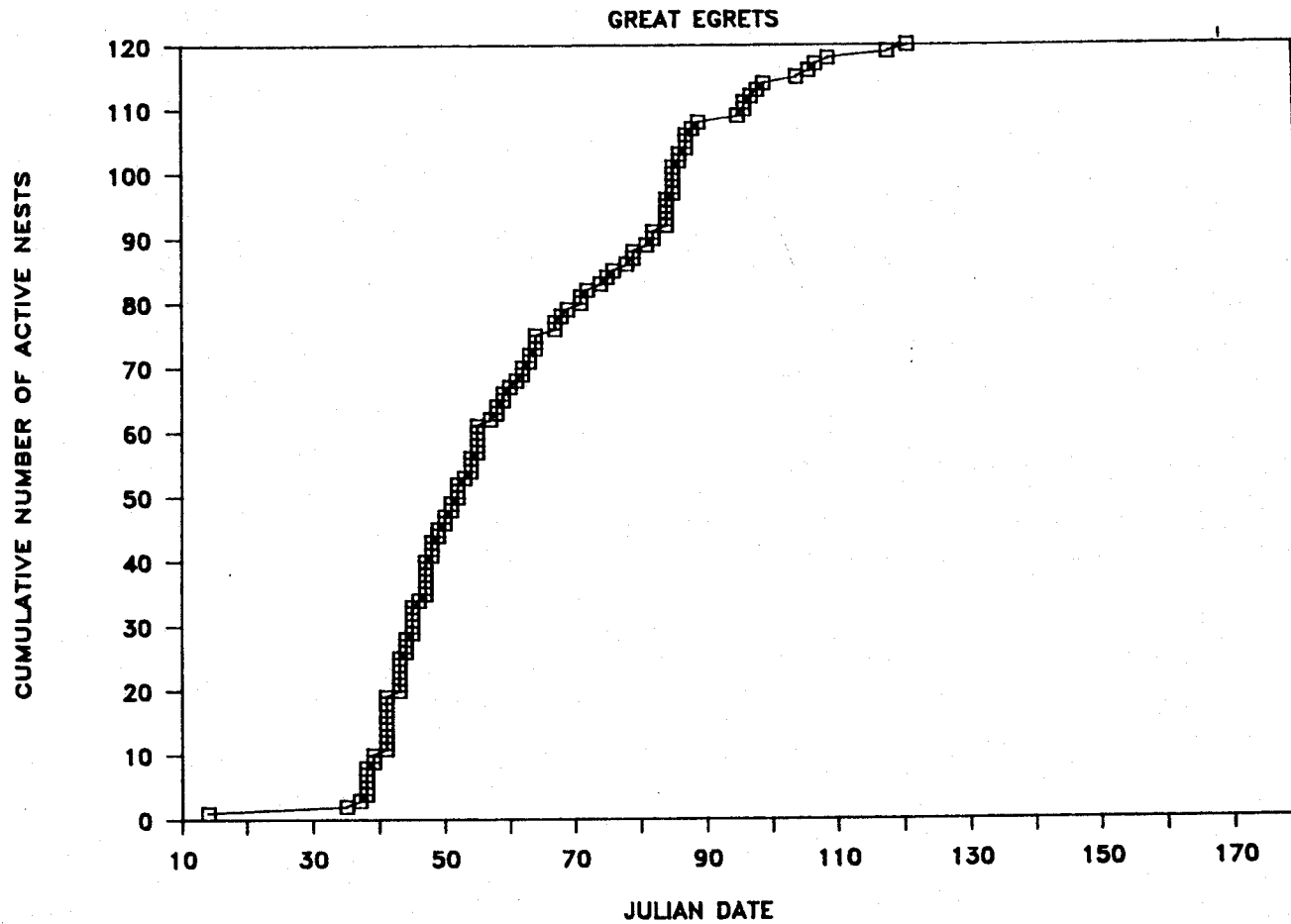


Figure 5. Date of Great Egret nest initiations (marked nests only).

# DATE OF NEST INITIATION

## TRICOLORED HERONS

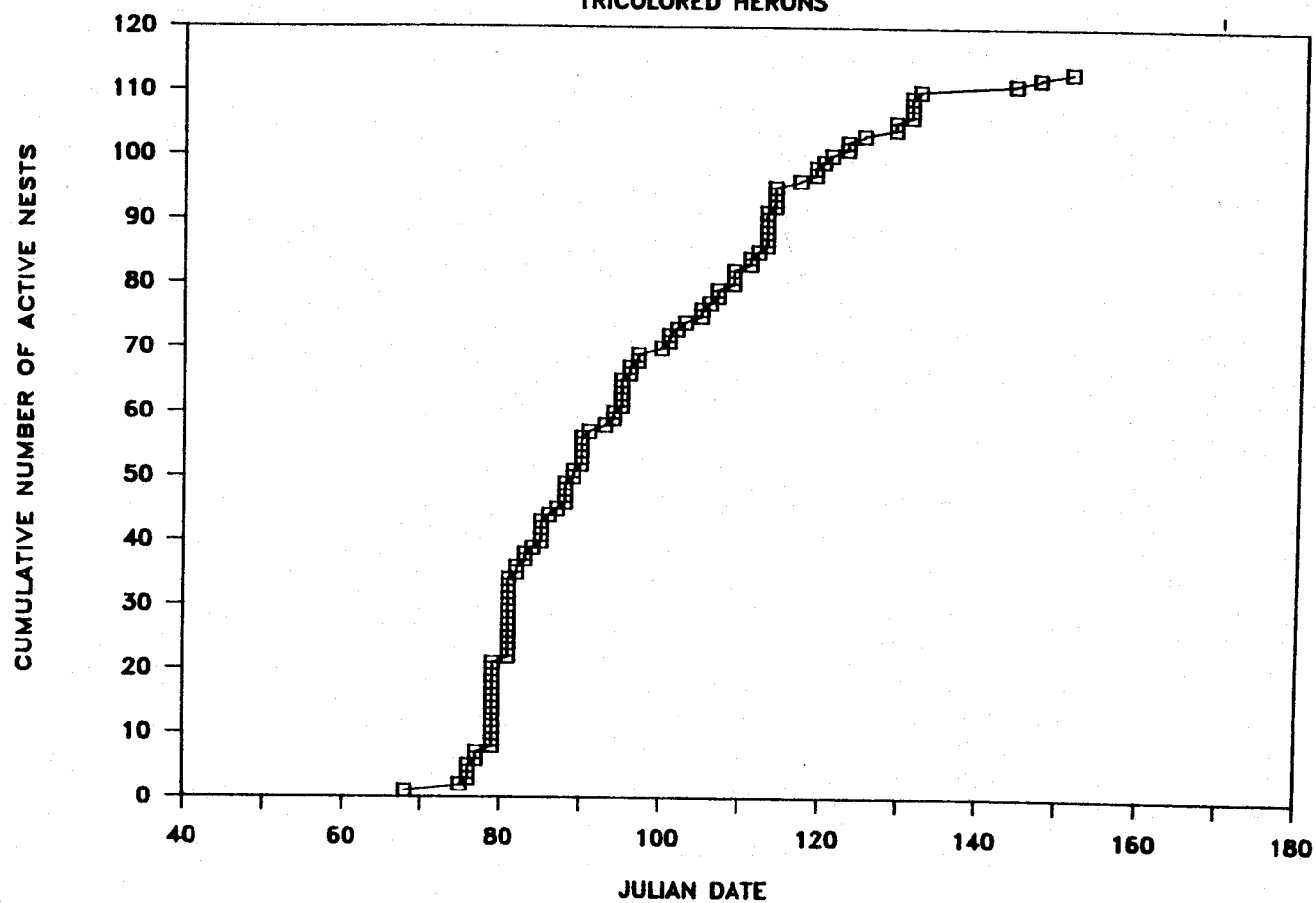


Figure 6. Date of Tricolored Heron nest initiations (marked nests only).

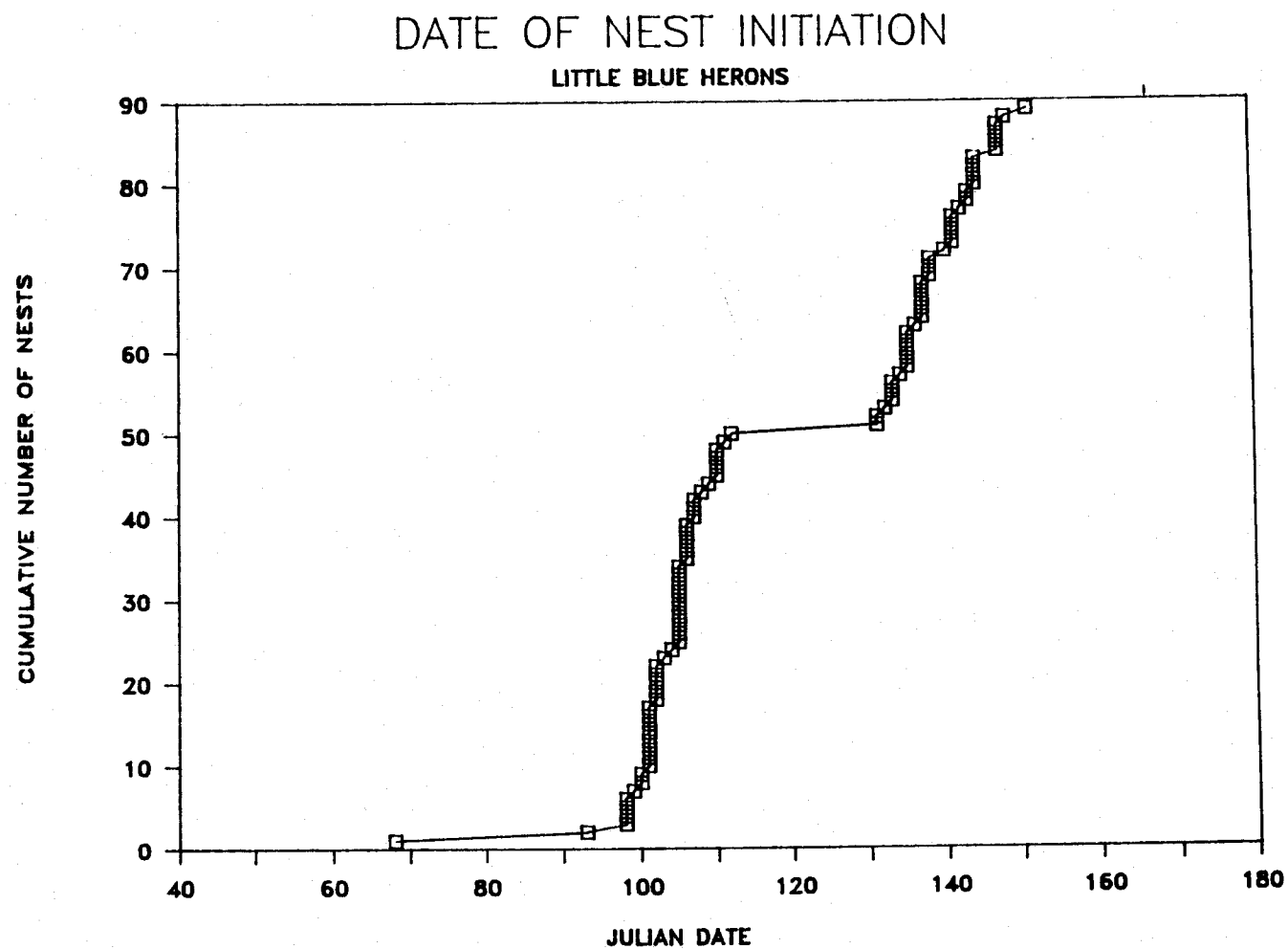


Figure 7. Date of Little Blue Heron nest initiations (marked nests only).

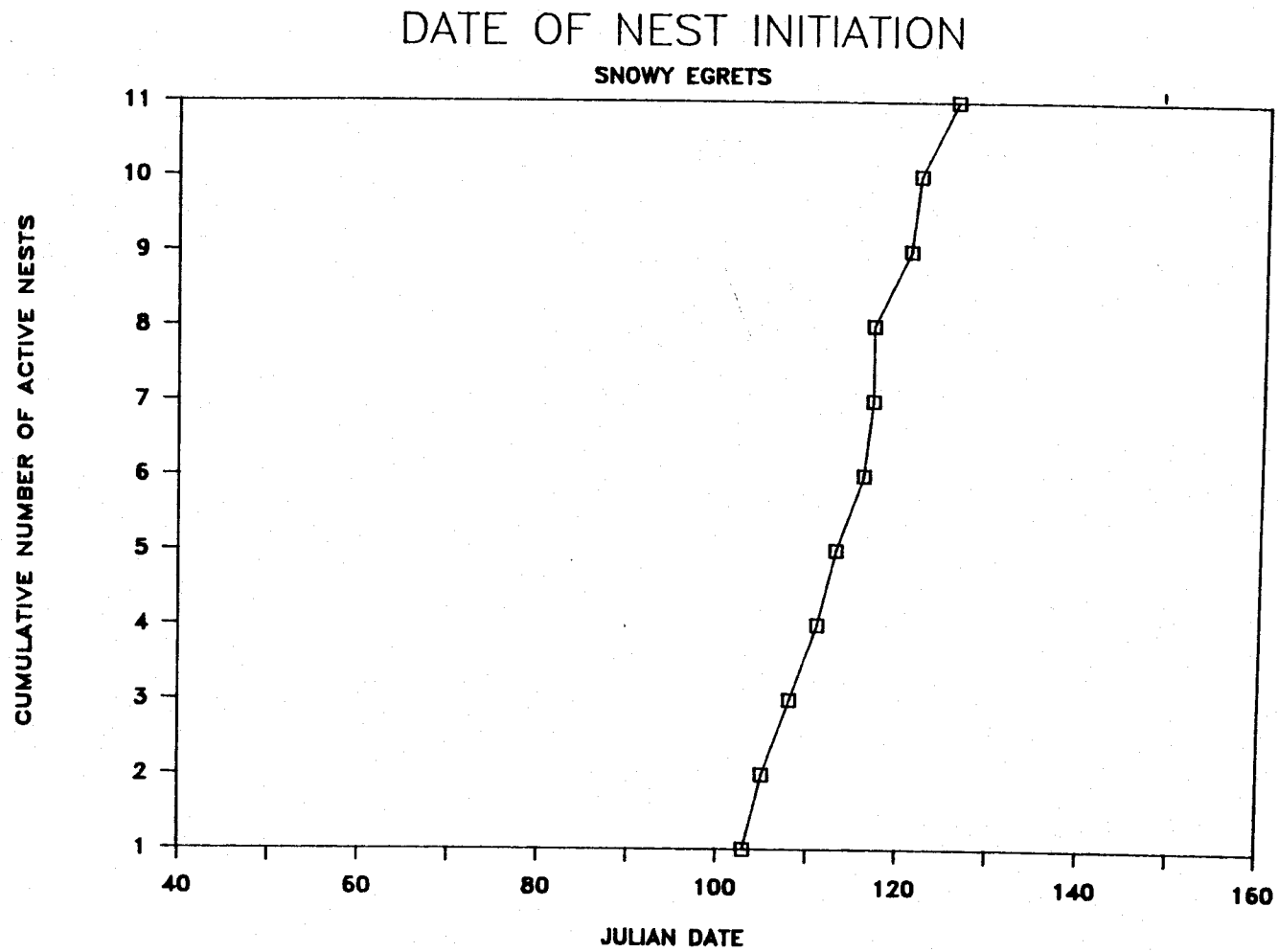


Figure 8. Date of Snowy Egret nest initiations (marked nests only).

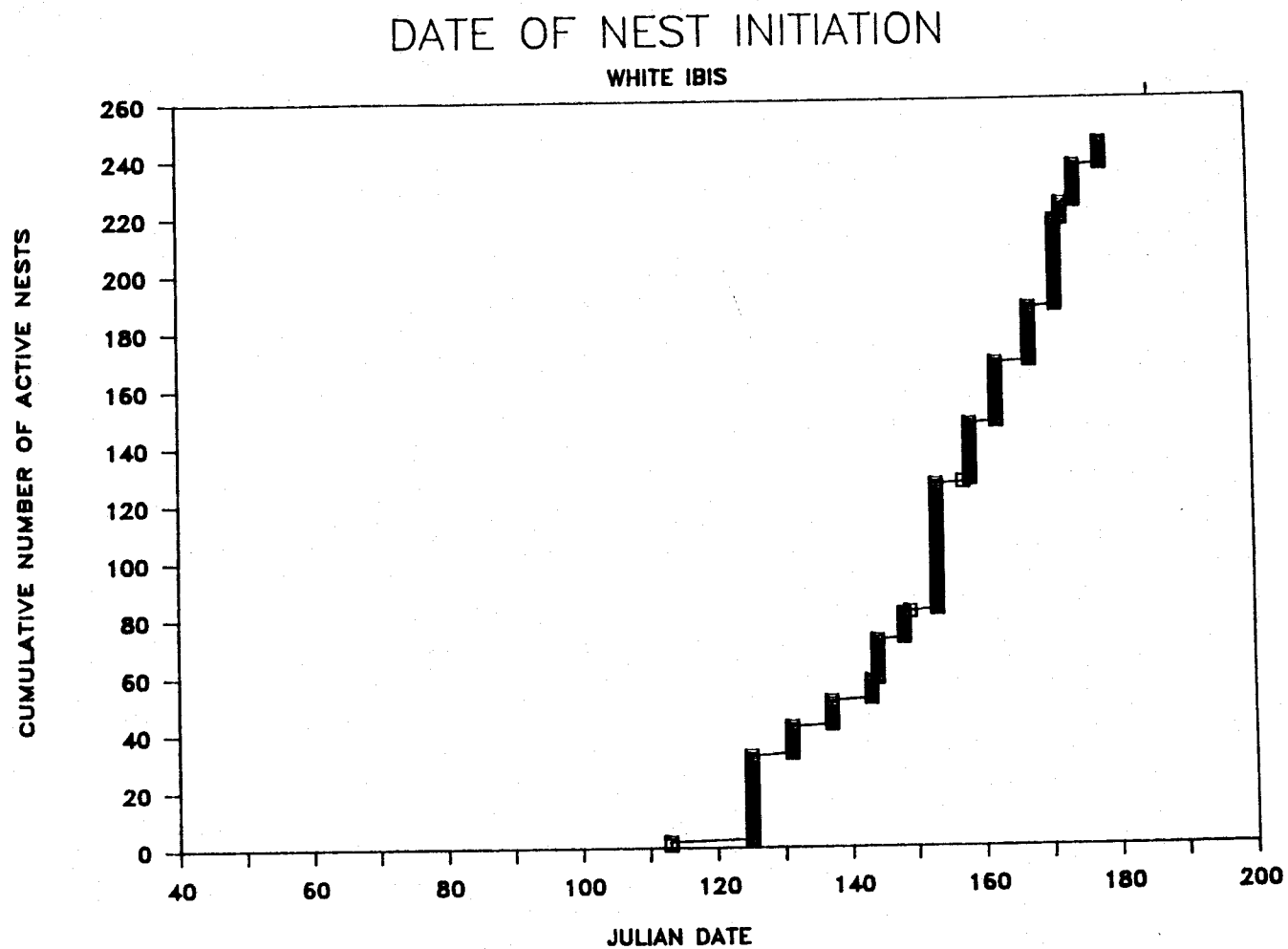


Figure 9. Date of White Ibis nest initiations (marked nests only).

Table 8 Species composition of nests marked for study, by colony.

| Colony                 | GE  | WI  | LB | TC  | SH | SN | NH | GLI | GB | GBA | TOTAL |
|------------------------|-----|-----|----|-----|----|----|----|-----|----|-----|-------|
| <u>ENP</u>             |     |     |    |     |    |    |    |     |    |     |       |
| Lost                   | 17  |     |    |     |    |    |    |     |    |     | 17    |
| Stix                   | 25  |     |    | 13  |    |    |    |     |    |     | 38    |
| Nick's                 | 22  |     |    | 51  |    |    |    |     |    | 1   | 73    |
| Total                  | 64  |     |    | 64  |    |    |    |     |    | 1   |       |
| <u>WCA 3</u>           |     |     |    |     |    |    |    |     |    |     |       |
| Andytown               | 61  |     |    |     | 1  |    |    |     | 1  |     | 63    |
| Big Melaleuca          | 18  | 110 |    |     | 1  |    | 3  |     | 1  |     | 113   |
| Alley North            | 17  | 84  | 3  | 53  | 22 | 15 | 24 | 10  |    |     | 228   |
| Frog City              | 35  |     | 1  | 26  | 10 |    |    |     |    |     | 72    |
| LBH                    |     |     | 51 | 9   | 11 |    |    |     |    | 1   | 72    |
| Mickey Mouse           |     |     | 44 | 6   | 3  |    |    |     |    | 3   | 56    |
| Total                  | 131 | 194 | 99 | 94  | 48 | 15 | 27 | 10  | 2  | 4   |       |
| <u>East Everglades</u> |     |     |    |     |    |    |    |     |    |     |       |
| East Everglades        | 13  |     |    | 15  | 33 |    |    |     |    |     | 61    |
| Coopertown Ibis        |     | 51  |    |     | 3  |    |    |     |    |     | 54    |
| Total                  | 13  | 51  |    | 15  | 36 |    |    |     |    |     |       |
| GRAND TOTAL            | 208 | 245 | 99 | 173 | 84 | 15 | 27 | 10  |    | 5   | 866   |

=10.84%  
of all nests in area

area (see exceptions at the end of this section).

Overall Mayfield nesting success estimates were derived from data collected at these 866 nests. Overall estimates (P) are expressed as the probability of any nest start surviving the entire nesting cycle (producing young of a given age). For instance, a P-value of 0.42 indicates that 42% of all nests are predicted to have survived the entire cycle. Alternatively, this figure also indicates that 58% of the nests failed at some point.

Mayfield nesting success estimates for all species studied are shown in Table 10. Species - specific clutch sizes and initiation dates for the study area are presented in Table 9; detailed summaries of nesting success, clutch sizes, and initiation dates for each colony are shown in Appendix 2.

Large differences in nesting success were apparent between WCA 3 and the central colonies of ENP. Tricolored Herons and Great Egrets had significantly different overall probabilities of nest survival in the two areas ( $Z = 12.636$ ,  $p < 0.001$  for Tricolored Herons;  $Z = 6.340$ ,  $p < 0.001$  for Great Egrets). These were the only species for which nesting success data was available in both areas.

Black-crowned Night-Herons nested in only a few colonies, but had very high nesting success ( $P = 1.00$ , no nests failed) where they did nest. The night-heron nests we studied were in colonies where other wading bird species had very poor nesting success due to heavy rains, egg predation, and abandonment (see Causes of Nest Failure). Night-herons are evidently not as susceptible as other species to these problems. In addition, they may benefit greatly from the nesting failure of surrounding birds, since night-herons are predatory and will

Table 9

Clutch size and clutch initiation dates of nests marked during nesting success study.

| Species           | <u>Clutch size</u> |           |        | <u>Initiation date*(Julian)</u> |           |       |
|-------------------|--------------------|-----------|--------|---------------------------------|-----------|-------|
|                   | N                  | $\bar{X}$ | S.D.   | N                               | $\bar{X}$ | S.D.  |
| GE-all colonies   | 208                | 2.54      | 0.6537 | 120                             | 63        | 21.28 |
| GE-ENP colonies   | 64                 | 2.40      | 0.719  | 27                              | 66        | 12.12 |
| GE-WCA 3 colonies | 131                | 2.63      | 0.605  | 87                              | 60        | 22.78 |
| TC-All colonies   | 174                | 2.973     | 0.9667 | 113                             | 97        | 18.40 |
| TC-ENP colonies   | 64                 | 2.844     | 0.8878 | 41                              | 83        | 4.54  |
| TC-WCA 3 colonies | 94                 | 3.053     | 1.0830 | 62                              | 107       | 19.16 |
| LBH               | 254                | 3.47      | 0.5896 | 89                              | 119       | 18.87 |
| SN                | 15                 | 2.60      | 1.451  | 11                              | 114       | 6.90  |
| GLI               | 10                 | 2.64      | 0.7714 | 7                               | 146       | 2.71  |
| WI                | 245                | 2.518     | 0.643  | 245                             | 153       | 18.94 |
| BCNH              | 27                 | 3.15      | 0.649  | 23                              | 112       | 5.53  |

\*Date first egg laid in nest.

Table 10

Estimated nest success and predicted productivity of fledged young  
for 7 wading bird species in the Everglades

| Species                                      | Overall* probability<br>of Nest Success (P) | Standard Deviation<br>of P | Total nest<br>in area | Predicted<br>number of<br>successful<br>nests in area |
|----------------------------------------------|---------------------------------------------|----------------------------|-----------------------|-------------------------------------------------------|
| Great Egret<br>(all colonies)                | 0.14795                                     | 0.025917                   | 1,751                 | **                                                    |
| Great Egret<br>(WCA 3 colonies)              | 0.4661                                      | 0.002172                   | 1,081                 | 503±2.35                                              |
| Great Egret<br>(ENP colonies)                | 0.0198                                      | 0.011231                   | 654                   | 13±7.30                                               |
| Tricolored Heron<br>(all colonies)           | 0.46131                                     | 0.038069                   | 1,033                 | **                                                    |
| Tricolored Heron<br>(WCA 3 colonies)         | 0.77780                                     | 0.041103                   | 350                   | 272±14.40                                             |
| Tricolored Heron<br>(ENP colonies)           | 0.11493                                     | 0.032589                   | 642                   | 14±20.92                                              |
| Little Blue Herons<br>(All colonies)         | 0.7284                                      | 0.044032                   | 437                   | **                                                    |
| Little Blue Herons<br>(ENP colonies)         | "                                           | "                          | 130                   | 95±5.72                                               |
| Little Blue Herons<br>(WCA 3 colonies)       | "                                           | "                          | 286                   | 208±12.59                                             |
| Black-Crowned Night<br>Hérons (all colonies) | 1.00000                                     | 0                          | 66                    | 66±0                                                  |
| White Ibis<br>(All colonies)                 | 0.02388                                     | 0.025732                   | 2,353                 | 56±60.54                                              |

Table 10  
(cont'd)

Estimated nest success and predicted productivity of fledged young  
for 7 wading bird species in the Everglades

| Species                         | Overall* probability<br>of Nest Success (P) | Standard Deviation<br>of P (sp) | Total nest<br>in area              | Predicted<br>number of<br>successful<br>nests in area |
|---------------------------------|---------------------------------------------|---------------------------------|------------------------------------|-------------------------------------------------------|
| White Ibis<br>(WCA 3 colonies)  | "                                           | "                               | 100                                | 2±2.57                                                |
| White Ibis<br>(ENP colonies)    | "                                           | "                               | 1,453                              | 34±37.39                                              |
| Glossy Ibis<br>(all colonies)   | 0.06528                                     | 0.061058                        | 30                                 | 2±1.83                                                |
| Snowy Egret<br>(All colonies)   | 0.71174                                     | 0.044032                        | 1,319                              | 938±58.08                                             |
| Snowy Egret<br>(ENP colonies)   | "                                           | "                               | 1,250                              | 890±55.04                                             |
| Snowy Egret<br>(WCA 3 colonies) | "                                           | "                               | 69                                 | 49±3.04                                               |
|                                 |                                             |                                 | Total estimated<br>Successful Nest | <u>2,167</u><br>(29.3% of all<br>nests successful)    |

\* See Appendix 1

\*\* Where estimates of P from the 2 areas are different, total number of  
successful nests in entire area is sum of predicted numbers of successful  
nests in WCA 3 and in ENP.

scavenge abandoned nest contents.

White Ibises had very poor nesting success in all three large colonies that were initiated. In addition, White Ibises are reported to have had very poor nesting success at the East River colony in ENP (T. Bancroft, pers. comm.).

Other reproductive success estimates varied from the rather low success of Great Egrets ( $P = 0.148$ ), to the very successful Little Blue Herons ( $P = 0.728$ ) and Snowy Egrets ( $0.712$ ). Little Blue Heron nest success estimates are derived from a large sample of nests (22.7% of all nest starts in the area were marked) and the estimates are probably representative. Only 15 Snowy Egret nests were marked, and all were in the northern part of WCA 3. The vast majority of Snowy Egrets nested in Rodgers River Bay colony in ENP, and their nesting success was not measured. Differences in local feeding habitat and weather between the Rodgers River colony and the Alley North colony probably make the Snowy Egret nest success estimates inapplicable to the Rodgers River Bay colony.

Sample sizes of the more dispersed nesting species were too small to make inference reliable. Only two Great Blue Heron nests were marked, and only five Green-backed Heron nests were marked. Although these species may nest commonly in the Everglades, their nesting success is probably not accurately reflected by the estimates given in Appendix 2.

Because large within-species differences in nesting success occurred within our study areas, it is probably inaccurate to apply our nesting success figures to the coastal mangrove colonies in ENP. In the past, coastal colonies in ENP had normal breeding success in years when the

inland colonies failed (W. Robertson, pers. comm., Kushlan 1977). Thus the application of nesting success figures derived from inland colonies to the coastal colonies (Table 10) is likely to give a conservative estimate of their production.

- With this in mind, we estimated the numbers of successful nests by multiplying numbers of nest starts within an area by the overall estimates of nest success (Table 10). Where possible, nesting success estimates from different areas were applied only to nests in those areas. The 7,402 nest starts (excluding Cattle Egrets) are predicted to have resulted in 2,167 nests that fledged some young. This results in an overall success rate of 29.3% for the entire Everglades.

Nesting success of Wood Storks at the Cuthbert colony was not monitored by marking nests. The number of nests was repeatedly counted from aircraft during the nesting season by us, by ENP research staff, and by National Audubon Society Research staff. We visited the colony on May 29 using a canoe, and counted the fledglings. Using these estimates, 275 nesting starts produced approximately 160 young (0.58 young/nest). This estimate is conservative, since some young had already fledged and may have been away from the colony at the time of the survey.

The larger Corkscrew Swamp rookery (700 pairs) underwent a major abandonment late in the season, and had less than 20 successful nests. Consequently the Cuthbert colony, though marginal in size and nesting success, probably was the only colony that produced appreciable numbers of young in South Florida this year.

### Causes of Nesting Failure

Most nest and colony failures could not be attributed to a single cause with certainty; however, the coincidence of hydrologic and meteorologic events with nest or colony failures sometimes provided circumstantial evidence supporting one or several causes (Table 11).

Onset of summer rains - Mass abandonments at Coopertown Ibis, Big Melaleuca, and sections of Alley North colony coincided with the onset of torrential rains and associated water level rise in late May and early June (Fig. 10). Abandonment apparently was the primary cause of nest failure at these colonies. Though a few nests were disturbed by scavengers, the majority had cold undisturbed clutches or moribund and dead young in them. Violent weather associated with thunderstorms may have been an important cause of these abandonments, as several nests in each of those colonies were partially dismantled or blown down. Nestlings found alive were usually drenched and shivering. Alternatively, the associated water level increases (see Fig. 10) could have been the cue for abandonment (see Water Level, below). At all three colonies, water levels surrounding the colony changed from a few centimeters to over 30 cm within two weeks. By late June, there were no areas shallow enough for ibises or small herons to forage within the boundaries of WCA 3.

In any event, it is impossible to separate the effects of these factors at the three colonies. Abandonments at Big Melaleuca and Coopertown Ibis, and heavy losses at Alley North colonies were probably due to a combination of several detrimental factors associated with prolonged heavy rains.

Although heavy rains are characteristic of the onset of the rainy season in South Florida (MacVicar 1981), the 1986 rains were heavier

Table 11 Factors associated with heavy losses of nests/nestlings

| Colony              | Predation | Severe<br>Weather | Low<br>Water | Sharp Water level<br>increases |                  | Mosquitoes |
|---------------------|-----------|-------------------|--------------|--------------------------------|------------------|------------|
|                     |           |                   |              | Summer<br>rains                | Winter<br>storms |            |
| Andytown (L)        | X         |                   |              |                                | X                |            |
| Alley North (L)     |           |                   |              | X                              |                  |            |
| East Everglades (A) |           | X                 | X            |                                |                  |            |
| Lost (A)            |           | X                 | X            |                                | X                |            |
| Panther Mound (A)   |           | X                 | X            |                                | X                |            |
| Stix ? (L)          |           |                   | X            |                                |                  |            |
| Nick's ? (A)        |           | X                 | X            |                                |                  |            |
| Big Mel (Ibis) (A)  | X         | X                 |              | X                              |                  |            |
| Big Mel (Egret) (L) |           | X                 |              |                                | X                |            |
| Coopertown Ibis (A) |           | X                 |              | X                              |                  |            |
| Lane River          |           |                   |              | X                              |                  | X          |

\* L= heavy losses of nests  
A= complete abandonment

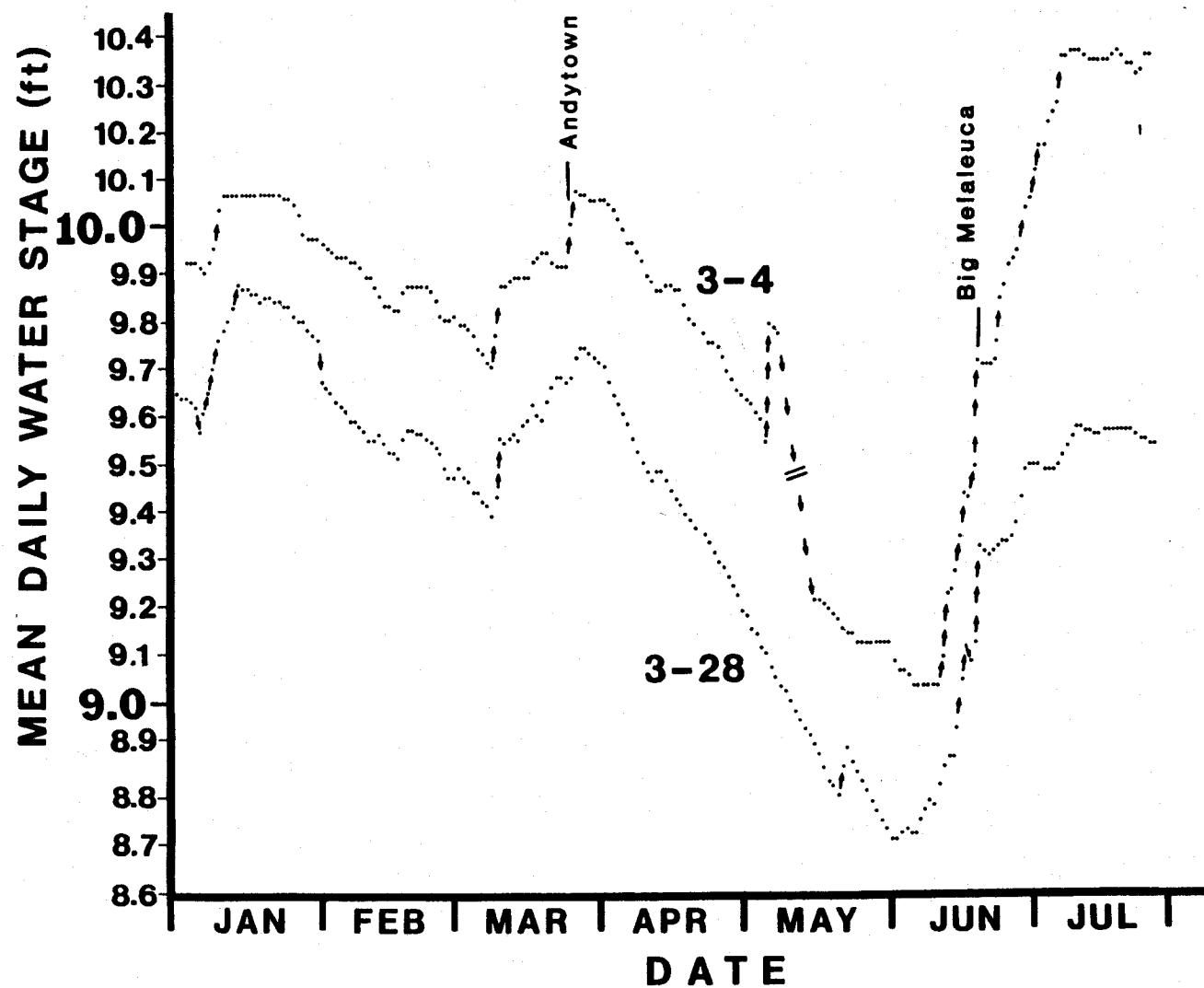


Figure 10. Water level in feet above mean sea level at water stations 3-4 and 3-28. Dates of abandonments at Andytown and Big Melaleuca colonies are shown.

than usual in June. In WCA 3, June rainfall was 34% greater than the 20-year average at water recording station 3-4 (MacVicar 1981). In ENP, June rainfall was 40.9% greater than the 36-year mean at the Tamiami Trail Ranger Station, 77.0% greater than a similar mean at the Everglades City station, and 116.2% greater than the 6-year mean at the Oasis Ranger Station (data from ENP Research Department).

Severe weather - At East Everglades colony, a complete abandonment of Tricolored Herons with eggs and Great Egrets with eggs and young occurred two days after one of the earliest, particularly severe thunderstorms of the rainy season (May 12). Unlike the abandonments at Alley North, Big Melaleuca, and Coopertown Ibis, the East Everglades abandonment was not associated with a sharp increase in local water levels. This severe storm was therefore implicated as a cause of the abandonments. Although some nests were destroyed, most were intact. Strangely, no eggs or young (or remains) were found in or near the nest, suggesting they had been completely eaten or scavenged. Thus the abandonment remains enigmatic. It could have been caused either by complete abandonment due to a single, severe storm or predation and complete scavenging of the contents of every nest.

Water level - Abandonments coincided with sharp increases in local water level at Stix, Nick's, Andytown, Big Melaleuca, Coopertown Ibis, and Alley North colonies. (Figs. 10, 11). As stated earlier, abandonments at the latter three also coincided with severe winds and wet season thunderstorms. At Andytown, Stix, and Nick's colonies, the abandonments were much earlier in the season, and the water level increases were due to periods of winter rain. Although these

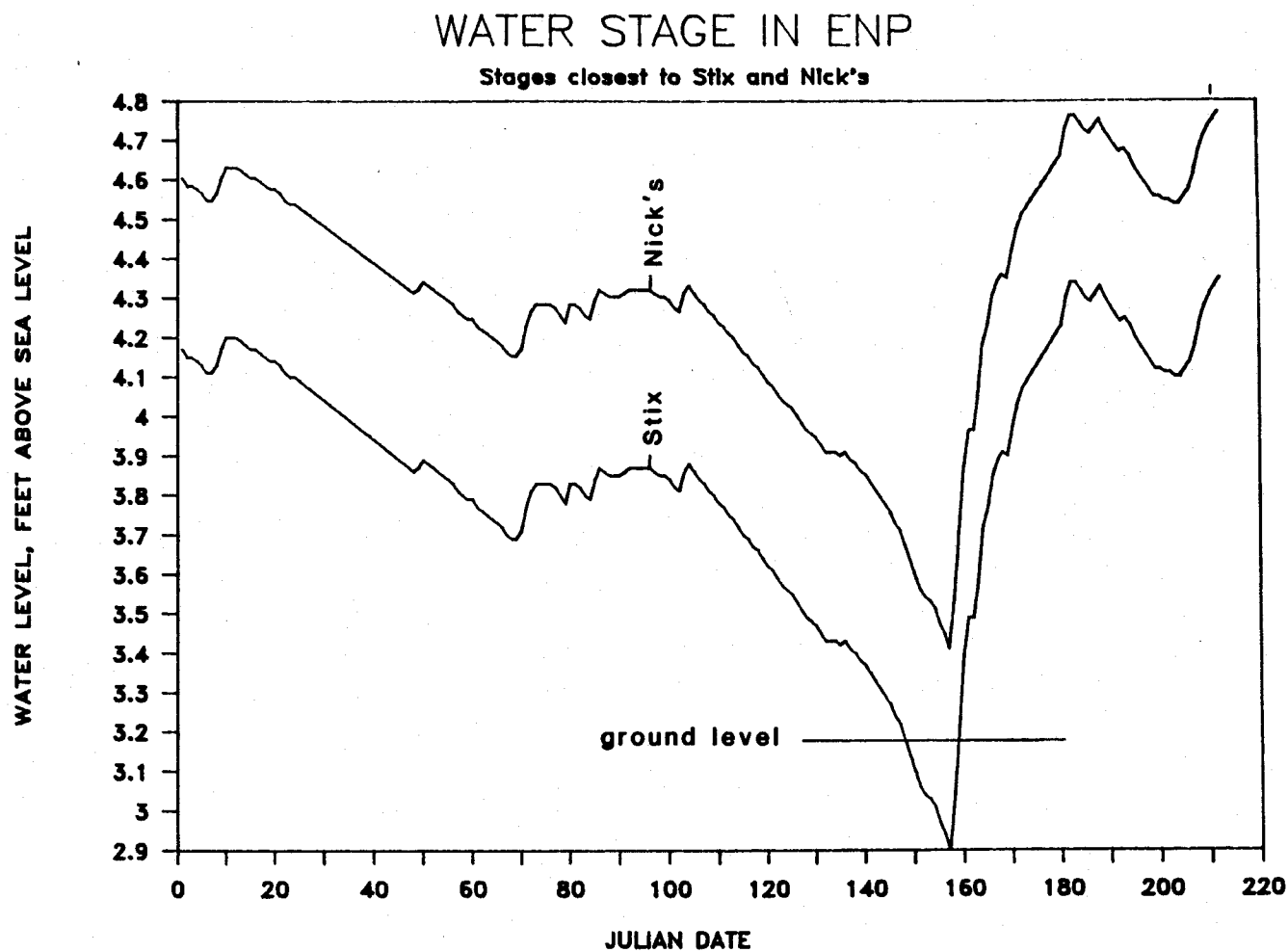


Figure 11. Water levels at recording stations closest to Stix and Nick's colonies in ENP, showing dates of abandonments.

abandonments could have been cued by the associated inclement weather, these three colonies endured several short frontal systems before and after the heavy losses that included high winds, a drop in temperature and some rain, but little water level rise. As shown below (see Predation), predation at these three colonies was probably not a significant cause of abandonments. Thus the rise in water level is a likely candidate as the cause of those abandonments.

In contrast, abandonments at Lost and Panther Mound colonies did not coincide with sharp increases in water level (Fig. 12). In fact, these colonies were abandoned at a time of steadily decreasing local water levels. The cause of abandonments at these latter two ENP colonies cannot be attributed to sharply rising water, although decreasing water levels remain a possible factor.

Predation - Predation rarely can be identified as a source of nest loss, since predation prior to abandonment is impossible to distinguish from post-abandonment scavenging. In the case of the late season losses at Alley North colony, and abandonments of Big Melaleuca and Coopertown Ibis colonies, predation was clearly not the cause. Abandoned nests at these locations still contained undisturbed clutches and uneaten young. At Stix and Nick's colonies many eggs were found broken and eaten in nests. In the majority of those cases, however, the eggs were pecked open, implying avian rather than mammalian predation. Boat-tailed Grackles (Quiscalus major) were the only avian predators seen at these colonies and probably were responsible. Grackles are opportunistic scavengers that are probably incapable of frightening adult herons off their nests; this suggests the eggs at Stix and Nick's colonies were

# WATER STAGE IN ENP

Lost and Panther Mound Colonies

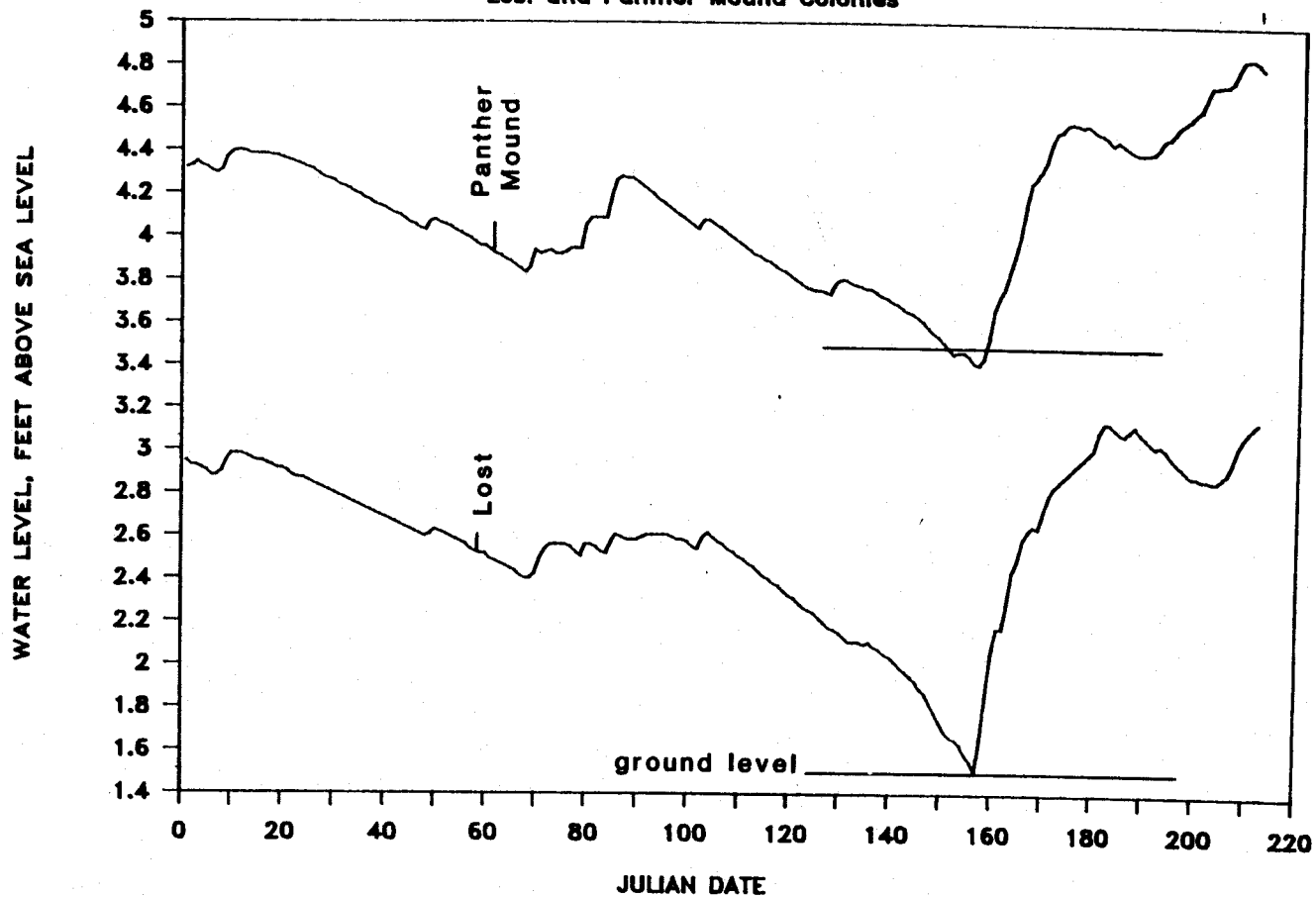


Figure 12. Water levels at recording stations closest to Lost and Panther Mound colonies, showing dates of abandonments.

scavenged and that the abandonments were not caused by egg predators.

Abandonments at Lost and Panther Mound colonies could not be attributed to water level fluctuations or prey population decreases (see Prey Abundance). Complete abandonment of these colonies was noted during aerial surveys, and nests were not examined following the abandonments. Mammalian predation therefore remains a possible cause of abandonment at these colonies.

At the Andytown colony, nest abandonments occurred shortly following partial or complete loss of clutches. These losses probably were not due to mammalian predators, since 3 areas in the colony that we baited with sardines and broken chicken eggs failed to show any tracks. Three of six dummy nests containing chicken eggs, however, were eaten by some avian predator (again, probably grackles). Predation of eggs by snakes remains a possibility in all colonies. Nest abandonments at Andytown probably were due to causes other than predation (see Water Level).

Mammalian predation may have been significant at Big Melaleuca colony during late-season ibis nesting. In 14 nests, finely broken eggshells were found, implying mammalian predation or scavenging. Predation was not the cause of the somewhat later abandonments during heavy June rains, since at that time, most abandoned nests had undisturbed clutches and broods.

Prey abundance - No abandonments could be linked exclusively to a decrease in prey abundance. At the time of the abandonments at Stix and Nick's colonies, prey populations in north-central Shark Slough showed no strong decrease in density or biomass (W. Loftus, pers. comm.). Unfortunately, this was the only part of the study area where prey sampling was being carried out in 1986, and similar inferences about

other areas within the Everglades are not applicable.

At the time of the late-season losses at Alley North colony, young ibises apparently were undergoing a switch in diet. Prior to the heavy rains, they were eating predominantly crayfish, as evidenced by casts and feces. During the period of abandonments, casts and feces became very watery and dark brown, suggesting a switch to predaceous diving beetles or amphibians (Kushlan 1974). This switch could be easily explained by water level increase alone, since ibises probably were forced to forage in new locations as water levels rose. In that case, prey availability rather than prey abundance is the changing variable, and probably should be considered a direct effect of water level fluctuations rather than an effect of the dynamics of prey populations.

#### Foraging Dispersion

A total of 226 birds were followed from 7 different colonies to feeding locations (Table 12, Figs. 13 - 16). In most cases, these foraging birds were followed singly, but a few large flocks also were followed. Foraging distances ranged from a few hundred meters to 28 kilometers. The majority of flights followed (64.6%) were from the Alley North colony, because it was the by far the largest colony. Because of the difficulty of keeping dark-colored birds in sight, only white-plumaged birds were followed. Since the sampling method was random with respect to white-colored species, the species composition of birds followed is probably representative of the white-plumaged birds foraging from the colonies. The most common birds followed were Great Egrets (45.5%).

Birds foraging from the Alley North colony were followed throughout

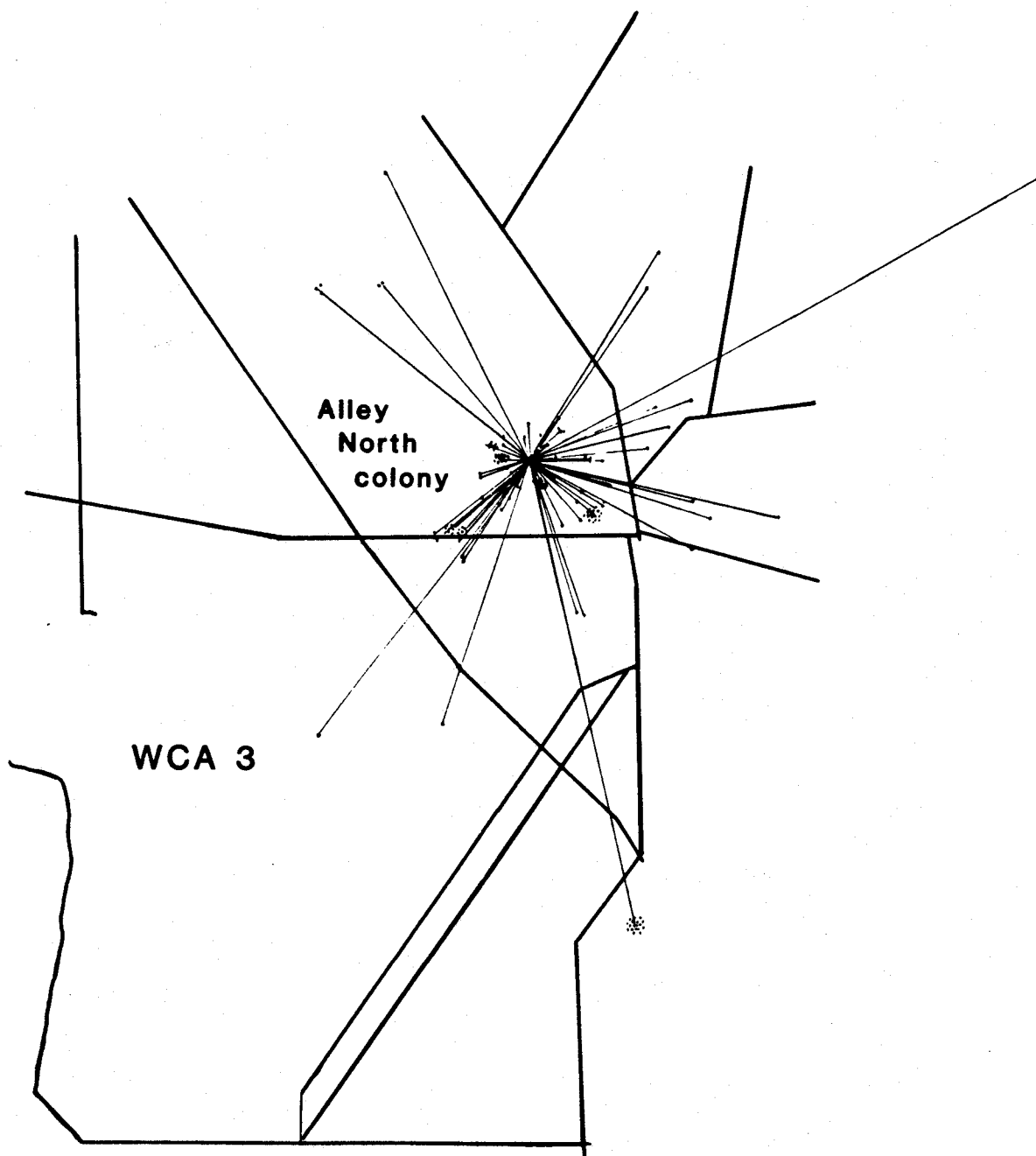
Table 12

Summary of foraging flights from all colonies studied

| Colony                         | Species | Number of flights followed | Mean distance to foraging site ( $\pm$ S.D.)* | Mean flight time (minutes $\pm$ S.D.) |
|--------------------------------|---------|----------------------------|-----------------------------------------------|---------------------------------------|
| Alley North                    | GE      | 49                         | 3.72(3.130)                                   | 9.84( $\pm$ 9.663)                    |
|                                | WI      | 85                         | 7.18(4.286)                                   | 30.58(14.036)                         |
|                                | SN      | 7                          | 7.61(4.364)                                   | 22.08(15.945)                         |
|                                | All     | 146                        | 5.92(4.284)                                   | 22.66(16.038)                         |
| Andytown                       | GE      | 5                          | 4.75(3.892)                                   | 20.32( $\pm$ 11.729)                  |
| Big Melaleuca                  | GE      | 2                          | 2.85(0.85)                                    |                                       |
|                                | WI      | 6                          | 15.88(1.913)                                  | 41.94(4.947)                          |
|                                | All     | 8                          | 12.63(5.898)                                  | 41.94(4.947)                          |
| Frog City                      | GE      | 31                         | 1.383(0.848)                                  | 4.31(2.700)                           |
| East Everglades                | GE      | 1                          | 9.70                                          | 25.75                                 |
| Stix and Nick's                | GE      | 14                         | 2.12(2.016)                                   | 7.57(6.217)                           |
| Cuthbert Lake<br>8.623(12.976) | WS      | 13                         | 2.138(2.9103)                                 |                                       |
| TOTAL                          |         | 354                        |                                               |                                       |

\*Nautical miles

Figure 13. Map of foraging flights followed from Alley North colony. Dense dotting indicates birds followed landed in dense foraging aggregations.



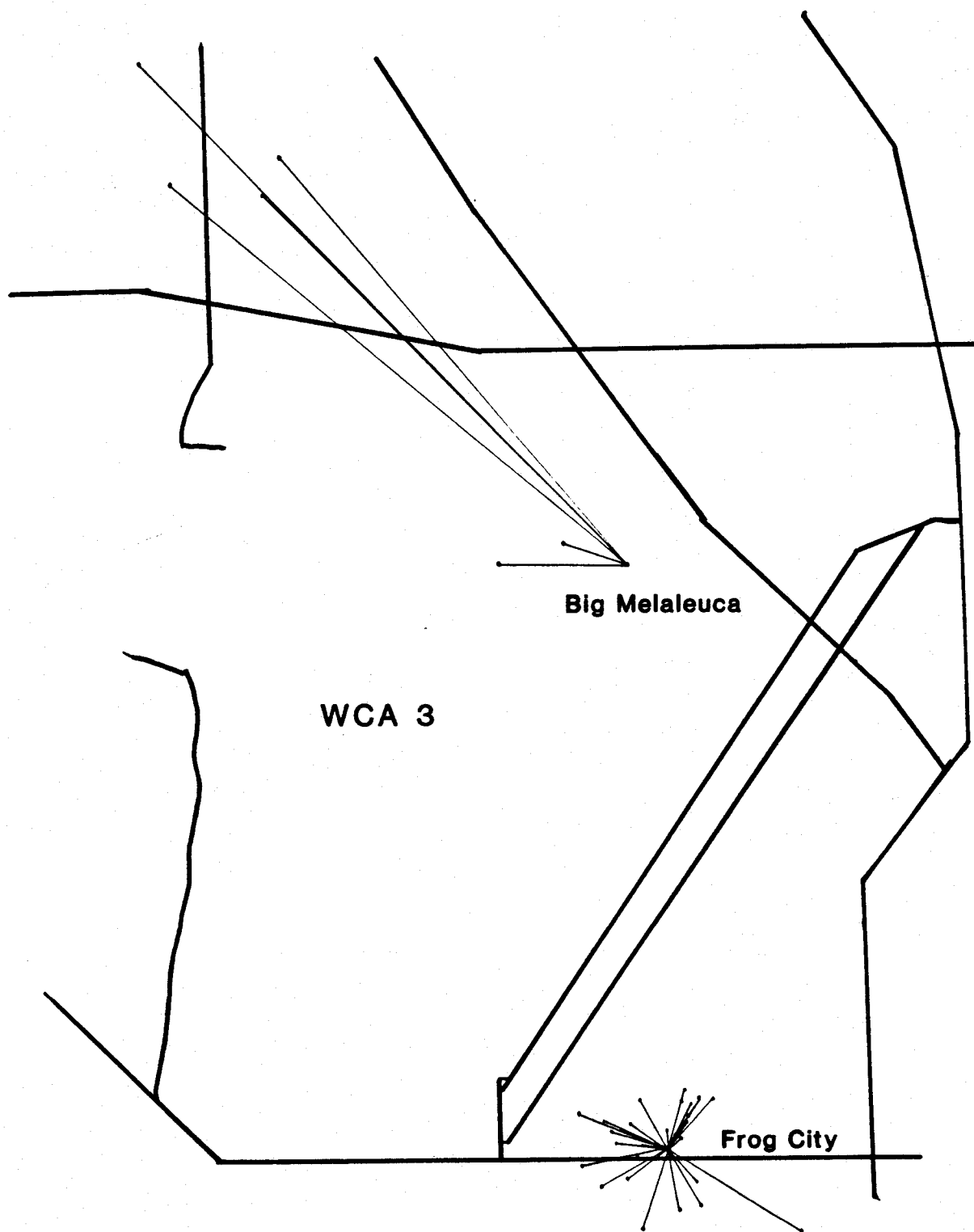
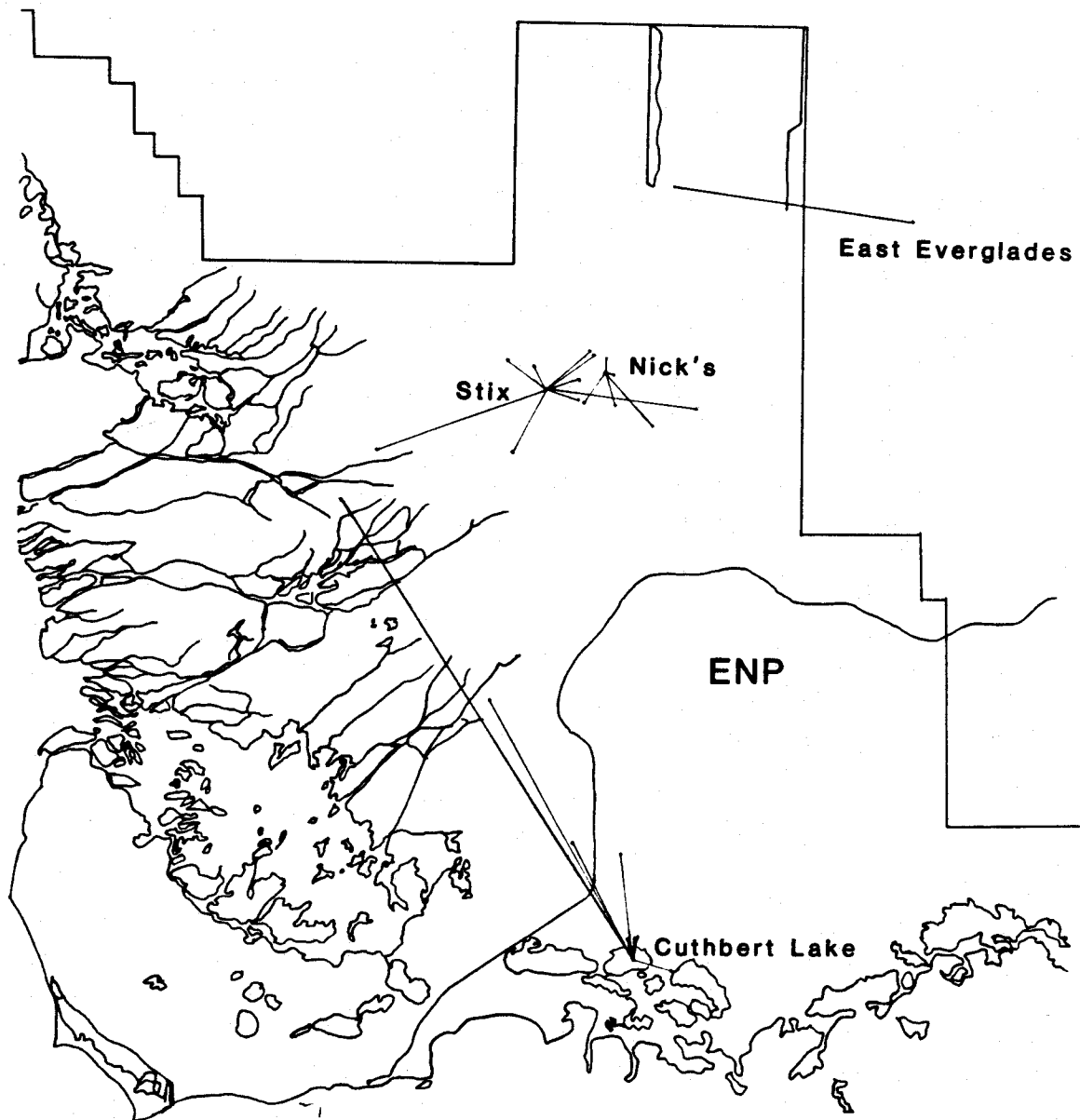


Figure 14. Map of foraging flights followed from Big Melaleuca and Frog City colonies.

Figure 15. Map of foraging flights followed from three colonies in ENP, and one colony in East Everglades.



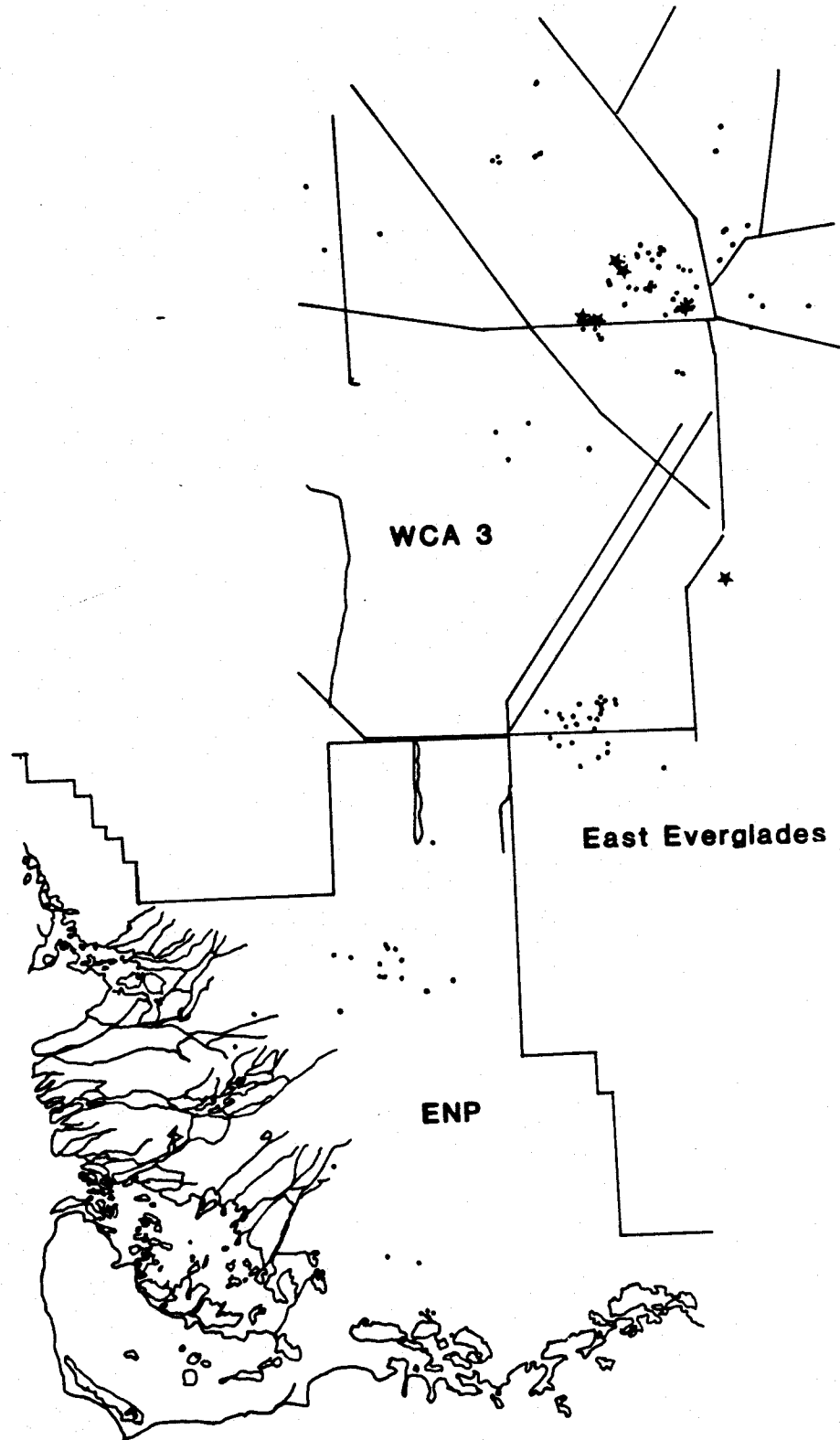


Figure 16. Foraging locations of birds followed from all colonies.

the latter part of the nesting cycle at that colony (see Fig. 17). Until the onset of summer rains, most birds were feeding close to the colony, often in huge feeding aggregations ( $> 500$  birds) within 2 km. The location of these aggregations are indicated in Fig. 13. Aggregations were found in open Eleocharis sloughs or in short sawgrass, and usually included White Ibises, Glossy Ibises, Great Egrets, Tricolored Herons, Little Blue Herons, Snowy Egrets, and Great Blue Herons. No direct observations were made on feeding behavior, but feces and casts of nestling Great Egrets and White Ibises in the Alley North colony contained predominantly crayfish parts. Great Egret nestlings also regurgitated small to medium-sized fishes on several occasions. Nestling Tricolored Herons and Snowy Egrets frequently regurgitated partially digested small fishes, but rarely crayfish. This suggests both crayfish and small fishes were an important part of the diet of nestlings, and that they were abundant in the feeding locations close to the colony.

Birds foraging from Alley North colony also flew long distances, predominantly to the northeast, east, and southeast. Five birds were followed to the northwest, but only 2 went more than 2 km to the west or southwest. This probably reflects the pattern of drying water in the northern part of WCA 3; most of the areas to the west and southwest of the colony were dry and unsuitable for foraging during much of the Alley North nesting cycle. It is notable that WCA 2A and 2B were important feeding sites for birds from the Alley North colony (Fig. 13). A few dense feeding aggregations were seen in WCA 2A and 2b, but not nearly as many as were found near the colony.

Only 8 birds were followed from Big Melaleuca colony (Fig. 14). Two

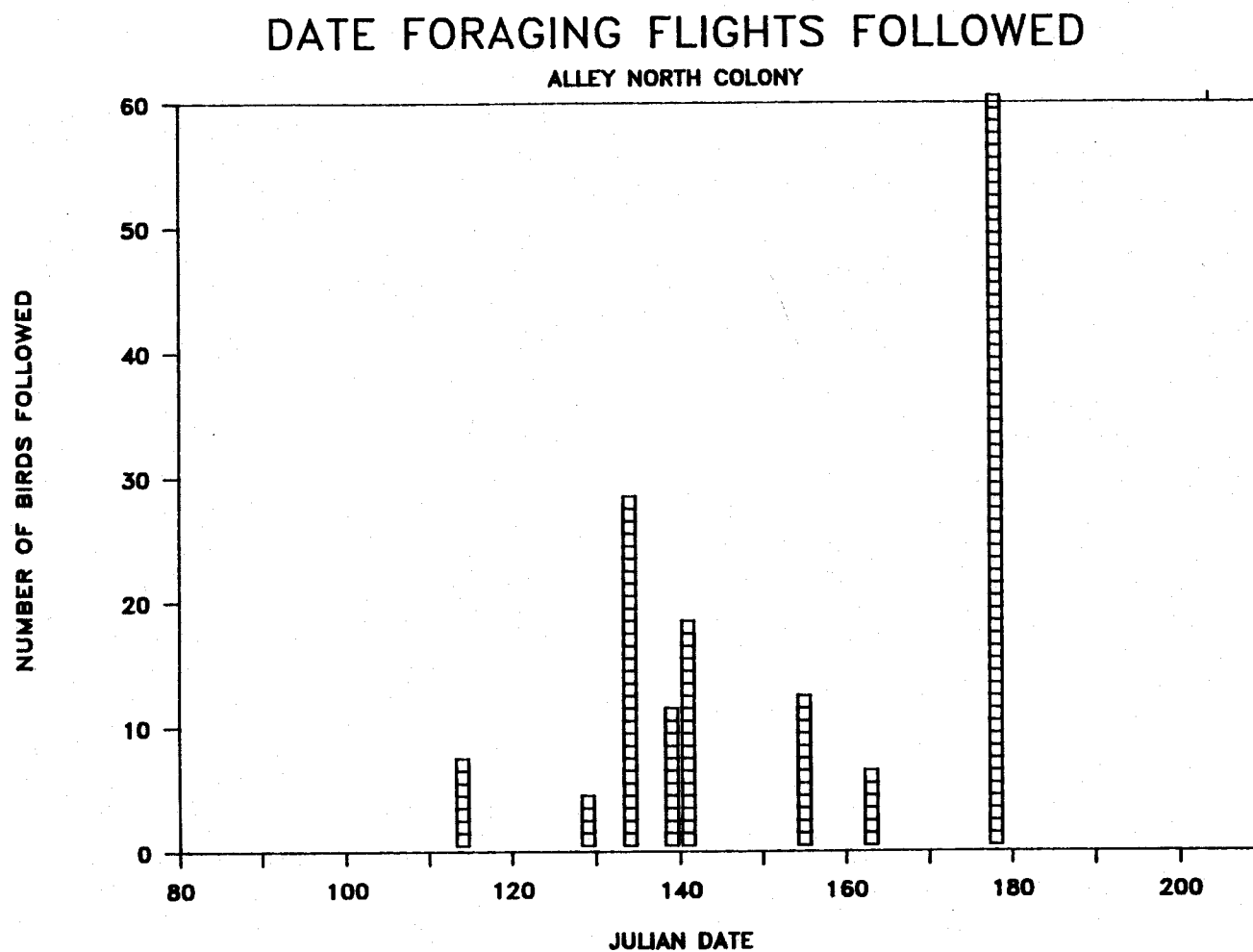


Figure 17. Dates of all foraging flights followed from Alley North colony.

Great Egrets were followed early in the season (1 April) and went fairly short distances to the west. Though this was a very small sample, many other Great Egrets were noted traveling in the same direction from the colony. Collectively, these observations suggest that Great Egrets were foraging relatively close to the Big Melaleuca colony ( $< 4$  km) at that time. The other 6 birds were White Ibises and were followed much later in the season (2 July), during the time that the colony was being abandoned. These birds all flew over 20 km to a flooded cowpasture outside WCA 3 to the northwest. At this time, water in the majority of the Water Conservation Areas was too deep for foraging; the long distances that the ibises had to fly to obtain food might have caused the abandonments at Big Melaleuca.

All birds followed from Frog City colony were Great Egrets. The distribution of these flights in the season is shown in Fig. 18. All of these birds foraged at locations close to the colony ( $< 3.5$  km, mean = 2.25 km) in WCA 3b and in the East Everglades area, and the locations were fairly evenly distributed in all directions from the colony (Fig. 14). Nearly all regurgitations by nestling Great Egrets in the Frog City colony were boluses of small fishes.

Fourteen birds (all Great Egrets) were followed from Stix and Nick's colonies (Fig. 15). Foraging flight data from these two colonies were pooled, since they were so close together (3.2 km) and nearly synchronous. All the foraging flights followed were from 2 April to 14 April, the period when both colonies abandoned. Great Egrets foraged relatively close to the colonies (mean = 3.4 km), and in nearly all directions. At the time that these flights were followed, there also were large feeding aggregations of Great Egrets, Snowy Egrets, White

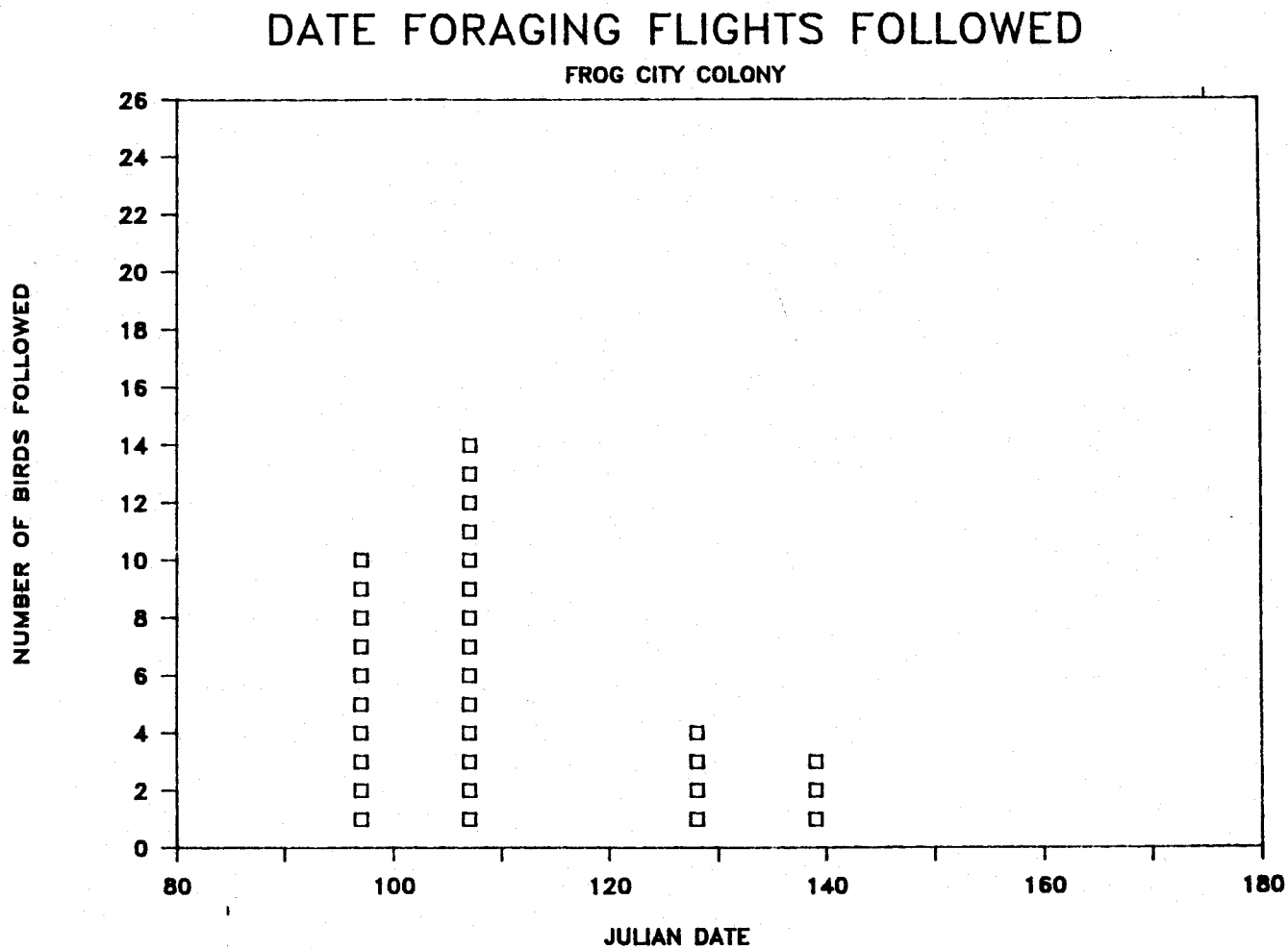


Figure 18. Dates of all foraging flights followed from Frog City colony.

Ibises, and White Pelicans (Pelicanus erythrorhynchos) detected in shallow pools near the headwaters of the Broad and Harney rivers, and Rookery Branch; however, only one Great Egret followed from Stix and Nick's colonies foraged there. The fact that birds from these colonies were not traveling long distances from the colony to feed suggests that food sources near the colony were adequate at the time of the abandonments.

From the Cuthbert Lake colony, 13 Wood Storks were followed to the first location where they landed (Fig. 15); however, this included five birds that flew the short distance ( $< 0.5$  km) from the colony to the mainland and landed in trees, apparently waiting for strong updrafts to form. In addition, we had to abandon six foraging flights after at least 30 minutes of flight time because the aircraft became low on fuel. These flights were not included in the data set and the sample of followed birds is therefore somewhat biased towards short flights.

No Tricolored Herons or Little Blue Herons were followed on foraging flights because of their dark plumage. Both species nested in numerous small, sometimes monospecific colonies on the west side of WCA 3. The abundance of colonies and good nesting success they experienced suggest that foraging and nesting conditions there were excellent for both species. Observations in LBH colony indicated Little Blue Herons there were feeding heavily on both grass shrimp (Palaemonetes sp.) and frogs. The preponderance of these items in boluses regurgitated by young suggested that these were important food items. Though frogs could have been obtained from a variety of locations, the grass shrimp are likely to have come only from ponds or from the nearby L-28 canal (W. Loftus, G. Powell, pers. comm.).

The west side of WCA 3 was the shallowest, and in many places nearly dry for several weeks of the season. Large groups of foraging Great Blue Herons, Great Egrets, White Ibises, and Snowy Egrets were seen from the air during March and April in the area just south of the short westward leg of L-28. This suggests the west side of WCA 3A did have an effective drydown, which concentrated prey enough to attract wading bird foraging aggregations, and to initiate successful nesting.

## DISCUSSION AND CONCLUSIONS

### Nesting Population and Nesting Success

In 1986, nesting of wading birds in the Everglades can unambiguously be-classified as poor. Compared with population estimates made in the 1930's, most wading bird species are currently reduced by one to two orders of magnitude (Kushlan and Robertson 1974, Ogden 1978, Kushlan and Frohring 1986). The total number of nest initiations (8,090) is less than one quarter of the number estimated in the 1974-1975 season by Kushlan and White (1977). Some species are proportionally more reduced than others by comparison with earlier studies.

During the late 1950's, when Wood Stork populations probably were still healthy, Everglades National Park was estimated to have supported a maximum of 1,900 nesting pairs (Kushlan and Frohring 1986). The 275 pairs that nested in ENP in 1986 is less than 15% of the former estimate and very similar to a "poor" year during the period of sharp population decline from 1967 to 1981 (Kushlan and Frohring 1986). The fact that the one Everglades colony in 1986 was successful is only mildly encouraging, since their nesting success was marginal. The 0.58 nestlings per nest start was quite low compared to the 2.25 per nest reported by Kahl (1964) for the south Florida area, and the 2.7 reported for the Birdsville, Georgia colony in 1986 (M. Coulter, pers. comm).

In 1986, breeding White Ibises were reduced drastically in number by comparison with even recent estimates. Kushlan (1977) reported that 24,712 and 26,600 pairs of White Ibises nested in the Everglades in 1972 and 1973, respectively. These probably were particularly good years for ibis nesting. A more moderate year for White Ibis nesting occurred in

1974-1975, with a reported 11,924 nests in the Everglades (Kushlan and White 1977). The 2,353 pairs that nested in 1986 is therefore less than 10% of the numbers attracted in a good year, and less than 20% of the numbers reported in a moderate year. Nesting success for White Ibises in 1986 also was the lowest for any of the species monitored. Only 56 White Ibis nests are predicted to have fledged any young this year. Effectively, 1986 may have been far less productive than previous years when even half the number of nests were initiated (1971, see Kushlan 1977).

The egrets and herons were in general better off than the storks and ibises. The 1,751 Great Egret nest initiations in 1986 were over 60% of the number (2,898) reported for the 1975 season (Kushlan and White 1977). Great Egrets in 1986 had poor nesting success (14.8%) however, with only an estimated 516 nests fledging any young.

Tricolored heron nest initiations were less than 36% of the 2,901 nests reported by Kushlan and White (1977) for 1975. Their nesting success overall (46%) was average, but significantly higher within WCA 3 colonies (77.8%).

Using Kushlan and White's (1977) estimates, over 80% more Little Blue Herons nested in 1986 than did in 1975, though this species often nests in monospecific colonies that are difficult to identify from the air. Kushlan and White's (1977) survey flights were not flown as frequently as ours, and they probably would not have discovered as many colonies in the fledging stage as we did. Similarly, they did not survey as much of WCA 3 on the ground as we did. Consequently, this year's Little Blue Heron estimates are probably not applicable to any previous work. Little Blue Heron nesting success was surprisingly high (72.8%), even

though many of the colonies monitored endured the same rains that were catastrophic to species at other colonies. Little Blue Herons evidently are not as susceptible to rising water levels, high winds or heavy rainfall as other species.

- Snowy Egret nest initiations were less than one third of those estimated for 1975. Where they were monitored in northern WCA 3, they showed good nesting success (71%); however, the vast majority of the Snowy Egrets nested in Rodgers River Bay colony, a coastal island where feeding choices and weather may have been very different from the central Everglades. Thus the grasslands of the Everglades did not attract very many Snowy Egrets, and nothing is known about the nesting success of the majority of the Snowy Egrets in 1986.

There is little comparative data for Great Blue Herons, Green-backed Herons, and Black-crowned Night-Herons. Kushlan and White (1977) noted these species where they were found in ground visits, but indicate their methods did not allow estimation of the numbers of these dispersed nesters. It is surprising, however, that Black-crowned Night-Herons were such successful (100%,  $n = 66$  nests) nesters; they endured the same conditions that caused thousands of White Ibises to abandon.

Factors leading to this poor nesting season are difficult to identify with certainty. Two general questions can be asked. Why did so few birds attempt to nest in the entire area? And, why were nest initiations and nesting success particularly low in the central grasslands of ENP?

The most difficult questions have to do with the low number of nesting starts, but there are several possible interpretations. The majority of the nesting population may have discovered good nesting

conditions in other parts of the Southeast and gone to nest there regardless of the conditions in the Everglades. For example, both White Ibises and Wood Storks began extensive nesting range expansions, particularly in the past 20 years (Ogden 1978, Frederick in press). Though Wood Storks seem to have fairly strong breeding site fidelity, most wading birds are opportunistic nesters (Kushlan 1974, 1977, Rudegeair 1975) and probably can be expected to respond to good nesting conditions in the Everglades. This requires, of course, that the birds are in the area at some stage of migration or dispersal to assess the local conditions. A current ENP research project is monitoring numbers of wading birds in ENP and WCA 3 throughout the year, and should provide data to address this latter issue.

If large numbers of wading birds were present during this past winter and early spring, then they probably did not nest in the Everglades either because conditions were poor there or because conditions were better elsewhere. Because the Southeast experienced the worst drought on record in 1986, it is doubtful that other locations in the region had particularly good breeding conditions. This suggests then, that the low number of nest initiations were the result of poor nesting conditions in the Everglades.

Wading birds probably use water levels as criteria for nest initiation (Kahl 1964, Kushlan et al. 1975) and even small increases in water level during the dry season can cause abandonment. Rainy weather and associated water level increases occurred in January, February, and March in ENP (Figures 10 and 11). This late winter/early spring period is when many wading birds usually initiate nesting (Kushlan et al. 1975, Kushlan 1974); it is possible the weather and/or water level

fluctuations at this time caused wintering wading birds to nest elsewhere. The evidence, however, is inconclusive.

Only about 300 nests of any wading bird species were initiated in the central grasslands of ENP. This figure is two orders of magnitude lower than the number found in a good year in the 1970's (Kushlan 1977, Kushlan and White 1975). Further, it is one order of magnitude lower than the number nesting in WCA 3 in 1986. Nesting success of birds that bred in ENP was significantly lower than that of the same species nesting in WCA 3. In addition, 4 of the 7 colonies in the ENP grasslands abandoned completely, while no complete abandonments occurred in WCA 3. It is unclear why so few birds settled in ENP or why they had such poor nesting success.

The abandonments in ENP could not be attributed to a decrease in prey populations, and in several cases, predation also could be ruled out as a cause. Weather events at the time of the abandonments were probably quite similar at the ENP colonies and the unabandoned southern WCA 3 colonies.

Water depths, however, were quite different. Water depths in ENP were generally much lower than in WCA 3 throughout the nesting season. During the dry season (January 1 through May 21), Panther Mound in ENP had a mean water depth (ground elevations subtracted from heights above mean sea level) that was 30.97 cm lower than the mean near the center of WCA 3 (station 3-4). In addition, most of ENP had no surface water for a portion of the dry season (at least 12 days at Panther Mound). This general difference in water levels may explain why numbers of nest initiations and nesting success was so different in the two areas. Again, the circumstances did not allow a conclusive test of this

hypothesis.

### Foraging Dispersion

The fact that wading birds are consistently feeding in a given site indicates that the site is probably an adequate food source for the species present; however, it does not necessarily indicate that the site is optimal in either a relative or absolute sense. In fact, it may take a large sample of feeding locations to determine the requirements for a particular species, since wading birds cannot instantaneously assess feeding quality over a large area.

Data from the Alley North colony are probably the only quantitatively accurate sample collected thus far. The results indicate that the area within 4 km of the colony was very attractive as feeding habitat to nearly all species of birds from the colony. Indeed, the colony probably formed in that area because of the adjacent feeding habitat. Additionally, WCA 2A and 2B also were frequently used by breeders at the Alley North colony. Though birds foraging in other areas of the Everglades usually fed at the edges of Eleocharis sloughs, foraging areas near Alley North often were in short sawgrass.

Data from the Frog City colony did not constitute as large a sample, but similarly indicated that foraging conditions near that colony were attractive for a long part of the nesting period. All other colonies had such small sample sizes that drawing useful conclusions is not possible.

Finally, it was evident from the concentration and good nesting success of Little Blue and Tricolored Heron colonies on the west side of WCA 3A that feeding and nesting conditions there were adequate for the

species.

#### Future Work

During the 1987 field season all aspects of research will follow the protocol described in this report, so that results of the two seasons can be compared. We also plan to collect additional types of data to more completely describe the conditions necessary for nesting success.

Water Levels - It is unclear exactly what kinds of changes in water levels lead to abandonment of nests and colonies. As evidenced by this year's results, sharp increases often are associated with abandonment. Do wading birds also require minimum water levels beneath nests to successfully nest? If so, is this requirement constant throughout the nest cycle or time of year? The analyses of these questions from the 1986 data are severely hampered by the lack of precise water level information at each colony. Though water levels can be estimated from existing recording stations, those stations are relatively far apart, and there probably is unacceptable error associated with the estimation (Probst and Rosendahl 1981). To alleviate this problem, we will install water staff gauges in and near all colonies to determine absolute water depths at the colonies. Repeated reading of these gauges will give precise information for each colony in 1987, and will permit the development of predictive equations for each of those sites from the nearest permanent water station. The ability to accurately predict small changes in water level from permanent gauging stations could be very useful for many other studies in the Everglades in the future. In addition, staff gauges have already been installed at the colonies found in 1986, and will be repeatedly read during the 1987 season. This will

eventually allow more precise back-estimation of water levels at those colonies for specific dates in 1986, from the records of permanent water gauging stations.

Predation - In an effort to better define the role of predation in nest failure, baiting stations will be established near all colonies found in 1987. This should allow the identification of the tracks of mammalian predators in the immediate area. We plan to avoid attracting predators to the colonies by placing baiting stations at least 0.5 km from colonies. We also plan to cover the bottoms of a portion of the nest-tree trunks in each colony with a sticky substance to obtain tracks of predators climbing those trees. This will allow a more direct identification of predators climbing the trees, and will be the only way to identify snake predation. Thus mammalian and reptilian predators will be identified by tracks, and avian predators will be identified by process of elimination, and occasionally by evidence in the nest. Assuming grackles are the only avian predators around most colonies, avian predation will be taken as a sign of scavenging. These methods should allow far more opportunity to identify predation as a source of nest failure, and distinguish it from post-abandonment scavenging.

Finally, we plan to continue ongoing communication with other complementary studies in the Everglades region. The National Audubon Society Research Center is conducting a study of nesting success and foraging dispersion of herons in the Lane River colony in ENP. Tom Bancroft and his colleagues have agreed to collect nesting success data using the same methods we have used; this will allow direct comparisons of factors affecting nesting success in coastal mangrove colonies with those in the central grasslands. Furthermore, the N.A.S. research staff

have been determining foraging locations of breeders at the Lane River colony by radio telemetry of marked birds, and may begin similar work at colonies that we are monitoring in the central grasslands in 1987. In addition to our planned foraging dispersion study, this cooperation could add tremendously to our knowledge of foraging locations of wading birds in the central grasslands.

The distribution of foraging wading birds currently is being monitored throughout the year by systematic reconnaissance flights (a joint effort involving ENP, South Florida Water Management District, and Florida Game and Freshwater Fish Commission). The results of that study will reveal the numbers of wading birds in all areas of the Everglades during the pre-nesting season. This information will help determine whether a substantial proportion of wintering birds are leaving the area to nest (implying nesting conditions are unsuitable at the time of nest initiation) or whether the current depauperate nesting population is the direct result of a depauperate wintering population (implying current nesting conditions were adequate). Taken collectively, the results of these studies have vastly increased potential for identifying the conditions responsible for fluctuations in nesting numbers and nesting success in the Everglades.

### LITERATURE CITED

- Allen, R.P. 1964. Our only native stork, the Wood Ibis. Natl. Geogr. Mag. 125:294-306
- Ankney, C.D., and C.D. MacInnes. 1978. Nutrient reserves and reproductive performance of female Lesser Snow Geese. Auk 95:459-471.
- Bent, A.C. 1926. Life histories of North American marsh birds. U.S. Nat. Mus. Bull. #135.
- Bildstein, K.L. 1984. Age-related differences in the foraging behavior of White Ibises and the question of deferred maturity. Col. Waterbirds 7:146-148.
- Black, B.B., M.W. Collopy, H.F. Percival, A.A. Tiller and P.G. Bohall. 1984. Effects of low level military training flights on wading bird colonies in Florida. Florida Coop. Fish and Wildlife Res. Unit, School Forest Resources and Conservation, University of Florida. Technical report #7.
- Browder, J.A. 1976. Water, wetlands and Wood Storks in southwest Florida. Ph.D. dissertation. Univ. Florida, Gainesville, Florida.
- Browder, J.A. 1978. A modeling study of water, wetlands, and Wood Storks. In: A. Sprunt, IV, J.C. Ogden, and S. Winckler, (eds.). Wading Birds. National Audubon Soc. Res. Rep. 7: 325-346.
- Christy, R.L., K.L. Bildstein, and P. DeCoursey. 1981. A preliminary analysis of energy flow in a South Carolina salt marsh: wading birds. Col. Waterbirds 4:96-103.
- Custer, T.W. and R.G. Osborn. 1978. Feeding-site description of three heron species near Beaufort, North Carolina. In: A. Sprunt, IV, J.C. Ogden, and S. Winckler, (eds.). Wading Birds. National Audubon Soc. Res. Rep. 7: 355-360.
- Frederick, P.C. (in press). Chronic tidally-induced nest failure in a colony of White Ibises (Eudocimus albus). Condor.
- Fujioka, M. 1985. Food delivery and sibling competition in experimentally even-aged broods of the cattle egret. Behav. Ecol. Socio. 17: 67-74.
- Hancock, J., and J.A. Kushlan. 1984. The herons handbook. Harper and Row, New York.
- Hensler, G.L. 1985. Estimation and comparison of functions of daily nest survival probabilities using the Mayfield method. Pages 289-301 in BJT Morgan and P.M. North, (eds.) Statistics in

- Ornithology. Springer - Verlag, NYNY, 418 pg.
- Hensler, G.L., and J.D. Nichols. 1981. The Mayfield method of estimating nesting success: A model, estimators, and simulation results. *Wilson Bulletin* 93:42-53.
- Jenni, D.A. 1969. A study of the ecology of four species of herons during the breeding season at Lake Alice, Alachua County, Florida. *Ecol. Monogr.* 39:245-270.
- Kahl, M.P. 1964. Food ecology of the Wood Stork (Mycteria americana). *Ecol. Monogr.* 34: 97-117.
- Kushlan, J.A. 1974. The ecology of the White Ibis in southern Florida: a regional study. Ph.D. dissertation, University of Miami, Coral Gables, Florida.
- Kushlan, J.A. 1976a. Wading bird predation in a seasonally fluctuating pond. *Auk* 93:464-476.
- Kushlan, J.A. 1976b. Feeding behavior of North American herons. *Auk* 93:86-94.
- Kushlan, J.A. 1977. Population energetics of the American White Ibis. *Auk* 94: 114-122.
- Kushlan, J.A., and P.C. Frohring. 1986. The history of the southern Florida Wood Stork population. *Wilson Bull.* 98:368-386.
- Kushlan, J.A., J.C. Ogden, and A.L. Tilmant. 1975. Relation of water level and fish availability to Wood Stork reproduction in the southern Everglades, Florida. U.S. Geological Survey Open File Report 75-434.
- Kushlan, J.A., and D.A. White. 1977. Nesting wading bird populations in Southern Florida. *Fl. Scientist* 40:65-72.
- Lack, D. 1968. Ecological adaptations fro freeing in birds. London, Methuen and Co., Ltd.
- MacVicar, T.K. 1983. Rainfall averages and selected extremes for Central and South Florida. South Florida Water Management District Technical Publication 83-2.
- Mayfield, H.F. 1961. Nesting success calculated from exposure. *Wilson Bull.* 73:255-261.
- Mayfield, H.F. 1975. Suggestions for calculating nest success. *Wilson Bull.* 87:456-466.
- O'Connor, R.J. 1978. Brood reduction in birds: selection for fratricide, infanticide, and suicide? *Anim. Behav.* 26: 79-96
- Ogden, J.C. 1978. Recent population trends of colonial wading

birds on the Atlantic and Gulf coastal plains. In: A. Sprunt IV, J.C. Ogden and S. Wincker, (eds.). Wading Birds. Nat. Audubon Soc. Res. Report 7:135-153.

Palmer, R.S. 1962. Handbook of North American Birds, Vol. 1. Yale Univ. Press, New Haven.

Probst, R.J. and P.C. Rosendahl. 1981. Shark Slough water level - correlation analysis. Technical Report T-618. National Park Service, South Florida Research Center, Everglades National Park.

Robertson, W.B., and J.A. Kushlan. 1974. The southern Florida avifauna. Miami Geological Soc. Mem. 2:414-452.

Rudegeair, T.J. 1975. The reproductive behavior and ecology of the White Ibis (Eudocimus albus). Ph.D. dissertation, University of Florida, Gainesville, Florida.

Shields, M.A. 1985. An analysis of Fish Crow predation on eggs of the White Ibis at Battery Island, North Carolina. M.S. thesis, University of North Carolina, Wilmington.

Shields, M.A., and J. Parnell. 1986. Fish Crow predation on eggs of the White Ibis at Battery Island, North Carolina. Auk 103:531-539.

Sprunt, A., IV and M.P. Kahl. 1960. Mysterious Mycteria: our American stork. Audubon 62:206-209, 234, 252.

Werschkul, D.F. 1979. Nestling mortality and the adaptive significance of early locomotion in the Little Blue Heron. Auk 96:116-130.

Winckler, D.W. and J.R. Walters. 1983. The determination of clutch size in precocial birds. In: R.F. Johnston, (ed.). Current Ornithology 1 : 33-63.

Appendix 1: Formulae and definitions for calculating nesting success using the Mayfield method. Derivations for formulae are in Hensler and Nichols (1981), and Hensler (1985).

K = number of nests observed

Y = a random variable taking the value of 1 if the kth nest is successful

T = a random variable denoting the number of days the kth nest was observed until it succeeded or failed.

N = the number of unsuccessful nests ( $K - \sum Y$ )

E = the total exposure days ( $\sum T$ )

p = the daily survival rate

j = the number of days in the given nesting period (i.e. incubation, nestling, total, etc.)

Daily Survival Rate (p):

$$p = \frac{1 - \frac{N}{K}}{\sum T}$$

Variance of p (v):

$$v = \frac{p(1-p)}{KT}$$

Survival for period (pj):

$$p_j = (p)^j$$

Variance of pj (vj):

$$v_j = \frac{p(1-p)}{KT} (p^{j-1})^2$$

Overall Nesting Success (P):

$$P = (p_1)^{j_1} (p_2)^{j_2} (p_3)^{j_3} \dots (p_k)^{j_k}$$

Appendix 1: (Cont.)

Overall Variance of P (V):

For two periods:

$$V_2 = ( (pj_1)^2 vj_2 ) + ( (pj_2)^2 vj_1 ) + (vj_1 vj_2)$$

For three periods:

$$V_3 = ( (pj_1 pj_2)^2 vj_3 ) + ( (pj_3)^2 v_2 ) + (v_2 vj_3)$$

Note: Standard Deviations for each period or rate are simply

$$\sqrt{v} \quad \sqrt{vj} \quad \sqrt{V}$$

Formulae for deriving nestling success are the same as for nest success, (substituting nestlings for nests in all cases), except that survival estimates (p) must be grouped according to brood size (pb). When calculating overall survival,

$$P = (pb_1 N_1) + (pb_2 N_2) + \dots + (pb_k N_k)$$

Where  $N_1$  = number of young from broods of size 1.

Variance of P in this case is:

$$sP = ( (N_1)^2 vpb_1 ) + ( (N_2)^2 vpb_2 ) \dots + ( (N_k)^2 vpb_k )$$

(Hensler, pers. comm., and Nichols, pers. comm.)

Z-statistic used to test for statistical differences between nesting success estimates ( )::

$$Z = \frac{p_1 - p_2}{\sqrt{v_1 + v_2}}$$

Appendix 2Table 1White Ibis nesting success at Big  
Melaleuca Colony.

|                                                 | Nesting Period |                    |           |                 |
|-------------------------------------------------|----------------|--------------------|-----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling  | Overall Success |
| Expected number of days in period; J            | 6              | 21                 | 41        |                 |
| Number of nests; K                              | 30             | 105                | 42        |                 |
| Number of unsuccessful nest; $Y_k$              | 2              | 65                 | 35        |                 |
| Total nest days of observation; $T_k$           | 148            | 931                | 318.5     |                 |
| Estimated daily survival probability; p         | 0.98649        | 0.92911            | 0.8901    |                 |
| Estimated standard deviation of p               | 0.0094870      | 0.0083670          | .0175210  |                 |
| Estimated success probability for period; $p^J$ | 0.92161        | 0.30836            | 0.19598   | 0.05569         |
| Estimated standard deviation of $p^J$           | 0.0531990      | 0.0446651          | 0.0540182 | 0.0178050       |
|                                                 | $\bar{X}$      | Standard Deviation |           | N               |
| Clutch Size                                     | 2.427          | 0.6804             |           | 110             |
| Initiation date                                 | 152.34         | 4.7248             |           | 61              |

## Appendix 2

## Table 2

Nesting success of White Ibis nesting at  
Coopertown Ibis Colony.

|                                                 | Nesting Period |                    |           |                 |
|-------------------------------------------------|----------------|--------------------|-----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling  | Overall Success |
| Expected number of days in period J             | 6              | 21                 | 14        |                 |
| Number of nests; K                              | 0              | 51                 | 6         |                 |
| Number of unsuccessful nest; $Y_k$              |                | 43                 | 4         |                 |
| Total nest days of observation; $T_k$           | 0              | 164.5              | 21        |                 |
| Estimated daily survival probability; p         |                | 0.73860            | 0.80952   |                 |
| Estimated standard deviation of p               |                | 0.0342492          | 0.085683  |                 |
| Estimated success probability for period; $p^J$ |                | 0.00784            | 0.05191   | 0.00042         |
| Estimated standard deviation of $p^J$           |                | 0.0058211          | 0.7691900 | 0.0008091       |
|                                                 | $\bar{X}$      | Standard Deviation |           | N               |
| Clutch Size                                     | 2.471          | 0.49913            |           | 51              |
| Initiation date                                 | 157.5          | 0.500              |           | 6               |

## Appendix 2

## Table 3

Nesting success of White Ibis nesting at Alley North Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 21                 | 14       |                 |
| Number of nests; K                              | 52             | 76                 | 70       |                 |
| Number of unsuccessful nest; $Y_k$              | 4              | 6                  | 10       |                 |
| Total nest days of observation; $T_k$           | 198.5          | 1002.5             | 861      |                 |
| Estimated daily survival probability; p         | 0.97985        | 0.99401            | 0.98839  |                 |
| Estimated standard deviation of p               | 0.00995        | 0.00224            | 0.00360  |                 |
| Estimated success probability for period; $p^J$ | 0.88502        | 0.90842            | 0.84912  | 0.68267         |
| Estimated standard deviation of $p^J$           | 0.054050       | 0.03562            | 0.04392  | 0.060915        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.667          | 0.64241            |          | 84              |
| Initiation date                                 | 130.472        | 9.5058             |          | 72              |

## Appendix 2

## Table 4

White Ibis nesting success at all colonies studied.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 21                 | 14       |                 |
| Number of nests; K                              | 82             | 232                | 118      |                 |
| Number of unsuccessful nest; $Y_k$              | 6              | 114                | 49       |                 |
| Total nest days of observation; $T_k$           | 346.5          | 2098               | 1200.5   |                 |
| Estimated daily survival probability; p         | 0.98268        | 0.94519            | 0.95918  |                 |
| Estimated standard deviation of p               | 0.0070         | 0.004899           | 0.005657 |                 |
| Estimated success probability for period; $p^J$ | 0.90050        | 0.40577            | 0.55798  | 0.20388         |
| Estimated standard deviation of $p^J$           | 0.03853        | 0.034133           | 0.04650  | 0.025732        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.518          | 0.64259            |          | 245             |
| Initiation date                                 | 141.24         | 13.4980            |          | 139             |

Appendix 2Table 5

Survival of White Ibis nestlings at all colonies studied.

|                                                       | <u>Nestling Survival</u> |                   |                   |                    |
|-------------------------------------------------------|--------------------------|-------------------|-------------------|--------------------|
|                                                       | Nesting Period           |                   |                   |                    |
|                                                       | 1 Young<br>Broods        | 2 Young<br>Broods | 3 Young<br>Broods | Overall<br>Success |
| Expected number<br>of days in<br>period; J            | 14                       | 14                | 14                |                    |
| Number of nests; K                                    | 19                       | 82                | 144               |                    |
| Number of<br>unsuccessful<br>nest; $Y_k$              | 12                       | 31                | 72                |                    |
| Total nest-days of<br>observation; $T_k$              | 121.5                    | 929               | 1243              |                    |
| Estimated daily<br>survival<br>probability; p         | 0.90123                  | 0.96663           | 0.94221           |                    |
| Estimated standard<br>deviation of p                  | 0.004796                 | 0.02706           | .005831           |                    |
| Estimated success<br>probability for<br>period; $p^J$ | 0.23320                  | 0.62180           | 0.43371           | 0.20388            |
| Estimated standard<br>deviation of $p^J$              | 0.098051                 | 0.053065          | 0.042705          | 0.025732           |

## Appendix 2

## Table 6

Nesting success of Great Egrets at East  
Everglades Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 1              | 4                  | 9        |                 |
| Number of unsuccessful nest; $Y_k$              | 1              | 3                  | 7        |                 |
| Total nest days of observation; $T_k$           | 3.5            | 21.5               | 126.5    |                 |
| Estimated daily survival probability; p         | 0.71429        | 0.86047            | 0.94466  |                 |
| Estimated standard deviation of p               | 0.24153        | 0.074726           | 0.02032  |                 |
| Estimated success probability for period; $p^J$ | 0.13281        | 0.04260            | 0.30257  | 0.00171         |
| Estimated standard deviation of $p^J$           | 0.269388       | 0.07769            | 0.136730 | 0.008668        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.308          | 0.60569            |          | 13              |
| Initiation date                                 | 87.5           | 9.0323             |          | 6               |

## Appendix 2

## Table 7

Nesting success of Great Egrets at Frog City Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 5              | 23                 | 32       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 3                  | 6        |                 |
| Total nest days of observation; $T_k$           | 18             | 236                | 599.5    |                 |
| Estimated daily survival probability; p         | 1.00000        | 0.98729            | 0.99500  |                 |
| Estimated standard deviation of p               | 0              | 0.00728            | 0.008944 |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 0.76440            | 0.90001  | 0.68797         |
| Estimated standard deviation of $p^J$           | 0              | 0.118568           | 0.054742 | 0.114807        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.514          | 0.55402            |          | 35              |
| Initiation date                                 | 84.190         | 9.1632             |          | 21              |

## Appendix 2

## Table 8

Nesting success of Great Egrets at  
Andytown Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 29             | 58                 | 61       |                 |
| Number of unsuccessful nest; $Y_k$              | 1              | 27                 | 20       |                 |
| Total nest days of observation; $T_k$           | 132            | 686                | 516.5    |                 |
| Estimated daily survival probability; p         | 0.99242        | 0.96064            | 0.96128  |                 |
| Estimated standard deviation of p               | 0.007483       | 0.007416           | 0.008485 |                 |
| Estimated success probability for period; $p^J$ | 0.95540        | 0.43032            | 0.43634  | 0.17939         |
| Estimated standard deviation of $p^J$           | 0.043592       | 0.069836           | 0.080920 | 0.045328        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.933          | 0.4021             |          | 61              |
| Initiation date                                 | 44.58          | 8.25855            |          | 50              |

## Appendix 2

## Table 9

Nesting success of Great Egrets at Big Melaleuca Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 2              | 13                 | 11       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 7                  | 3        |                 |
| Total nest days of observation; $T_k$           | 12             | 103.5              | 173      |                 |
| Estimated daily survival probability; p         | 1.00000        | 0.93237            | 0.98266  |                 |
| Estimated standard deviation of p               | 0              | 0.024678           | 0.009899 |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 0.22979            | 0.69256  | 0.15914         |
| Estimated standard deviation of $p^J$           | 0              | 0.127749           | 0.146889 | 0.096536        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.500          | 0.60092            |          | 18              |
| Initiation date                                 | 54.3           | 5.7801             |          | 10              |

## Appendix 2

Table 10

Nesting success of Great Egrets at  
Alley North Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 2              | 6                  | 15       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 0                  | 0        |                 |
| Total nest days of observation; $T_k$           | 12             | 63.5               | 211      |                 |
| Estimated daily survival probability; p         | 1.00000        | 1.00000            | 1.00000  |                 |
| Estimated standard deviation of p               | 0              | 0                  | 0        |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 1.000000           | 1.00000  | 1.000000        |
| Estimated standard deviation of $p^J$           | 0              | 0                  | 0        | 0               |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.294          | 0.95577            |          | 17              |
| Initiation date                                 | 109.667        | 7.6522             |          | 6               |

Appendix 2Table 11Nesting success of Great Egrets at  
Lost Colony.

|                                                       | Nesting Period |            |          |                 |
|-------------------------------------------------------|----------------|------------|----------|-----------------|
|                                                       | Laying         | Incubation | Nestling | Overall Success |
| Expected number<br>of days in<br>period; J            | 6              | 28         | 21       |                 |
| Number of nests; K                                    | 17             | 0          | 0        |                 |
| Number of<br>unsuccessful<br>nest; $Y_k$              | 17             | 0          | 0        |                 |
| Total nest days of<br>observation; $T_k$              | 59.5           | 0          | 0        |                 |
| Estimated daily<br>survival<br>probability; p         | 0.71429        |            |          |                 |
| Estimated standard<br>deviation of p                  | 0.058558       |            |          |                 |
| Estimated success<br>probability for<br>period; $p^J$ | 0.13281        |            |          | 0.13280         |
| Estimated standard<br>deviation of $p^J$              | 0.065336       |            |          | 0.065336        |

## Appendix 2

Table 12

Nesting success of Great Egrets at  
Nick's Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 4              | 19                 | 7        |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 14                 | 7        |                 |
| Total nest days of observation; $T_k$           | 22             | 180                | 62       |                 |
| Estimated daily survival probability; p         | 100            | 0.92222            | 0.88710  |                 |
| Estimated standard deviation of p               | 0              | 0.01995            | 0.040187 |                 |
| Estimated success probability for period; $p^J$ | 1.00           | 0.18262            | 0.08080  | 0.01475         |
| Estimated standard deviation of $p^J$           | 0              | 0.083011           | 0.076874 | 0.016816        |
|                                                 | $\bar{X}$      | Standard Deviation | N        |                 |
| Clutch size                                     | 2.500          | 0.5839             | 22       |                 |
| Initiation date                                 | 66.82          | 11.6057            | 11       |                 |

Appendix 2Table 13Nesting success of Great Egrets at  
Stix Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 4              | 15                 | 17       |                 |
| Number of unsuccessful nest; $Y_k$              | 1              | 5                  | 9        |                 |
| Total nest days of observation; $T_k$           | 19             | 87                 | 229      |                 |
| Estimated daily survival probability; p         | 0.94737        | 0.94253            | 0.96070  |                 |
| Estimated standard deviation of p               | 0.051225       | 0.02494            | 0.01280  |                 |
| Estimated success probability for period; $p^J$ | 0.72296        | 0.28853            | 0.43086  | 0.08987         |
| Estimated standard deviation of $p^J$           | 0.234558       | 0.160407           | 0.120932 | 0.067307        |
|                                                 | X              | Standard Deviation | N        |                 |
| Clutch size                                     | 2.520          | 0.57410            | 25       |                 |
| Initiation date                                 | 65.25          | 12.4172            | 16       |                 |

## Appendix 2

Table 14

Nesting Success of Great Egrets nesting  
in all colonies studied within WCA 3.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 38             | 100                | 91       |                 |
| Number of unsuccessful nest; $Y_k$              | 1              | 37                 | 26       |                 |
| Total nest days of observation; $T_k$           | 174            | 1089               | 1500     |                 |
| Estimated daily survival probability; p         | 0.99425        | 0.96602            | 0.98267  |                 |
| Estimated standard deviation of p               | 0.005657       | 0.005477           | 0.003317 |                 |
| Estimated success probability for period; $p^J$ | 0.96601        | 0.48389            | 0.69268  | 0.32378         |
| Estimated standard deviation of $p^J$           | 0.033406       | 0.057748           | 0.049881 | 0.002172        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.634          | 0.6048             |          | 131             |
| Initiation date                                 | 59.75          | 22.782             |          | 87              |

## Appendix 2

## Table 15

Nesting success of Great Egrets nesting in all colonies studied within Everglades National Park.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days; in period J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 25             | 35                 | 26       |                 |
| Number of unsuccessful nest; $Y_k$              | 18             | 19                 | 16       |                 |
| Total nest days of observation; $T_k$           | 100.5          | 267                | 291      |                 |
| Estimated daily survival; p                     | 0.82089        | 0.92884            | 0.94502  |                 |
| Estimated standard deviation of p               | 0.038236       | 0.015716           | 0.013342 |                 |
| Estimated success probability for period; $p^J$ | 0.30600        | 0.21220            | 0.30495  | 0.01980         |
| Estimated standard deviation of $p^J$           | 0.85547        | 0.075485           | 0.090558 | 0.011231        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.398          | 0.71905            |          | 64              |
| Initiation date                                 | 65.89          | 12.1177            |          | 27              |

## Appendix 2

Table 16

Nesting success of Great Egrets nesting in all colonies studied.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 64             | 139                | 126      |                 |
| Number of unsuccessful nest; $Y_k$              | 20             | 59                 | 49       |                 |
| Total nest days of observation; $T_k$           | 278            | 1377.5             | 1917.5   |                 |
| Estimated daily survival probability; p         | 0.928057       | 0.957168           | 0.974445 |                 |
| Estimated standard deviation of p               | 0.01549        | 0.00539            | 0.003464 |                 |
| Estimated success probability for period; $p^J$ | 0.638924       | 0.398803           | 0.580647 | 0.147951        |
| Estimated standard deviation of $p^J$           | 0.064015       | 0.047732           | 0.045093 | 0.025917        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.5408         | 0.6537             |          | 208             |
| Initiation date                                 | 62.516         | 21.2779            |          | 120             |

Appendix 2Table 17Survival of Great Egret nestlings  
in all colonies studied.

|                                                       | Brood Size        |                   |                   | Overall<br>Success |
|-------------------------------------------------------|-------------------|-------------------|-------------------|--------------------|
|                                                       | 1 Young<br>Broods | 2 Young<br>Broods | 3 Young<br>Broods |                    |
| Expected number<br>of days in<br>period; J            | 21                | 21                | 21                |                    |
| Number of nests; K                                    | 5                 | 126               | 162               |                    |
| Number of<br>unsuccessful<br>nest; $Y_k$              | 4                 | 59                | 79                |                    |
| Total nest days of<br>observation; $T_k$              | 61.5              | 1787              | 2077.5            |                    |
| Estimated daily<br>survival<br>probability; p         | 0.934959          | 0.966983          | 0.961973          |                    |
| Estimated standard<br>deviation of p                  | 0.03143           | 0.00412           | 0.00412           |                    |
| Estimated success<br>probability for<br>period; $p^J$ | 0.243583          | 0.494086          | 0.443022          | 0.461578           |
| Estimated standard<br>deviation of $p^J$              | 0.172038          | 0.045353          | 0.040582          | 8.753174           |

## Appendix 2

## Table 18

Nesting Success of Tricolored Herons at  
LBH Colony

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 7              | 63                 | 9        |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 3                  | 1        |                 |
| Total nest days of observation; $T_k$           | 22             | 634                | 104      |                 |
| Estimated daily survival probability; p         | 1.00000        | 0.99527            | 0.99038  |                 |
| Estimated standard deviation of p               | 0              | 0.002646           | 0.009539 |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 0.92692            | 0.87348  | 0.80965         |
| Estimated standard deviation of $p^J$           | 0              | 0.040612           | 0.118153 | 0.115220        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.278          | 0.53287            |          | 71              |
| Initiation date                                 | 96.20          | 14.4139            |          | 5               |

## Appendix 2

## Table 19

Nesting Success of Tricolored Herons at  
Frog City Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 11             | 18                 | 25       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 10                 | 1        |                 |
| Total nest days of observation; $T_k$           | 61             | 32                 | 308      |                 |
| Estimated daily survival probability; p         | 1.00000        | 0.97245            | 0.99675  |                 |
| Estimated standard deviation of p               | 0              | 0.008544           | 0.003162 |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 0.63957            | 0.95549  | 0.61112         |
| Estimated standard deviation of $p^J$           | 0              | 0.09040            | 0.043502 | 0.090832        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.192          | 0.55603            |          | 37              |
| Initiation date                                 | 91.000         | 12.22516           |          | 22              |

## Appendix 2

## Table 20

Nesting Success of Tricolored Herons at  
East Everglades Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 8              | 40                 | 15       |                 |
| Number of unsuccessful nest; $Y_k$              | 5              | 28                 | 13       |                 |
| Total nest days of observation; $T_k$           | 34             | 272.5              | 126.5    |                 |
| Estimated daily survival probability; p         | 0.85294        | 0.89725            | 0.89723  |                 |
| Estimated standard deviation of p               | 0.060737       | 0.018385           | 0.026981 |                 |
| Estimated success probability for period; $p^J$ | 0.38505        | 0.17644            | 0.21912  | 0.01489         |
| Estimated standard deviation of $p^J$           | 0.164517       | 0.057872           | 0.092306 | 0.010961        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.966          | 0.12472            |          | 15              |
| Initiation date                                 | 97             | 5.0568             |          | 14              |

## Appendix 2

Table 21

Nesting Success of Tricolored Herons at  
Alley North Colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 37             | 67                 | 50       |                 |
| Number of unsuccessful nest; $Y_k$              | 2              | 6                  | 0        |                 |
| Total nest days of observation; $T_k$           | 160.5          | 831.5              | 634      |                 |
| Estimated daily survival probability; p         | 0.98754        | 0.992784           | 1.00000  |                 |
| Estimated standard deviation of p               | 0.00871        | 0.002828           | 0        |                 |
| Estimated success probability for period; $p^J$ | 0.92752        | 0.89059            | 1.00000  | 0.826042        |
| Estimated standard deviation of $p^J$           | 0.49344        | 0.04213            | 0        | 0.058842        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.085          | 1.20439            |          | 53              |
| Initiation date                                 | 115.212        | 12.3184            |          | 33              |

## Appendix 2

## Table 22

Nesting Success of Tricolored Herons at  
Stix Colony.

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 8              | 8                  | 0        |                 |
| Number of unsuccessful nest; $Y_k$              | 2              | 6                  |          |                 |
| Total nest days of observation; $T_k$           | 40.5           | 83.5               | 0        |                 |
| Estimated daily survival probability; p         | 0.95061        | 0.92814            |          |                 |
| Estimated standard deviation of p               | 0.03404        | 0.028249           |          |                 |
| Estimated success probability for period; $p^J$ | 0.73796        | 0.30328            |          | 0.22381         |
| Estimated standard deviation of $p^J$           | 0.158577       | 0.147756           |          | 0.121455        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.769          | 0.79940            |          | 13              |
| Initiation date                                 | 83.38          | 4.5535             |          | 8               |

## Appendix 2

## Table 23

## Nesting Success of Tricolored Herons at Nick's Colony.

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 34             | 43                 | 0        |                 |
| Number of unsuccessful nest; $Y_k$              | 8              | 43                 |          |                 |
| Total nest days of observation; $T_k$           | 154            | 366                | 0        |                 |
| Estimated daily survival probability; p         | 0.94805        | 0.88251            |          |                 |
| Estimated standard deviation of p               | 0.017861       | 0.016823           |          |                 |
| Estimated success probability for period; $p^J$ | 0.72609        | 0.153538           |          | 0.09830         |
| Estimated standard deviation of $p^J$           | 0.082177       | 0.041310           |          | 0.032171        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.863          | 0.9079             |          | 51              |
| Initiation date                                 | 82.67          | 4.549              |          | 34              |

## Appendix 2

Table 24

Nesting Success of Tricolored Herons at  
all colonies studied in ENP

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 42             | 51                 | 0        |                 |
| Number of unsuccessful nest; $Y_k$              | 10             | 49                 |          |                 |
| Total nest days of observation; $T_k$           | 194.5          | 449.5              | 0        |                 |
| Estimated daily survival probability; p         | 0.94858        | 0.89099            |          |                 |
| Estimated standard deviation of p               | 0.0158110      | 0.014697           |          |                 |
| Estimated success probability for period; $p^J$ | 0.72855        | 0.15775            |          | 0.11493         |
| Estimated standard deviation of $p^J$           | 0.072971       | 0.041640           |          | 0.032589        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.844          | 0.88774            |          | 64              |
| Initiation date                                 | 82.81          | 4.5577             |          | 42              |

## Appendix 2

## Table 25

Nesting Success of Tricolored Herons at  
all colonies studied in WCA 3.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 59             | 197                | 90       |                 |
| Number of unsuccessful nest; $Y_k$              | 2              | 22                 | 3        |                 |
| Total nest days of observation; $T_k$           | 265.5          | 2103.5             | 1114     |                 |
| Estimated daily survival probability; p         | 0.992467       | 0.98954            | 0.997307 |                 |
| Estimated standard deviation of p               | 0.005291       | 0.002000           | 0.001414 |                 |
| Estimated success probability for period; $p^J$ | 0.955644       | 0.845166           | 0.96295  | 0.77776         |
| Estimated standard deviation of $p^J$           | 0.030657       | 0.030311           | 0.020989 | 0.041103        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.053191       | 1.082913           |          | 94              |
| Initiation date                                 | 106.78         | 18.9723            |          | 63              |

## Appendix 2

Table 26

Nesting success of Tricolored Herons at all colonies studied.

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 102            | 261                | 107      |                 |
| Number of unsuccessful nest; $Y_k$              | 12             | 71                 | 16       |                 |
| Total nest days of observation; $T_k$           | 460            | 2651               | 1247.5   |                 |
| Estimated daily survival probability; p         | 0.97391        | 0.97322            | 0.98718  |                 |
| Estimated standard deviation of p               | 0.007416       | 0.003              | 0.003162 |                 |
| Estimated success probability for period; $p^J$ | 0.85334        | 0.64767            | 0.83467  | 0.46131         |
| Estimated standard deviation of $p^J$           | 0.03907        | 0.033388           | 0.03771  | 0.038069        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 2.973          | 0.96662            |          | 174             |
| Initiation date                                 | 97.667         | 18.6937            |          | 120             |

## Appendix 2

## Table 27

Survival of Nestling Tricolored Herons  
in all colonies studied.

|                                                       | Brood Size        |                   |                   |                   | Overall<br>Success |
|-------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|                                                       | 1 Young<br>Broods | 2 Young<br>Broods | 3 Young<br>Broods | 4 Young<br>Broods |                    |
| Expected number<br>of days in<br>period; J            | 14                | 14                | 14                | 14                |                    |
| Number of nests; K                                    | 6                 | 32                | 213               | 52                |                    |
| Number of<br>unsuccessful<br>nest; $Y_k$              | 0                 | 6                 | 50                | 13                |                    |
| Total nest days of<br>observation; $T_k$              | 78.5              | 354.5             | 2024              | 518               |                    |
| Estimated daily<br>survival<br>probability; p         | 1.00000           | 0.98307           | 0.97530           | 0.97490           |                    |
| Estimated standard<br>deviation of p                  | 0                 | 0.00678           | 0.003317          | 0.006856          |                    |
| Estimated success<br>probability for<br>period; $p^J$ | 1.00000           | 0.78743           | 0.70455           | 0.70059           | 0.71847            |
| Estimated standard<br>deviation of $p^J$              | 0                 | 0.076825          | 0.034893          | 0.069143          | 8.61459            |

## Appendix 2

## Table 28

Nesting Success of Little Blue Herons at LBH colony.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 7              | 63                 | 50       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 3                  | 1        |                 |
| Total nest days of observation; $T_k$           | 22             | 634                | 482.5    |                 |
| Estimated daily survival probability; p         | 1.00000        | 0.99527            | 0.99793  |                 |
| Estimated standard deviation of p               | 0              | 0.002646           | 0.0020   |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 0.92692            | 0.97137  | 0.90038         |
| Estimated standard deviation of $p^J$           | 0              | 0.40612            | 0.028214 | 0.047345        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.745          | 0.43581            |          | 51              |
| Initiation date                                 | 103.417        | 6.3240             |          | 48              |

## Appendix 2

## Table 29

Nesting success of Little Blue Herons at Mickey Mouse Colony.

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 4              | 35                 | 44       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 3                  | 6        |                 |
| Total nest days of observation; $T_k$           | 22             | 275                | 561.5    |                 |
| Estimated daily survival probability; p         | 1.00000        | 0.98909            | 0.98931  |                 |
| Estimated standard deviation of p               | 0              | 0.006245           | 0.004243 |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 0.83903            | 0.86036  | 0.08565         |
| Estimated standard deviation of $p^J$           | 0              | 0.085017           | 0.052828 | 0.721871        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.148          | 0.5894             |          | 44              |
| Initiation date                                 | 139.703        | 4.9531             |          | 37              |

## Appendix 2

## Table 30

Nesting Success of Little Blue Herons at all colonies studied.

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 22                 | 14       |                 |
| Number of nests; K                              | 63             | 200                | 98       |                 |
| Number of unsuccessful nest; $Y_k$              | 7              | 22                 | 8        |                 |
| Total nest days of observation; $T_k$           | 265.5          | 2103.5             | 1088     |                 |
| Estimated daily survival probability; p         | 0.99248        | 0.98954            | 0.99265  |                 |
| Estimated standard deviation of p               | 0.00529        | 0.0020             | 0.002449 |                 |
| Estimated success probability for period; $p^J$ | 0.95564        | 0.84517            | 0.90184  | 0.72840         |
| Estimated standard deviation of $p^J$           | 0.030657       | 0.030311           | 0.032943 | 0.044032        |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.4706         | 0.58955            |          | 99              |
| Initiation date                                 | 118.978        | 18.85186           |          | 89              |

Appendix 2Table 31Survival of Nestling Little Blue Herons  
at all colonies within the study area.

|                                                       | Brood Size        |                   |                   |                   | Overall<br>Success |
|-------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|                                                       | 1 Young<br>Broods | 2 Young<br>Broods | 3 Young<br>Broods | 4 Young<br>Broods |                    |
| Expected number<br>of days in<br>period; J            | 14                | 14                | 14                | 14                |                    |
| Number of nests; K                                    | 3                 | 18                | 159               | 132               |                    |
| Number of<br>unsuccessful<br>nest; $Y_k$              | 0                 | 7                 | 34                | 18                |                    |
| Total nest days of<br>observation; $T_k$              | 30.5              | 200               | 1479              | 1045.5            |                    |
| Estimated daily<br>survival<br>probability; p         | 1.00000           | 0.9650            | 0.97701           | 0.98278           |                    |
| Estimated standard<br>deviation of p                  | 0                 | 0.012961          | 0.003873          | 0.0040            |                    |
| Estimated success<br>probability for<br>period; $p^J$ | 1.00000           | 0.60727           | 0.72210           | 0.78417           | 0.74441            |
| Estimated standard<br>deviation of $p^J$              | 0                 | 0.114489          | 0.040302          | 0.044938          | 8.974322           |

## Appendix 2

Table 32

Nesting Success of Snowy Egrets at Alley North Colony, the only colony where Snowy Egret nests were monitored.

|                                                 | Nesting Period       |                    |          |                 |
|-------------------------------------------------|----------------------|--------------------|----------|-----------------|
|                                                 | Laying               | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6                    | 22                 | 14       |                 |
| Number of nests; K                              | 37                   | 67                 | 15       |                 |
| Number of unsuccessful nest; $Y_k$              | 2                    | 6                  | 2        |                 |
| Total nest days of observation; $T_k$           | 160.5                | 831.5              | 189      |                 |
| Estimated daily survival probability; p         | 0.98754              | 0.99278            | 0.98942  |                 |
| Estimated standard deviation of p               | 0.00872 <sup>1</sup> | 0.002828           | 0.007416 |                 |
| Estimated success probability for period; $p^J$ | 0.92750              | 0.89059            | 0.86162  | 0.71174         |
| Estimated standard deviation of $p^J$           | 0.049344             | 0.042129           | 0.090742 | 0.09065         |
|                                                 | $\bar{X}$            | Standard Deviation |          | N               |
| Clutch Size                                     | 2.467                | 1.58605            |          | 15              |
| Initiation date                                 | 114.45               | 6.90669            |          | 11              |

Appendix 2Table 33

Survival of Nestling Snowy Egrets at Alley North, the only colony where Snowy Egret nests were monitored.

|                                                 | Brood Size     |                |                |                | Overall Success |
|-------------------------------------------------|----------------|----------------|----------------|----------------|-----------------|
|                                                 | 1 Young Broods | 2 Young Broods | 3 Young Broods | 4 Young Broods |                 |
| Expected number of days in period; J            | 14             | 14             | 14             | 14             | 14              |
| Number of nests; K                              | 0              | 6              | 24             | 16             |                 |
| Number of unsuccessful nest; $Y_k$              |                | 0              | 7              | 4              |                 |
| Total nest days of observation; $T_k$           | 0              | 64             | 261            | 169            |                 |
| Estimated daily survival probability; p         |                | 1.00000        | 0.97318        | 0.97633        |                 |
| Estimated standard deviation of p               |                | 0              | 0.00362        | 0.01166        |                 |
| Estimated success probability for period; $p^J$ |                | 1.00000        | 0.683447       | 0.71509        | 0.73574         |
| Estimated standard deviation of $p^J$           |                | 0              | 0.09832        | 0.119904       | 3.04116         |

## Appendix 2

Table 34

Nesting success of Glossy Ibises at Alley North Colony, the only colony where Glossy Ibis nests were monitored.

|                                                 | Nesting Period |                    |          | Overall Success |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling |                 |
| Expected number of days in period; J            | 6              | 21                 | 14       |                 |
| Number of nests; K                              | 8              | 9                  | 0        |                 |
| Number of unsuccessful nest; $Y_k$              | 1              | 8                  |          |                 |
| Total nest days of observation; $T_k$           | 43             | 69                 | 0        |                 |
| Estimated daily survival probability; p         | 0.97674        | 0.88406            |          |                 |
| Estimated standard deviation of p               | 0.022978       | 0.038536           |          |                 |
| Estimated success probability for period; $p^J$ | 0.86833        | 0.07518            |          | 0.06528         |
| Estimated standard deviation of $p^J$           | 0.122596       | 0.068828           |          | 0.061058        |
|                                                 | X              | Standard Deviation |          | N               |
| Clutch size                                     | 2.50           | 0.67082            |          | 10              |
| Initiation date                                 | 143.875        | 5.4872             |          | 8               |

Appendix 2Table 35Nesting success of Green-backed  
Hérons at all colonies studied

|                                                 | Nesting Period |            |          | Overall Success |
|-------------------------------------------------|----------------|------------|----------|-----------------|
|                                                 | Laying         | Incubation | Nestling |                 |
| Expected number of days in period; J            | 6              | 21         | 14       |                 |
| Number of nests; K                              | 0              | 3          | 4        |                 |
| Number of unsuccessful nest; $Y_k$              |                | 1          | 0        |                 |
| Total nest days of observation; $T_k$           | 0              | 21.5       | 54       |                 |
| Estimated daily survival probability; p         |                | 0.95349    | 1.0000   |                 |
| Estimated standard deviation of p               |                | 0.04540    | 0        |                 |
| Estimated success probability for period; $p^J$ |                | 0.36780    | 1.0000   | 0.36781         |
| Estimated standard deviation of $p^J$           |                | 0.367914   | 0        | 0.606559        |

Appendix 2Table 36Nesting success of Black-crowned  
Night Herons at Alley North Colony

|                                                 | Nesting Period |            |          |                 |
|-------------------------------------------------|----------------|------------|----------|-----------------|
|                                                 | Laying         | Incubation | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28         | 21       |                 |
| Number of nests; K                              | 15             | 24         | 26       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 0          | 0        |                 |
| Total nest days of observation; $T_k$           | 66             | 358        | 500      |                 |
| Estimated daily survival probability; p         | 1.00000        | 1.00000    | 1.0000   |                 |
| Estimated standard deviation of p               | 0              | 0          | 0        |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 1.00000    | 1.0000   | 1.00000         |
| Estimated standard deviation of $p^J$           | 0              | 0          | 0        | 0.0             |

## Appendix 2

## Table 37

Nesting Success of Black-Crowned Night  
Heron at all colonies studied.

|                                                 | Nesting Period |                    |          |                 |
|-------------------------------------------------|----------------|--------------------|----------|-----------------|
|                                                 | Laying         | Incubation         | Nestling | Overall Success |
| Expected number of days in period; J            | 6              | 28                 | 21       |                 |
| Number of nests; K                              | 16             | 25                 | 27       |                 |
| Number of unsuccessful nest; $Y_k$              | 0              | 0                  | 0        |                 |
| Total nest days of observation; $T_k$           | 66             | 360                | 521      |                 |
| Estimated daily survival probability; p         | 1.00000        | 1.00000            | 1.00000  |                 |
| Estimated standard deviation of p               | 0              | 0                  | 0        |                 |
| Estimated success probability for period; $p^J$ | 1.00000        | 1.00000            | 1.00000  | 1.0             |
| Estimated standard deviation of $p^J$           | 0              | 0                  | 0        | 0               |
|                                                 | $\bar{X}$      | Standard Deviation |          | N               |
| Clutch Size                                     | 3.1481         | 0.6500             |          | 27              |
| Initiation date                                 | 111.174        | 3.990              |          | 23              |

## Appendix 2

Table 38

Survival of Nestling Black-crowned  
Night Herons at all colonies studied

|                                                       | Brood Size        |                   |                   |                   | Overall<br>Success |
|-------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|                                                       | 1 Young<br>Broods | 2 Young<br>Broods | 3 Young<br>Broods | 4 Young<br>Broods |                    |
| Expected number<br>of days in<br>periods; J           | 21                | 21                | 21                | 21                |                    |
| Number of nests; K                                    | 8                 | 6                 | 24                | 16                |                    |
| Number of<br>unsuccessful<br>nest; $Y_k$              | 0                 | 0                 | 4                 | 1                 |                    |
| Total nest days of<br>observation; $T_k$              | 8                 | 80                | 1013              | 67.5              |                    |
| Estimated daily<br>survival<br>probability; p         | 1.00000           | 1.00000           | 0.99605           | 0.98519           |                    |
| Estimated standard<br>deviation of p                  | 0                 | 0                 | .001732           | .0014697          |                    |
| Estimated success<br>probability for<br>period; $p^J$ | 1.00000           | 1.00000           | 0.92027           | 0.730933          | (1)                |
| Estimated standard<br>deviation of $p^J$              | 0                 | 0                 | 0.038230          | 0.2291030         | (2)                |

(1) = 0.867689

(2) = 3.778747